

Entelechies

Proceedings of ANPA 16

K. G. Bowden, *Editor*

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Alternative Natural Philosophy Association

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Alternative Natural Philosophy Association

These Proceedings bring together the collection of papers presented at the 16th annual meeting of the Alternative Natural Philosophy Association held in Cambridge in September, 1994.

Further copies of the Proceedings may be obtained from C. W. Kilmister, Red Tiles Cottage, High St, Barcombe, Lewes BN8 5DH. (Telephone 01273 400 922.)

EDITORIAL

This year has been one of the most exciting, for ANPA members, that I can remember. After two enormously successful ANPA meetings in Cambridge, in Septembers 1993 and 1994, four of us, Pierre Noyes, Mike Manthey, Lou Kauffman and myself, were invited to, and presented papers at PHYSCOMP94, the third International Conference on Physics and Computation in Dallas, Texas, in November 1994. Clive Kilmister's remarkable book *Eddington's Search for a Fundamental Theory* has been published by Cambridge University Press, and his joint work with Ted Bastin, entitled *Combinatorial Physics*, of the "Menshevik" point of view within ANPA, is due to be published by World Scientific shortly. Prepublication copies are promised, to be visible at the 1995 meeting. Meanwhile over on the other side of the Atlantic, Pierre Noyes and Lou Kauffman have jointly written a new paper entitled *Discrete Physics and the Derivation of Maxwell's Equations from the Formalism of Quantum Mechanics*, which, as this Proceedings goes to press, is in print for the *Proceedings of the Royal Society*. Congratulations to Lou and Pierre! I don't believe that the full implications of this paper will be clear for some time yet. (It is an interesting reminiscence that the last ANPA related paper to be published by the Royal Society was *The Analysis of Observations* by Ted Bastin and Clive Kilmister, over forty years ago. The title reflects the consistency and clarity of their view, over the intervening period, culminating in their forthcoming book. It was not until nearly ten years after the publication of this paper that the Hierarchy itself was discovered.) I am currently editing a Special Issue of the *International Journal of General Systems* on ANPA related material (The Emergence of Physical Structure from Information Theory), and have received a number of excellent contributions. Pierre Noyes and Ted Bastin are both, to my knowledge, also working on forthcoming books. For me personally, one of the highlights of the year was attending the ANPA West Annual Meeting at Stanford in February, for the first time. It was a pleasure for me to discover how well organised, mature, creative and independent a body ANPA West is.

This is the Proceedings of the 1994 ANPA Conference at the University of Cambridge. The editorship has unfortunately fallen my lot. I say unfortunately because the retiring editor Faruq Abdullah has been sadly handicapped by family illness. Faruq's enormous contributions to ANPA in the past are greatly appreciated by all, and we sincerely hope that his situation eases soon. On the positive side the Proceedings now has an ISBN number, due to the initiative of Viv Pope who has also generously taken over the production of the ANPA Newsletter (which also has an ISSN number). Copies will be distributed to the British Library, the Bodleian, the University of Cambridge etc. While I remember, I have received videos (25 tapes!) of the Dallas Conference, from Texas Instruments in Dallas. These will be distributed to the same libraries as the Proceedings. I should also mention here that copies of the remarkable ANPA video tapes of Clive Kilmister, Ted Bastin and David McGoveran, in conversation in Cambridge, and produced last year by DEC, are now (and have been for some time) available within ANPA. The Proceedings is now produced by the Print Unit of the University of East London. For their support and help I would particularly like to thank Anne Kropholler, Al Freimanis and Anna Bass.

For some time now the contents of the Proceedings, and indeed the structure of the ANPA Conferences, has been falling naturally into three parts. To give the Proceedings more of a structure I have formalised this in this issue by naming the three divisions, **Developments** in Combinatorial Hierarchy related work, **Variations** on the orthodox theories and new **Alternatives** to both. Partly in order to maintain a good balance, I have included classical approaches to orthodox theories (such as Relativity) in the second section. This almost exactly maps onto the three days of the Conference chaired by Mike Homer, Mike Manthey and myself respectively (although not in the same order). I trust however that this initiative does *not* induce any unwarranted conformity in future offerings! (Although I do have a few requests about presentation rather than content, below.) I have retained the title Alternatives for the volume as a whole.

Pierre Noyes amongst others has often wondered about the apparant plethora of (apparently contradictory) approaches sometimes available to arrive at the same results in Physics. In Ted Bastin's Presidential address, Entelechies, he suggests a fascinating explanation for this in the context of McGoveran and Kilmister's approaches to the correction for the Fine Structure Constant. Kilmister, Manthey, Noyes, Tom Etter and myself continue our attempts to shine light in a discrete world. **Developments** is considerably enhanced by the discovery, by John Amson and Pierre Noyes, of a number of papers in a box in John Amson's attic in St Andrews, Scotland, from the days of Cambridge Language Research Unit in the early nineteen sixties. These papers are as inspiring and innovatory as if they had been published today. I am pleased to include two of them (by John Amson and Ted Bastin) as an appendix to this section. Another two (by John Amson and the late Frederick Parker-Rhodes) will be published in the IJGS Special Issue. In **Variations**, Peter Marcer, Viv Pope, Tony Deakin, Clive Kilmister, Edward Grey and Rainer Zimmerman (Germany) continue their deliberations on Relativity and other matters, along with Mogens Wegener from the Institute of Ideas in Denmark and Peter Eisenhardt (Germany), whom we welcome. In **Alternatives** we also welcome a profusion of new (and old) members, Emmanuel Ransford (France), Seigfreid Wouthuysen (Holland), Geoffrey Constable, Scott Starson (USA), Francis Sanchez (France) and Harold Aspden who each have alternative physical theories of their own, some with relevance to Discrete Physics.

I would like to try to introduce some conformity of *style* for future issues of the Proceedings. Ideally I would like contributions to be submitted in International Journal of General Systems format (I have some copies of their Notes for Authors) or similar. At least, Times Roman, 12 point, double spaced, *single sided, two copies*, is preferred, although I will still accept typescripts in Courier. Main heading capitalised, centred, other headings capitalised to the left. Page numbers NOT bottom right. *Only copy in good English will be considered, and remember, this is a formal Proceedings.* Remember also to include your **name** (surprising how many people omit this!), affiliation or address, email address and the **version number** of the draft. I often get sent more than one version of a paper and invariably mix them up! Send copy to *Keith Bowden, 47 Park Avenue, Barking, Essex IG11 8QU*. Please help me by conforming to all this as closely as you can. Finally, let me wish all who will be attending, an excellent meeting for 1995!

Keith Bowden
University of East London
August 1995

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Part 1: Developments

ANPA 1994

What do you say about ANPA to a group of Standard Modellers

Mike Homer
September 1994

Standard Model

- Scale
 - Quantum ...very small
 - Newtonian ...human scale
 - Relativistic ...very large
- Some constants put in by hand
- Diracs numerical observation(10E40)
- Time added as an afterthought
- Space is a Platonic receptacle
- Not really one model

Scenario

- A talk to a group at CERN/SLAC
 - Generalists
 - friendly
- Your goals
 - convey the ANPA story
 - get feedback

Standard Modellers Principles

- Continuousness
- ?(Dual or converse of Discrimination)
- Structure
 - No history
 - No context
- ?(Not Combinatorial)
 - Analytic
- Information not a basic concept
- Object emphasis
- Computing as counting

Today

- 20 minute presentation
- 40 minute discussion
 - Improve the presentation
- improvements
 - add in any missing points
 - priorities/emphasis
 - highlight the uniqueness of ANPA
 - reorder the sequence of the story
- new presentation will be published

Standard Physics Status

- No significant results for 10 years
- 10 constants to be put in by hand
- Cost of experiments unbearable
- Quantum thinking "fuzzy"
- Newtonian thinking embedded
- Relativity thinking accepted
- Connectivity rejected(EPR/Bell/^^^)

ANPA Model

- All scales
- No constants put in by hand
- Produces Diracs and Eddingtons numbers
- Time "precedes" space (Mantley, Etter)
- Space (3D) from the theory
- One model..
 - COMBINATORIAL HIERARCHY
 - Principles

Questions

- Standard Physics
 - Model
 - Principles
 - Status
- ANPA Physics
 - Model
 - Principles
 - Status
- ANPA outside of Physics

ANPA Principles

- Discreteness
- Discrimination
- Process
 - History
 - Context
- Combinatorial
 - Synthetic (Leibnitz)
- Information a basic concept
- Relationship emphasis
- Computing is modelling

Combinatorial Hierarchy

- Two Simultaneous Processes
 - An evolving discovery/discrimination process
 - A naming/labeling process
- A four level hierarchy emerges
- Discrimination changes at each level(?)
- Coupling Constants V. lies appear
- Hierarchy evolution terminates
 - labels evolve
 - entities to be labelled evolve more rapidly

ANPA Physics Status

- Significant results recently
- No constants put in by hand(?)
- Computation Experiments inexpensive
- Quantum thinking clear
- Newtonian thinking purged
- Relativity thinking integrated
- Connectivity (relationships) basic

Concerning Theories

- Beliefs
- Axioms
- Theorems
- Practice/experiments
- Feedback
- Mathematics
- Goals

ENTELECHIES

Ted Bastin

The word "entelechy" (*εντελεχεια*) was used by Aristotle to mean the completion of a thing as a result of which it became actual and not merely potential. Later, its meaning shifted and it came to refer to the essential part or soul. Leibniz used it for the monad. It seems that the modern use of 'soul' to mean a sort of separable governor or intelligent organizer for the body would have been alien to Aristotle and perhaps far too crude. He seems to have used 'soul' as a word familiar in common speech, and 'entelechy' is presumably needed to make the idea more precise. On the other hand they are not to be identified. The entelechy has something of teleology or goal directedness about it. Perhaps one could say that it is the principle that carries the development. It would therefore have an extension in time. I shall use it with this last aspect emphasized, even at the risk of some distortion of the meaning. I observe that in modern science we have no concept which plays this role. Classical mechanics is Markovian in the sense that every state of a system can be deduced (if it can be deduced at all) from the immediately preceding state. It is never necessary to bring in information separately from any previous time except insofar as that information is mediated by the successive states of the system at the intervening times. We do not, as it were, need to take into account *as well* any supplementary looping back. (Whether this is true or not for the Feynman histories I have not worked out).

In the nineteenth century we find Driesch using 'entelechy' to describe the vital part of an organism, and it was Driesch who put a lot of physiological understanding into vitalism. Recently Sheldrake has revived interest in Driesch and the term 'entelechy', in connexion with his view of a time-span which is causally effective in morphology. Marshall had suggested a 'resonance' between time-separated similar structures as a way of looking at precognition, and Sheldrake saw a similar thing happening in biology. In his view, the development of organisms is directly influenced by the form which similarly structured organisms took in the past, so that there is a sort of positive feedback bond which jumps the intervening heredity. I think he tends to obscure this simple position by talking of morphic fields.

I shall argue that 'entelechy' is an appropriate term for an essential idea in the development of combinatorial physics, apart from the attractiveness of the word itself. We naturally want to know what new things combinatorial physics has to tell us about wider regions of enquiry. In my opinion we fail to grasp the opportunities we are offered if we say in effect 'the combinatorial theory has given the essentials of physics: now we can apply the ordinary physical concepts in new areas while making use of the greater freedom which the combinatoric method gives us'. As an example of what I mean we might think of the discussions we have had in these meetings about magnetism in healing. My off-the-cuff reaction is to say at once 'Why magnetism? What's so special about that?' It may be necessary to show that the combinatorial theory has a satisfactory place for electromagnetism, but surely, having done that, we want to explore other and new relationships which the combinatorial theory proposes rather than revert to old ones which are so familiar that their seams of originality have probably been pretty well worked out. Faruq Abdullah had a remarkable success in promoting and helping with the work of Stephen Walpole. You remember that Walpole's method involved making a survey of brain frequencies modulated on a 20 or so megahertz carrier wave and correcting what seemed to be imbalances. One thing he has been able to do has been to help people with bad migraines. Now what I am

suggesting is that we should not look upon this work as exploiting hitherto unsuspected properties of electromagnetism, but rather as exploiting timing structures in the brain

From what I have been saying it sounds as though I expect the concepts which the combinatorial theory gives us all to be profoundly different from the old ones which they are meant in the first place to underpin. However the changes have a unifying principle in what we call 'process', and lead, inevitably, to changes in our views about *time*. We are used to thinking there is a thing called 'time' which we know about from mechanics. "Time like an ever rolling stream" time. We know we have to put something in the place of this intuitive Newtonian concept, but when it comes to exploiting the combinatorial concept in newer areas we find we have almost all the job of introducing a meaning for that 'time' word still to do. The logical tool of the combinatorial theory is to have temporal sequences which are needed in extenso for some purposes but which can be collapsed to a unit for others. This idea of preserving this dual function is basic to the combinatorial theory, and in this paper I shall gradually build up a meaning and ambience for the word 'entelechy' by developing it further. I think that the idea of 'purpose' which is usually brought in with the term 'entelechy' is adequately covered by this formalization. At any rate I shall not need to refer to it any more, and if anyone feels that the vital aspect of the entelechy has been lost, that is another matter to be discussed.

Before I go further, a word on vitalism. The word got its unenviable reputation from the way it was adopted by crusading obscurantists. Their use of the word 'vitalism' is what I have called the 'thus far and no further' sort. They deeply desire to be assured that there is a world forever protected against the incursions of reason and experiment, or perhaps which has its own sort of reason which is of an ultimately separate sort. Once we disavow this kind of silliness, talk of vital forces, or indeed of entelechies, need raise no eyebrows, unless -that is- one happens to be of the equally silly opposite persuasion that we already are in possession of the intellectual apparatus to understand life and everything to do with it. The use of these words is only a commonsense recognition of how things are, provided that we steer clear of the assumption that before we have made a context for them we have already said something significant by using them.

* * * * *

Also, I want to pass on a bit of information about some developments which I have come across in the current literature which show that some others are becoming aware of the urgency of reconciling a universal and objective time with the principles of quantum theory. *We* realize we cannot assume it, and perhaps cannot have it at all if we start from process, but we might have been tempted to think of that as our parochial problem constructed by the purists among us. I start from work of Chris Isham. He wants eventually to be able to reconstruct whatever concepts of quantum mechanics he needs and discard the rest, and he says "Ultimately we are interested in situations where there is no preferred time-structure at all". I will give no details except that he has something like a quantum-logical lattice structure which is distantly analogous to our mapping structure. Well, three cheers for all that with obvious reservations about justifying the mapping structure by appeal to quantum logic. The mathematical tool he uses is called the *decoherence functional*. He gets it from Gell-Mann and Hartle. Those authors worry about getting the separability of processes in the world which is assumed in Newtonian physics and decide that a definite procedure of decohering the quantum picture is the answer. In other words you reverse the old

quantum theoretical picture that you have a Newtonian world to start with and have to construct quantum coherence. The universe within which this coherence is to be found is that of Feynman histories, and the decoherence functional tells you whether the probability of an individual history is a concept that you can properly apply. So far so good, and I thought "here is a famous physicist facing up to the problems which we have found so inexorable". I passed their paper on to Clive, who, rather unfairly I thought, read the paper properly. I had evidently read it with rose-tinted spectacles, for they say: "In our simplified treatment, then, the fixed background space-time provides a well-defined notion of time, ..". One asks what the decoherence is all about if one knows in advance where the enquiry is bound to lead. Are not a fixed space-time and a Newtonian conceptual framework much the same, or have I missed something? The 'simplified treatment' turns out to be an admission that you can't really have the fixed background if you bother about gravitation. Thus a huge logical difficulty is passed off as a technical problem, with the implied suggestion that it could have a technical solution.

I make a break here by switching to something practical which illustrates the need for entelechies, and suggests the direction in which we should extend our discussions of *time* so as to make the best use of the freedoms provided by the combinatorial physics. My practical topic is homeopathic medicine. The point I wish to make is that in the practice of homeopathic medicine, preparations of medicines are made deliberately *in sequence*. The sequence is a sequence of progressive dilutions, and it is a commonplace to remark that to have effectiveness increasing with decreasing concentration, is something quite unfamiliar in science.

It is almost as though the successive dilution procedure is there to mark or emphasize the sequentiality, so that there might be other things one could equally employ to do the marking. We should keep open the possibility in our minds that the *only* reason for the diluting is to establish the sequentiality. This possibility is made slightly more plausible by the practice of 'percussing' (or it may be concussing or precussing or discussing or some other kind of 'cussing') of the solutions, in which process the bottles are banged a certain number of times on the bench. I suppose - though I am not sure - that the number of bangs is monotonically increasing or else monotonically decreasing with the number of dilutions, which would make sense if the object of the cussing were to emphasize the sequentiality.

Of course I don't understand what is going on; and I expect there are few people who would claim they did, so my putting of the existence of sequentiality in pride of place is only a hunch. Likewise I do not know whether it is important that the people concerned in this medical practice need to be aware of the establishment of sequentiality if this medical procedure is to work with the patients. Also who is it who has to know? Can it just be the practitioner? or just the patient? or should it be both? I expect that somewhere along the line there has to be an intervention of mental process. However we must bear in mind that our method is to exhibit these mental processes as entirely defined by an extension of the familiar physical time, and we conjecture that if we are successful in that then the classification into physical and mental effects will drop away.

Now I return to the basic recursion of the hierarchy and entelechies. The hierarchy is a structure in which two systems which we may call the 'constructive system' and the 'mapping system' respectively, interact. Through this interaction the successive collapses and expansions are handled. Kilmister puts the situation in terms of

labels which become attached to sets of elements. (Program Universe had the same need, though the mathematics of the way it was handled was quite different.) The assumption on which he now bases the hierarchy construction is that we never create labels if existing ones will do, so as never to insert arbitrary choices. This has been called 'Conway's device', and it inserts 'Process' into the earlier forms of the hierarchy which left unspecified the way in which strings can be concatenated into single elements and expanded again. In this way the instructions for expansion and contraction would be encoded using the dual matrix system, thus making a very compact construction which contained recursion and suggested the way to develop time. Now it is very important to decide whether in this progression or 'navigation' through the hierarchy, choices are made randomly or not. If they are, then we can say we are sticking to the principle of indifferent choice, and we can argue that nothing we do is constraining the system. If we do anything different then we abandon objectivity in the ordinary sense of that word.

In progressing toward a physical identification of the hierarchy we repeatedly use the argument that we should stick to the indifferent choice as long as we can and until we are forced to make a change. In particular change in level and hence change from one dimension to another happens in this way. This all has an impact on our understanding of entelechies. As I pointed out, every primitive concatenation process of the hierarchy strictly includes an entelechy. However the device of indifferent choice enables us to overlook this fact and think differently. We are always running away from acknowledging the entelechies, and treating the strings as classical sets until we can't do that any longer. The reason is of course that we need the classical sets to represent the classical sort of things like values for momenta and position. Well we can get some of the way towards that, but really only via the recording of frequencies -but that is to run ahead. The fact that what we really have is entelechies and only the special circumstances of the indifference assumption allows us under very restricted circumstances to forget that, is where we stand. It is convenient, and may help a bit to imagine what is going on, to speak of these classical sets which are so far from primitive as being *simultaneous*. This means that because of the indifference assumption we cannot draw attention to any order in which they take place precisely because all possible orderings are included. We could say that the entelechies know where they are going, but the simultaneous sets do not. Newtonian physics takes on the classical sets as its birthright and with the assumption that they can be extended indefinitely, and perforce takes over with them a total rigidity or determinism from which it can never escape except by flights of fancy. Thence arises the basic paradox of the fixed space-time background that it assumes complete freedom in the face of complete denial of it.

Accordingly I define 'entelechy' as a significantly related set of structures which cannot be reduced by the normal recursive steps of the hierarchy to a larger simultaneous structure, and must therefore be regarded as spread over a time span. In this definition I am coming to terms with the fact that the hierarchy may be regarded as a ruse or stratagem for getting some freedom to speak the language of classical physics.

Accordingly then, I try to get some sort of simplest possible mathematical picture of the entelechy by thinking out what would be the simplest cases of entelechies which could not be spirited away by the operations of the simple hierarchy in the way I have just been discussing. What -we ask ourselves- would be the first things that would come to hand?

Physicists' time:

We have to go back to the basics on which we constructed the hierarchy to pick up the consequences of the apparatus of testing entities which appear out of the vasty deep, and to our labours to construct a system in which they could be said to be counted. Further assumptions are involved in assigning them a frequency, but in any case that is the empirical input to the theory. (When I say "we" I mean Clive, of course.) The frequency idea is needed to get further in the discussion of the scale-constants, as well as to get towards physicists' time.

It is essential if we are to speak of frequencies as distinct from counting that there be at least two sequences to compare, and we find this in McGoveran's treatment of the hydrogen atom leading to his correction of the 'bare' or integral calculation of the fine-structure constant. I remind you at this point that in all the discussions within this group since Noyes' first interpretation of the coupling constants as ratios of scattering frequencies, a sharp distinction has been maintained between this bare integral value and the non-integral part of the experimental value. One gets the basic structure on which all depends; then draws a line and starts with a clean sheet to talk about the bits. You might say we draw a line under the bare value and start again with the odd bit filling our entire horizon.

For the moment, 'frequency' is used in the colloquial sense as when we speak of the relative frequency of encountering a black as compared with that of a white cat on a walk, and not as in the frequency of a pendulum. However McGoveran does proceed to an idea more like the frequency of a pendulum. He speaks of the *cyclicities* which arise in a finite structure like the hierarchy, and wishes to find in them the origin of the cyclicities which are historically associated with the moving parts of a hydrogen atom. His method seems unexceptionable. New elements added to the construction at each stage give information about how the world is. They embody the empirical input, and when we can infer some structure to their appearance we may speak of corresponding *objects*. The *frequency* of elements which constitute such an object is the first source of information about it. To determine such a frequency, the process must label the elements and also keep a record of the number of them. McGoveran's cyclicities are calculated from the mapping space in the hierarchy which specifies the relations between labels. He uses them to calculate the non-integral part of the fine-structure constant. Kilmister does the same. Evidently there is a difference of method. McGoveran uses the matrix mapping, and gets a closed system. Kilmister does not, but pushes his construction method further and avoids closure. In both cases the respective methods are used to get to the non-integral part of the coupling constant. Both get good agreement with experiment, which is a cause for surprise tinged with embarrassment: I shall return to this *malheur de richesse* to end my remarks.

Kilmister's method is intended to take us beyond the discrete cyclicities. It looks like the old problem of passing from the quantized to the continuum -with overtones of the correspondence principle. In fact the whole background to the discussion is very different. The field of frequencies is discrete anyway, but even the idea that we could make a break into a domain in which we could define analogues to conventional dynamical concepts by some limiting process is a mirage. All we are saying is that frequencies may arise which do not define a matrix map. Kilmister considers that any such extension already has some of the properties of physicists' time.

I shall make a few general remarks about the way Kilmister gets toward the time required for relativity. The programme is to get from the frequencies to the finite velocity of light before giving any meaning to other velocities, and to work towards

some primitive topology and geometry assuming absolutely nothing spatial -particularly not equivalent observers.

Let us use an ordered pair (x,y) to denote the successive appearances of x , where y is a natural number denoting the order of appearances of x . Thus successive appearances of x will be written $(x, 1), (x, 2), (x, 3), \dots$. It is legitimate and may help in putting this step into its place to consider that we are here introducing a primitive form of *measurement*, since we are bringing two elements of the structure which arose separately into consideration at the same time. However our use of the ordered pair raises questions about our 'process' construction of the hierarchy model. The new entities (ordered pairs) have to be subsumed in some way under the scheme for construction. For an ordered pair (x,y) where y is a natural number denoting the order of occurrence of x , the placing of each x in a space of adequate properties to give sufficient accessibility will be called the *process-time* or *p-time*. Kilmister then shows how to get fractional times, which he calls *r-time*, so as to be nearer familiar thinking.

We now meet again the familiar general question of how the numbers which we describe as frequencies and which can be as large as we find them, come to be as it were coloured by or conditioned by the dimensional structure of the hierarchy. It is in fact very helpful to keep looking back to all that work done on Program Universe ten years ago where this question was answered using things called content strings appended to the hierarchy strings which were also called labels. We can look back dispassionately now and see how much we learnt, though at the time we (that is Clive and I) could only express inadequately formulated unease about that method. Its inadequacies are clearer now. Mathematically it was artificial -not growing out of the algebra- and underlying that was the objection that conventional properties were given to the content strings. They openly invited us to fill them in with conventional dynamic concepts or discrete analogues of those. This in turn suggested that one could go back and survey the dynamics of the entities behind the primitive stages of the hierarchy construction, and this, to our minds, amounted to repudiation of the basic philosophy of the hierarchy model according to which the start was the start of everything. However we didn't know where to go; only where not to go. This was frustrating for everyone and it has taken a long time to look a bit further, which is what I am talking about now.

To assimilate the frequency definition into the hierarchy structure, Kilmister shows that any *r-time* is constructed from some dcs, and any dcs is potentially able to yield an *r-time* if the process demands it. Consider the problem of extending the concept of *r-time* to include further cyclicities. There are two possibilities. The first may be exemplified by considering say the occurrence of an element 3. The construction is much the same as before. One can begin (and something equivalent will arise eventually anyway) by taking the *r-time* r_s for elements of S and give values for the *p-time* of 3, n_3 , by a conventional rule: -

(a) If there are k_3 3's between r'_s and r''_s , give them the conventional values of r_s -time:

$$r'_s + \{u/(k_3 + 1)\} (r''_s - r'_s), (u = 1, 2, \dots k_3).$$

(b) If k_3 points of the sequence defined by S lie between n_3' and $n_3'' = n_3' + 1$, give them the p_3 -time values

$$n_3' + u/(k_3 + 1).$$

This produces the whole sequence labelled, in two ways. Since the two should be equivalent, seek a linear relation between them in any way. (In analysing the system

from outside, one might use least squares, as before.) Call this linear relation $\approx L(n_j)$. Then redefine an r-time by the rule:

$$r_T = L(n_j) \text{ if } n_j \text{ is integral, } r_T = r_S \text{ otherwise.}$$

The construction has been for the set $S \cup \{3\}$, but from what has just been said we get r-times for dcss, so that we have derived an r-time for $S' = D(S \cup \{3\})$. In the same way, if two r-times r_S, r_T have been constructed separately, the elements of T may be taken over one at a time until a new r-time for $D(S \cup T)$ has been constructed. This "internal" procedure works so long as S, T are at the same level. It fails if S and T are at different levels, and the corresponding relation between r_S and r_T is then an "external" one. Since there is always a dcs which is a complete level, we may be compelled to consider external relations.

Kilmister proceeds using only the internal relation to link up with one formulation in the literature of relativity -that of Milne's 'Kinematic Relativity'. It would not be accurate to say he takes over Milne's results: rather he provides a more adequate basis for a picture which Milne had got in part. This refounding takes the form of replacing the intuitive idea of the observer and the even more intuitive idea of two or more equivalent observers using frequency-based time relations. The cost of all this is to abandon the claim to be talking about an objective previously existing world out there which is independent of the construction, and one of the fruits is that one sees where geometry really comes from, and its relation to the finite velocity of light in terms of the Lorentz relations.

I shall not go further into detail on all this, but shall take a new turning at the point at which Kilmister mentioned the external relations but took the other fork of the road. Milne surprisingly took a one-dimensional universe as a sufficient example. Conventional of course; but dubious in view of the generality he claimed over spatial relationships. I suppose first that the frequencies appear which cannot form an internal relation and must therefore be external: that is to say they demand a level change. Now level changes are the source of 3-D space. Therefore if you can imagine the 3-D -ness in abstraction from any other spatial properties then that's what follows from the flow of r_{ext} -time.

Now we want to have a record of the time changes and this is what the linear mapping space is for. The points in the space represent the labelling processes and if we want to stand aside from the continuing process and look at it (and it is hard to give it any meaning without that facility) then we can only do so by using the algebraic relations in the mapping space, representing the changes by matrix transforms. The trick is this. We have a string with numbers derived from the frequencies and expressed as our ordered pairs and we want to record the process which it represents. Now the apparatus provided for that purpose is a change in the string corresponding to some matrix transform, and there is no other possibility. Therefore we now have two strings:- the original and the one it turns into, and a set of frequencies as well. We can think of the set-up as a rotation of the space of one string into the other and the amount of the rotation specifying, or specified by (whichever way you like to look at it) the numbers. Moreover since we are dealing with a 4-space we can consider one of the dimensions to be timelike, in which case the rotations will represent rates of change with respect to time, though whether we should think in configuration space or in momentum space or some other space I do not now consider. (At the level where the strings are of length 4, that is the dimensionality. At higher levels we find the same structure persisting because we can take them as product spaces, so 4 is the basic characteristic.)

You will reasonably be asking why after all this hard work to establish a process theory including a new view of dimensionality I suddenly revert to what looks like a completely conventional euclidean 4-space. If this could be done, why not have done it to begin with? I answer that these innovations are in a sense purely formal. We had to record the stages and to specify all the operations that are imagined in -for example- relativity. Let me try to make my meaning clearer. If we follow Kilmister's programme to show that a lot of what passes for experimental description in relativity theory is actually deducible from the process model, we still have to admit that people want to use this theory to run continuously into the language of ordinary macroscopic physics. We may have put some content into the notion of 'observer' that makes sense in a process theory, but everyone will want to go on as the language invites to speak of several equivalent observers, and then non-equivalent observers, and so on right into ordinary language about the world.

This seems an extremely cumbersome procedure with its two different ways of looking at the world that we use alternately -nipping back and forth between the two. Well yes; but please it's not *my* fault. That is what physics at present is; and you may say it's an awful mess if you like. It seems that things that cannot happen in the process happen in the imagination of physicists who are unaware of the duality of process and labelling and see the label structure as the only reality (thus getting into lots of confusions like those surrounding the ideas of non-locality). The point to realize is that if we look at current physics from a process point of view we are surprised that the whole business of jumping from one description of the world to another is left to the imagination, and no one sees anything odd in it, even though we all know about the paradox that classical physics specifies a deterministic world which our ideas of experimentation (and certainly the whole of quantum theory) belie. By contrast, a process view requires that everything be incorporated in the theory.

So we reach the conclusion that the space time which affords our dynamical concepts is a coding system and therefore an imaginative construct to enable us to think about the more fundamental process which it inadequately describes. We meet the limitations of the coding system particularly in quantum physics and in relativity, where conceptual muddles and paradoxes appear because we fail to see them for what they are. We should not be surprised at them. Now it is already a help to foresee the limitations of the conceptual framework, but it would be nice to think we can do better. May it not be that dashing back and forth between a Newtonian space and time and the real process of the universe is the best we can do, given our mental make-up? I started ambitiously with the entelechy which was to retain the process aspect in what should replace the time concept. Now we see more clearly that if we do that we have to abandon the time of physics, and the problem is that we are likely to have nothing of an organized kind to put in its place. We should like a glorious general theory of entelechies, but it looks as though we are left with very little at all. Wiser perhaps, but in some ways sadder. Moreover there is a question which is set for us by all this: the Newtonian conceptual framework accords with experiment over a considerable range. Why? This is where I say "I make no hypotheses".

Earlier I mentioned areas of experience -particularly homeopathic medicine- which seemed naturally to incorporate the hierarchic principle of freedom to concatenate sequences to single units and to expand them. By my definition this required entelechic time as distinct from Newtonian time. And the latter was precluded. What we have seen since is the reason why the two kinds of time cannot co-exist. There are very many more such areas of experience which are suppressed in modern

science because they require the entelechic time. You get paradoxes if you require that they fit into the conventional time picture. They are mostly grouped under the term "paranormal". As I see it these phenomena represent a challenge to find a (non-Newtonian) reordering of temporal relations which makes better sense of them. In fact most of the paranormal phenomena can be thought of as strong suggestions that there is a better ordering to be found.

During the past few ANPA meetings I have pushed what seemed to me to be consequences of the hierarchy picture to the logical limits to show some simple consequences which have immediate experimental significance -though significance of an outrageous sort. The outrage comes about because they conflict with the usual way of thinking at an embarrassingly simple level. People, including me, seem always to be subject to something like the Freudian censor which for a long time prevents their following through these logical possibilities. When finally the censor gets overridden, a change comes about, and one finds oneself contemplating the new possibility, like Stout Cortes who, with eagle eyes, gazed on the Pacific, and all his men stared at each other with a wild surmise, silent upon a peak in Darien. Then gradually the whole thing comes to seem less outrageous, and the wild surmise turns to mild surprise as a larger background begins to form itself into which the new can fit. The moral seems to be that the hierarchy picture, or indeed any combinatorial model, has a lot of potential for wild surmise, but that we can only tear away the backdrop of our usual way of thinking step-by-step, and can take each step, only slowly.

Two or three years back I suggested that the right identification for 3D was to be found in the number of times it was possible to change level. Since then some work has been done which shows that this way of looking at dimension structure leads on to further insights.

Last year I raised the question whether geometry -good old Euclid in fact- had to be an independent constituent of physical theory, or whether some critical part of it at least could be deducible from the hierarchy picture. The critical question was whether the use of Pythagoras' theorem in relativity had to be imported into relativity, or whether, as we were claiming, it -and therefore a vital part of geometry- was a precondition deriving from an analysis of measurement in terms of the principles of construction of the hierarchy.

What can I come up with this year? I go back to my earlier mention of the embarrassing duplication of the fine-structure constant correction (the non-integral part which -separated from the 'bare' value- has become our arena). The duplication is very embarrassing indeed because on the face of it there is no way in which either calculation can be deduced from the other or in which each can be seen to follow from more general considerations. They seem to be derived from different ways of thinking, and, what's more, the mathematical steps which give the answers are certainly unrelated so that if one is true the other can't be. I have spent a lot of time wondering whether there could possibly be circumstances in which both could be true, and finally a possibility has occurred to me. It certainly fitted my earlier description because it seemed thoroughly preposterous at first.

Let us suppose to start with that Kilmister's method is correct. It is hard to see how it can not be, since he merely continues the argument about the successive testing of putative new entities. Then let us accept the argument which I have been outlining according to which we have to choose whether we let the matrix mapping represent the labelling function, or whether we continue to record new frequencies. The former gives

rise to McGoveran's hydrogen atom and the latter to Kilmister's correction term. The latter is not particularly related to any special thing like the hydrogen atom but corrects for the level uncertainty, and so is appropriate for all uses. The methods are really alternative ways of working, for McGoveran does not need to consider the possibility of getting the level wrong.

The next step in my argument is to imagine that for some reason it is desirable for the two calculations to lead to the same values, or to numerically closely similar ones. Then, so we argue, it will be necessary for systems in the world to exist which have the cyclicities which McGoveran assumes for the hydrogen atom. In other words, out of all the dynamical systems that we might have equally expected to be the common conclusion to our experimentation, that particular one exists which reconciles McGoveran and Kilmister. This is the preposterous step. We have an argument which deduces the need for hydrogen atoms. It *is* preposterous at first sight, but only because of our deep-seated feeling that the atoms and sub-atoms have to be there anyway, and that it is our subsequent job to try to make sense of them.

Our reaction is an overhang from the old Newtonian building blocks view, which we thought we had outgrown. The possibility I am putting forward ought not really to be so surprising: we have long been preaching that the atomic structures differ from classical objects pre-eminently because they are described by very simple stages in the hierarchy construction whereas the ordinary reality of classical objects arises out of a great deal of complexity -one might almost say 'confusion'. Sometimes we say that their properties are what they are because we have reached the limits of our descriptive power. At that limit it makes no sense to distinguish between what is there in the world and the structures needed to represent them. One is bound to be initially incredulous about my suggestion about the hydrogen atom, but the incredulity is out of place. Anyway we might as well be hung for a sheep as for a lamb and follow through the logic of our position to its natural conclusion.

LABELLING IN THE HIERARCHY

C W Kilmister

Red Tiles Cottage
High Street
Barcombe
Lewes
BN8 5DH, U K.

Happily the number of new faces at ANPA meetings makes it still desirable to carry on the tradition of having at least one paper which explains the combinatorial hierarchy, whose investigation gave rise to the ANPA meetings. So that is part of this paper; but the other part is in the best traditions of self-criticism, more at home behind the Iron Curtain before it was raised. I start with the first object.

My earlier ANPA papers¹ have all been concerned with some puzzlements over a particular algebraic construction due to Parker-Rhodes. I omit the physics context in which he elaborated this, and just detail the algebra. It was this:

(a) Consider two objects, denoted by two column vectors, $\begin{bmatrix} 0 \\ 1 \end{bmatrix}, \begin{bmatrix} 1 \\ 0 \end{bmatrix}$.

(b) A binary operation is defined between these,

denoted by +; it is in fact addition over the field Z_2 and is called discrimination.

(c) By means of this operation generate three "discriminately closed subsets"

viz.: $\left\{ \begin{bmatrix} 0 \\ 1 \end{bmatrix} \right\}, \left\{ \begin{bmatrix} 1 \\ 0 \end{bmatrix} \right\}, \left\{ \begin{bmatrix} 0 \\ 1 \end{bmatrix}, \begin{bmatrix} 1 \\ 0 \end{bmatrix} \right\}$.

(d) Characterise each such dcscs, S say, by a square matrix A and its "proper eigenvectors" u by the rule (everything being understood as over Z_2)

$$u \in S \iff Au = u.$$

(e) Rewrite the A's as column vectors of length 4.

(f) Go back to (c), generating $2^3 - 1 = 7$ dcscs.

(g) Repeat the process, producing at the successive levels 3, 7, 127, $10^{38} \dots$ operators, or successive totals 3, 10, 137, 10^{38} , after which the process cannot be continued.

The kind of queries I had about this construction were: Why vectors over Z_2 ? Why introduce matrices (and then turn them into vectors)? Why seek Alternatives: Proceedings of ANPA16

eigenvectors? Why add the number of operators at the end? As I explained in previous papers, I now have satisfactory answers to all these queries but I do not want to elaborate them again this year. My technique in answering them harked back to the work I did with Ted Bastin in the fifties² especially the aphorism we delivered there, that elements of a theory may be thoughts, sentences written or spoken, or manipulations with bits of the physical world. So I sought to interpret the algebra in terms of an autonomous process. (Of course, others had seen the importance of such a process theory for other reasons.) Initially I talked of an investigation but Ted has impressed on me that this suggests an investigator, so it is better to be as abstract as I can and say a process of interaction. This autonomous process is to be seen as proceeding initially in a primitive situation in which there is no distinction between ontology and epistemology (such a distinction will grow up as the process goes on).

My re-expression of Parker-Rhodes' construction then began in this way:

- (a) The world is divided into a part which is known and the rest which is not yet known.
- (b) Changes in this division are defined as an entity becoming known - in this way we ensure the discrete nature of the theory. Nothing more is assumed about the entities at this stage.
- (c) The process of interaction determines statistical results about these entities and this requires recognition of when one is a repetition of an earlier one.
- (d) The first entity may be called 1, the next different one 2 and so on..

In this framework I was able to show how its elaboration answered the questions above; the details are in the earlier papers cited.

In those papers I put it like this: the process is one of labelling entities. Now I move on to the self criticism part of the paper. This criticism was enforced by outside criticism. Ted wanted to know WHY such an emotive term was used. Alison Watson wanted to know WHO was doing the labelling.

My reaction has tended to be like the famous physicist (I think he was

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Austrian) whose lecture notes after his death were found to have marginal notes like "Argument weak; speak loudly". Now comes the self-criticism: who am I to prescribe just what the interactive process does? How can I know that it is labelling? Surely this was just the abstraction which I was supposed to be making!

I have gradually come to see that instead of the one object, the interactive process, we have two - the process and, going along with it, a theoretical analysis of the process. In the past we have called this theoretical analysis "the mathematics of the process" but no matter how we hedged that about with qualifications, it was a bad name. The only reason that the name arose was because the theoretical analysis proceeds with the use of symbols on paper. The theoretical analysis grows organically with the process; so that considerably more is going on than I had at first thought. What is really happening is this:

Any two entities are different, if only because they arise at different points of the process, but to have possibilities of statistical inference there has to be a criterion for one to be a repetition of an earlier one. If we call such entities equal, the process can be viewed as grouping the entities into sets of equal ones. I call these sets elements. All of this comes before the situation envisaged in the Parker-Rhodes construction, which only arises because, as it turns out, finite sets of these elements arise and these in turn are characterised by the mechanics of recognising whether an element is in the set or not. I do not want to go as far as that construction here; it is more of the nature of a technical elaboration. It is with the complexity of the earlier stage that I am concerned. This can be set out in three stages:

- (a) an entity becomes known and is unambiguously assigned to an element.
- (b) A set of entities, or indeed a set of elements, has to be treated as a single element. This is a familiar notion in set theory but here, since we have a process theory, it is more profound. It implies that the process of recognition is treated as a unit in its own right, which is the innovation

which turns out to be the real origin of the combinatorial hierarchy.

(c) There is a third requirement which I have tended to neglect in the past. When the entity is assigned to an element, this must take place from amongst a definite (but growing) collection of elements to which it might have belonged. Without this requirement, assigning an entity to an element would correspond to giving an infinite amount of information, and this would undercut the discrete nature of the process.

As soon as one element has arisen with a member, the theoretical analysis can begin. Afterwards it proceeds in step with the process. It begins with the introduction of a symbol to correspond to the element. I shall call this symbol in the analysis a label. The point of using such an emotive term is to distinguish it from other symbols which arise in the analysis and which cannot be labels (and for which it is important that they are not labels). As to who is doing the labelling, the answer is not quite clear-cut. The real situation is that the forbidden phrase "The process labels an entity" can be given a new lease of life as a convenient shorthand for "An entity has become known and unambiguously recognised as belonging to a certain element. This fact is marked in the theoretical analysis by introducing a symbol." I leave it to you whether you want to say that the process does it or I do it.

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A Topsy Example

by

Michael Manthey

and

Lars Uggerly Andersen

Jesper Arent

Jørn Heideman Christiansen

Thomas Kjær Nielsen

Jan Simonsen

Tom Bisgård Sørensen

Department of Mathematics and Computer Science

Aalborg University

Frederik Bajersvej 7E

9220 Aalborg DENMARK

manthey@iesd.auc.dk

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1 Introduction

The following describes work done under the supervision of the first author by the remaining authors - upper division undergraduates: how Topsy actually carries out a simple (but archetypical) task. Hopefully this will satisfy the many ANPA members who have been mystified in one way or another. For example, the 'actions' described in my Action Semantics article in the '92 ANPA proceedings as Clifford products are the very same actions described here. The hierarchy which is formed is closely related to the Combinatorial Hierarchy, although this is not very apparent from the simple example presented: see my article in the '93 ANPA Proceedings for current status on this front.

Finally, what follows is the *introductory* chapter of a 50-page semester project report on the application of Topsy to a simple vision problem. Those readers interested in this should contact the first author (manthey@iesd.auc.dk) for more information. Otherwise, most of the words belong to the other authors - I have only added a sentence or two here and there to clarify or deepen.

2 The PHASE WEB Paradigm in Topsy

The PHASE WEB paradigm posits that it is possible to gain exhaustive knowledge of the world based on sensory input (although one should not jump to philosophical conclusions based on this sentence; the reader is referred to [5] for a deeper treatment). More precisely, it posits that such knowledge can be extracted from the observed co-occurrence or mutual exclusion of

sensory events. Based on these observations of the synchronizational relationships obtaining between sensory events, including events internal to itself, Topsy erects a corresponding knowledge representation - a 'phase web' - which is capable of both classifying sensory events and acting (in the presence of goals) on the basis thereof in one integrated, fully distributed, multi-process structure. The PHASE WEB is an utterly *process-based* paradigm, where the structure of the world is encoded in the form of the synchronization relationships found to obtain between these processes.

We now present the basic concepts of the PHASE WEB and TOPSY via a simple example. Figure 1 shows a robot that can move a box from one platform to another.

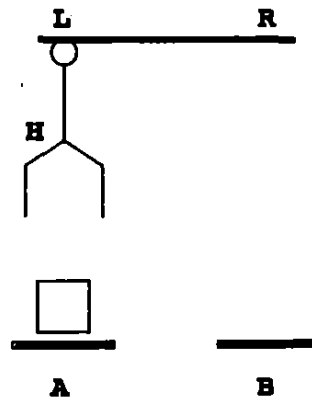


Figure 1: A simple world.

The problem is to teach TOPSY how to move the box between the two platforms, without necessarily showing it the actual moving *sequence*, but rather only various intermediate situations in the move, i.e. the four situations in Figure 4.

In fact, these four situations nearly exhaust the available state space, because this world is so simple. We therefore emphasize that TOPSY *need only be shown, in any order, a minimal basis of situations, which it then is able to combine in whatever ways it finds useful*. How this can be will hopefully become clear as we proceed.

The world (cf. Figure 1) is presented to TOPSY via the five sensors A , B , H , L and R . These sensors are called primitive-level sensors. The sensors A and B sense whether their respective platforms are full or empty, and H senses whether the hand is full or empty. The sensors L and R sense the position of the robot (Left or Right). All sensors are binary, i.e., using the hand sensor as an example, it can either be activated (H) or deactivated ($\bar{H}$).

TOPSY builds its web of knowledge from its observation of *co-occurring* sensor values. It might for example observe a co-occurrence from the world in the state shown in Figure 1, which we represent with the sensor-pair $(A, \bar{H})$, meaning that sensor A activated *co-occurs* with sensor H deactivated. This information will be connected with the opposite co-occurrence $(\bar{A}, H)$, when and if seen, to form the co-exclusion $((A, \bar{H}) \leftrightarrow (\bar{A}, H))$,¹ which is the highest level of

¹Strictly speaking, we should require seeing $(A, \bar{H})$ again to be certain that both $\leftarrow$ and $\rightarrow$ have been experienced. However, we short-circuit this on the grounds that it is very unlikely that the environment *cannot* in principle transform in both directions.

knowledge in the primitive (or lowest) level of the web. The constructed web is illustrated in Figure 2 as a Phase State diagram [7].

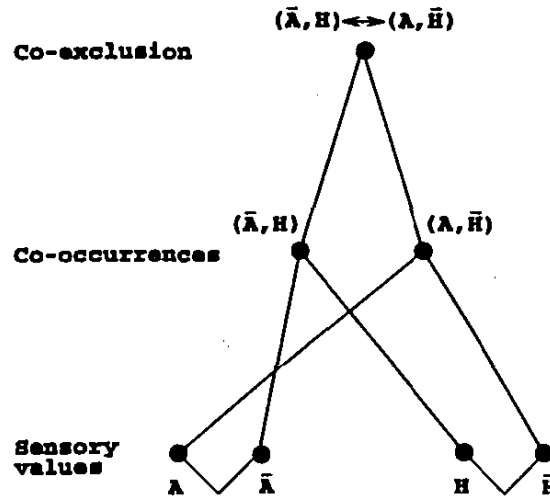


Figure 2: A simple Phase State Diagram.

A *co-exclusion* is a pair of mutually excluding co-occurrences, expressing e.g. that the box cannot be in the hand $(\bar{A}, H)$, and on a platform $(A, \bar{H})$ at the same time. A co-exclusion at this level forms a *basic action*, which implicitly includes the means (perhaps indirectly, via other cooperating actions) to cause a switch from a state satisfying one side of the co-exclusion (the *pre-condition*) to the other (the *post-condition*). The action formed by $((A, \bar{H}) \leftrightarrow (\bar{A}, H))$ corresponds to the box's movement back and forth between the platform A and the robot-hand H .

Conceptually, while this is a valid state transformation - after all, both ends of the transition have been observed - it is nevertheless possible that the resulting action must, in its actual application, be surrounded by a larger context (ie. other particular sensor values and action states) than this action encodes. Ensuring that this is the case is the responsibility of 'volunteering' (see below), and, ultimately, learning from experience. Also, a given action is only valid in worlds where the sensors on which it is based express the same world-properties.

An *effector* is an object that allows TOPSY to interact with the world; effectors are 'one-way' outward-bound, just as sensors are one-way inward-bound. This interaction will ultimately be reflected in the sensory values seen by TOPSY. An example of an effector is the one capable of making the change $(\bar{H} \rightarrow H)$. This effector is only *relevant* if the sensor H is in the state $\bar{H}$. If a goal to change the sensor H from the state $\bar{H}$ to H is present while the effector is *relevant*, the effector will (attempt to) propagate its change to the environment, resulting in the state change $\bar{H} \rightarrow H$ and indirectly - if the hand is over platform A - the change $A \rightarrow \bar{A}$.

A *goal* is defined as a desired change of the state of a sensor, e.g. $(\bar{A} \rightarrow A)$. Goals originate either from the user of TOPSY issuing an initial goal, or from volunteering actions which, on the basis of their defining co-exclusion, issue new goals. For example, if a goal to empty sensor A is present, the action formed from $((A, \bar{H}) \leftrightarrow (\bar{A}, H))$ will when *relevant* issue a goal to fill sensor H , $(\bar{H} \rightarrow H)$. This is called *volunteering*, and is a primary job of actions. There is more

to volunteering than just described and a more detailed walk-through of a basic action, given below, is necessary to fully understand it.

There are different forms of basic actions, named after the number of sensors they are composed of. The basic 2-action, already mentioned above, is composed of two² co-occurrences, each being a co-occurrence between the same *two* sensors. Basic 3- (and *n*-actions) are similar to 2-actions, differing only in the number of sensors co-occurring. Only basic 2- and 3-actions are of interest at this time, because they are fully capable of solving the robot problem.

Of particular interest in this connection is the special case of a basic 3-action called a basic (2+1)-action. The (2+1) expresses that it is a version of the basic 3-action, but where one of the involved sensors is constant in both co-occurrences. An example of a basic (2+1)-action, $((A, \bar{H})(L) \leftrightarrow (\bar{A}, H)(L))$, is shown in Figure 3, which is the same as Figure 2 except for the constant sensor *L*, which demands that the hand be in the leftmost position both before this action can take place and throughout the change.

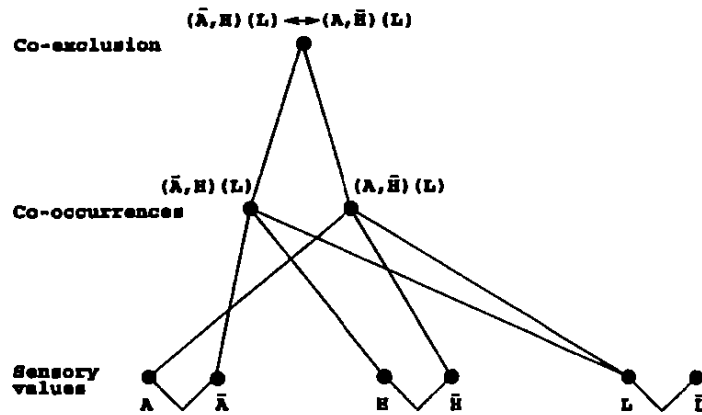


Figure 3: A basic (2+1)-action formed by two co-occurrences.

For an action to be *relevant* (applicable in the current situation) its *pre-conditions* must be fulfilled and there must be a *relevant* effector (ie. a genuinely possible change) associated, however indirectly, with (at least) one of the action's constituent sensors; the *relevance* of changes in the other elements of the pre-condition will then be volunteered. For example, a basic 2-action's pre-condition is that one of its two constituent co-occurrences obtains in the world; the other constituent co-occurrence is then viewed as the action's post-condition. In addition, the fact that an effector somewhere has indicated that it can carry out one of the required changes must have propagated to this action (probably via volunteering). If there now appears a goal to change one of the precondition values, the action will do its job i.e. issue (volunteer) goals to invert its pre-condition, and thus achieve its post-condition and therewith satisfy the goal.

²Triplets, quadruplets, etc. of co-occurrences seem to fall prey to the dictum that "2 is enough", and the simplest as well.

2.1 Learning by Observation

To learn by observation it helps to know what to look for. This is also the case with TOPSY. Although TOPSY can in principle do this by itself, we here allow ourselves to tell TOPSY which co-occurrences to look for, i.e. to *notice*.

In the robot example, we are only interested in noticing the following sensory co-occurrences:

Changing sensors	Constant sensor
A and B	
A and H	L (activated)
B and H	R (activated)
L and R	H (activated)

Table 1: Co-occurrences in the robot example.

These co-occurrences are chosen because they reflect the changes in the sensory state necessary to form the actions needed to move the box.

In the process of learning, TOPSY will be shown the four situations shown in Figure 4. *The order in which it sees such situations is not critical*, which is a consequence of the way TOPSY forms actions, namely from co-excluding co-occurrences: the act of co-excluding two co-occurrences is independent of the order in which the co-occurrences occurred - it is enough that they *did* occur! The world-situations are only shown in 'logical' order to clarify what happens.

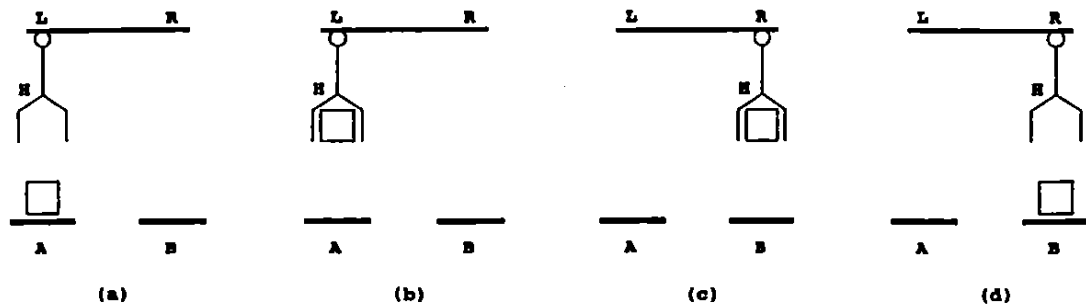


Figure 4: The four situations shown to TOPSY.

On the basis of situation 4a TOPSY notices the following co-occurrences:

- $C_1 = (A, \overline{H})(L)$
- $C_2 = (A, \overline{B})$

When TOPSY is shown situation 4b it notices the following co-occurrences:

- $C_3 = (\overline{A}, H)(L)$

- $C_4 = (L, \overline{R})(H)$
- $C_5 = (\overline{A}, \overline{B})$

The two co-occurrences C_1 and C_3 mutually exclude each other, forming a co-exclusion $((A, \overline{H})(L) \leftrightarrow (\overline{A}, H)(L))$. This leads to (or rather, leads TOPSY to construct) the Phase State structure diagrammed in Figure 3.

The remaining two situations (cf. Figure 4c and d) are shown to TOPSY, resulting in the set of co-occurrences:

- $C_6 = (\overline{L}, R)(H)$
- $C_7 = (\overline{B}, H)(R)$
- $C_8 = (\overline{A}, B)$
- $C_9 = (B, \overline{H})(R)$

The above co-occurrences two by two form the co-exclusions, that is, *actions*, shown in Table 2; C_5 's complementary co-occurrence has not occurred, so no action is formed using it (cf. also the discussion of *duals* later). The Phase State diagram resulting from this learning process is shown in Figure 5.

Co-Excl's	Components	Action name
$C_2 \leftrightarrow C_8$	$(A, \overline{B}) \leftrightarrow (\overline{A}, B)$	AB
$C_1 \leftrightarrow C_3$	$(A, \overline{H})(L) \leftrightarrow (\overline{A}, H)(L)$	AH(L)
$C_4 \leftrightarrow C_6$	$(L, \overline{R})(H) \leftrightarrow (\overline{L}, R)(H)$	LR(H)
$C_9 \leftrightarrow C_7$	$(B, \overline{H})(R) \leftrightarrow (\overline{B}, H)(R)$	BH(R)

Table 2: Mutually excluding co-occurrences and the names of their actions.

2.2 Using the Knowledge

Having taught TOPSY what it needs, we are ready to use it. We reset the world to the one shown in Figure 4a.

Before anything can happen we must give TOPSY some *effectors* that can actually carry out (or at least simulate) the actions connecting the four states shown in Figure 4a.

The effectors needed to carry out the robot example are:

- *Grasp* can fulfill a goal to fill the hand, i.e. activating the hand sensor H : $(\overline{H} \rightarrow H)$
- *Release* can fulfill a goal to empty the hand i.e. deactivating H : $(H \rightarrow \overline{H})$
- *Move right* can activate R , i.e. to move the robot hand to the right: $(\overline{R} \rightarrow R)$

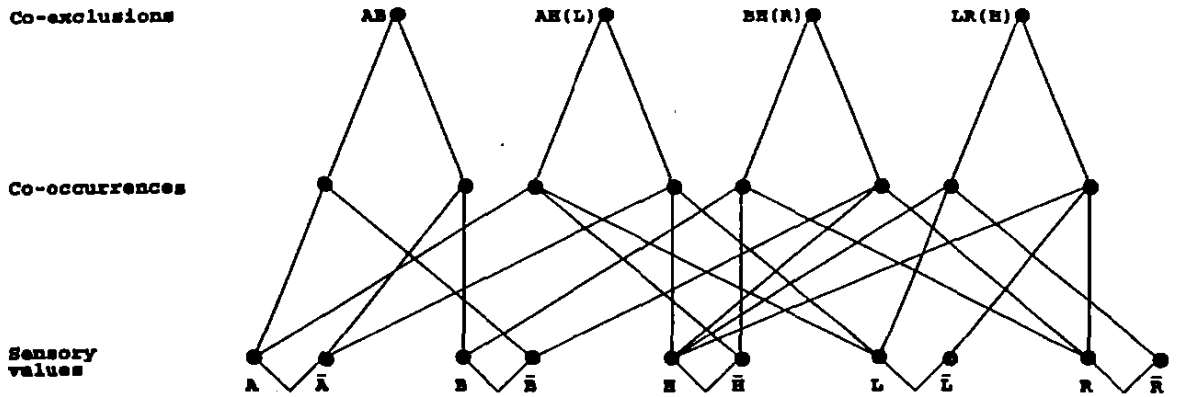


Figure 5: The resulting Phase State Diagram.

- *Move left* can activate L , i.e. to move the robot hand to the left: $(\bar{L} \rightarrow L)$ ³

TOPSY is now presented with a user-issued goal to move the box from platform A to platform B expressed in terms of sensor values: the state changes $(A \rightarrow \bar{A})$ and $(\bar{B} \rightarrow B)$. Having Figure 5 in mind, this corresponds to the action AB (cf. Table 2) or rather one of action AB 's characteristics, that is $((A, \bar{B}) \rightarrow (\bar{A}, B))$. It is enough to issue only one goal, for example to fill platform (sensor) B , since the missing goal on A will be volunteered by action AB .

In the current state, AB and $AH(L)$ are the only actions which are *relevant*, because their preconditions are fulfilled and there is a —em relevant effector (here, *grasp*) bound to one of their sensors. In detail: *grasp*'s relevance has triggered $AH(L)$ to *relevance*,⁴ and thence to volunteer the *relevance* of $A \rightarrow \bar{A}$, which in turn triggered AB to *relevance*. Since the goal $(\bar{B} \rightarrow B)$ is present, and action AB is otherwise *relevant*, AB volunteers the goal $(A \rightarrow \bar{A})$. Due to this goal, action $AH(L)$ volunteers the goal $(\bar{H} \rightarrow H)$, and a constraint goal $(L \rightarrow \bar{L})$ to maintain L activated. Such *constraint* goals are used to ensure that a sensor stays in its current state during the execution of an action to prevent other concurrently executing actions from interfering with the current action.⁵ Constraint goals are retracted when the goal which triggered the action is either fulfilled or retracted. Figure 6 shows the current state of the web; the triangles (arrowheads) express the presence of goals, and the triangle under L refers to holding L constant.

The effector *Grasp* is capable of performing $(\bar{H} \rightarrow H)$ and there is a goal for this, so the box is picked up by the hand. The goal $(\bar{H} \rightarrow H)$ and the constraint goal on L are now retracted by $AH(L)$ due to the fulfillment of the goal $(A \rightarrow \bar{A})$; see figure 7. The goal $(A \rightarrow \bar{A})$ remains, however, since it was issued by AB , which is not finished yet.

The goal $(\bar{B} \rightarrow B)$ is still present and now causes $BH(R)$ - which has now become *relevant* - to issue the constant goal $(\bar{R} \rightarrow R)$. Such *constant* goals are issued by an action in order to

³Clearly, L and R are coupled, so that $((L, \bar{R}) \leftrightarrow (\bar{L}, R))$, cf. action $LR(H)$ a little later.

⁴Of course, three effectors, $(\bar{H} \rightarrow H)$, $(L \rightarrow \bar{L})$, and $(\bar{R} \rightarrow R)$ are *relevant*, but only $(\bar{H} \rightarrow H)$ is 'interesting' to TOPSY, because only $AH(L)$ is interested in causing a change in the current situation.

⁵TOPSY deals with conflicting subgoals (in general) in the same way as it deals with everything else. Here we simply ignore this issue.

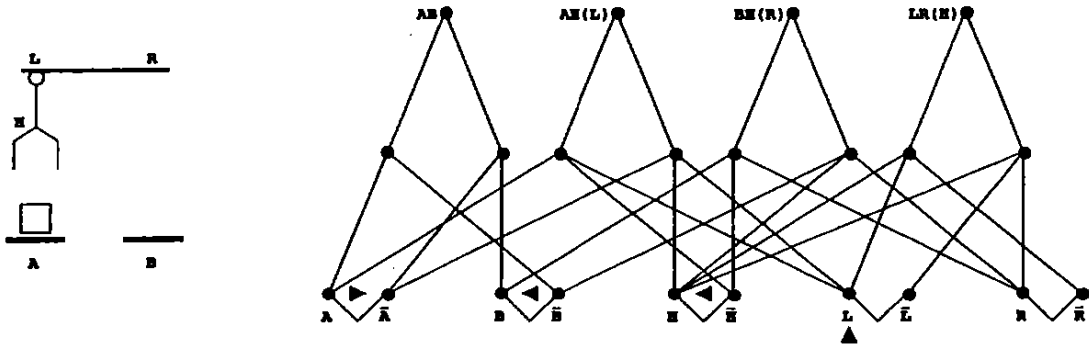


Figure 6: Ready to grasp the box.

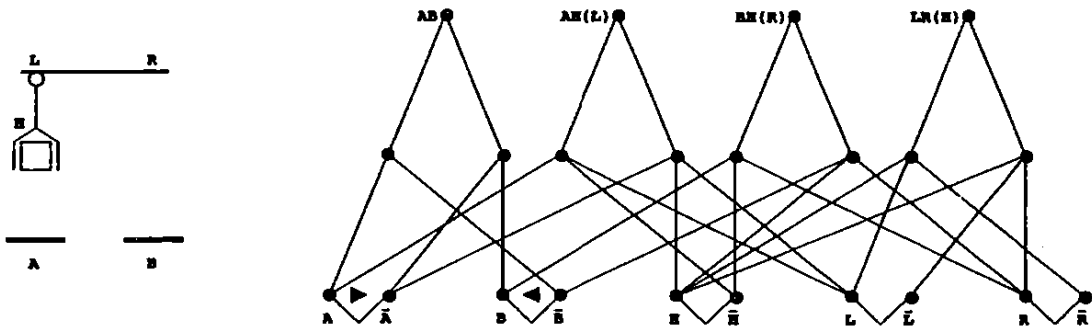


Figure 7: The box is grasped.

satisfy its constant sensor *before* carrying out its actual action. The relevance of $(2+1)$ -actions does not depend on the state of the constant sensor. The action $BH(R)$ is therefore relevant without R 's being activated. The presence of $(\bar{R} \rightarrow R)$ triggers the action $LR(H)$, which issues the constraint goal $(H \rightarrow H)$ to maintain H in its current state ("Don't drop the box") and volunteers $(L \rightarrow \bar{L})$. See Figure 8.

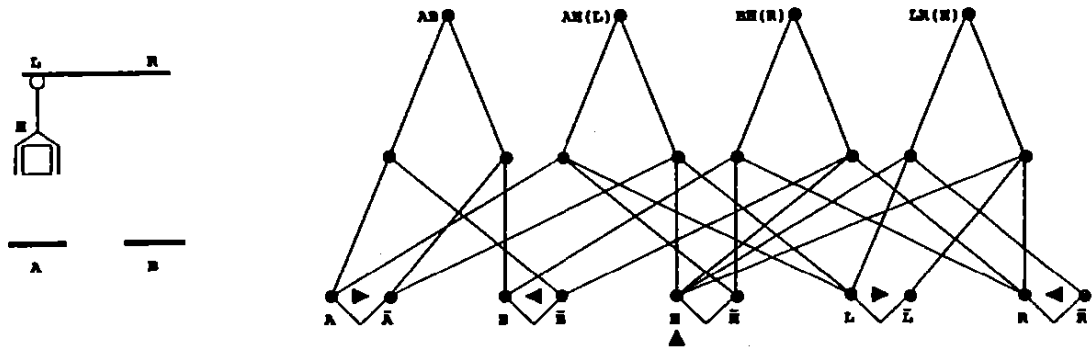


Figure 8: Ready to move the hand.

The effector *Move right* sees the goal $(\bar{R} \rightarrow R)$ and, being *relevant*, carries it out. The hand now moves to the rightmost position. The action $LR(H)$ retracts the goals $(L \rightarrow \bar{L})$ and $(H \rightarrow H)$ due to their being fulfilled. $BH(R)$ now realises that its constant sensor is fulfilled and issues the goal $(H \rightarrow \bar{H})$. The effector *Release* knows how to do this and is *relevant*, and therefore carries it out. $BH(R)$ now realises that both its goals have been fulfilled and therefore retracts them. The goals of the action AB are also fulfilled and are therefore retracted by AB . The moving of the box is thus complete, due to the fact that the initial goal $(\bar{B} \rightarrow B)$ has been fulfilled. The box has therefore been moved from platform A to platform B using the observation-based knowledge encoded in the web. Nor does moving the box from A to B exhaust the web's knowledge. For example, by issuing the goal $(\bar{A} \rightarrow A)$, it could move the box back to platform A. More interestingly, the web can also solve the problem of Figure 4a, but where the hand is initially empty and over B.

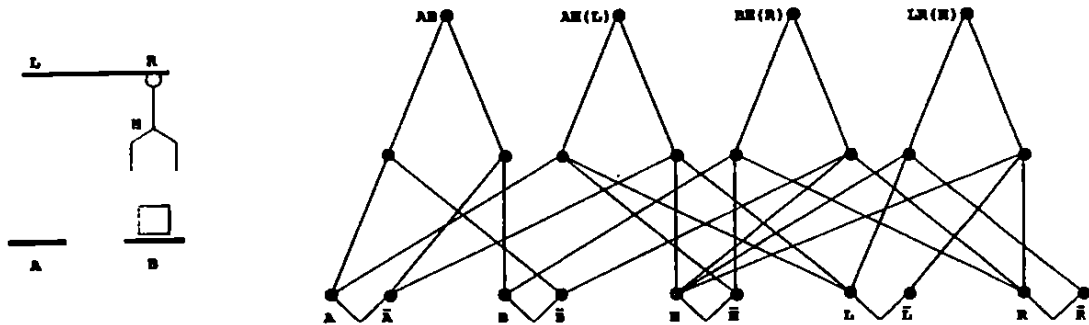


Figure 9: The box-move is completed.

3 Meta-levels

The PHASE WEB Paradigm also includes the concept of meta-levels. *Meta-levels* are built using the relevance of the underlying actions as sensors. A sensor reflecting the relevance of an action is thus called a meta-sensor. A meta-sensor is 'activated' when its corresponding action is relevant, and 'deactivated' when the action is irrelevant. This makes it possible to create meta-level co-occurrences from co-occurring action relevances (meta-sensors), and thus build a new set of *meta-actions* from these co-occurrences. This can clearly be generalized to an arbitrary number of meta-levels. Figure 10 illustrates how the basic actions X , Y and Z act as meta-sensors by showing their relevance to the next level.

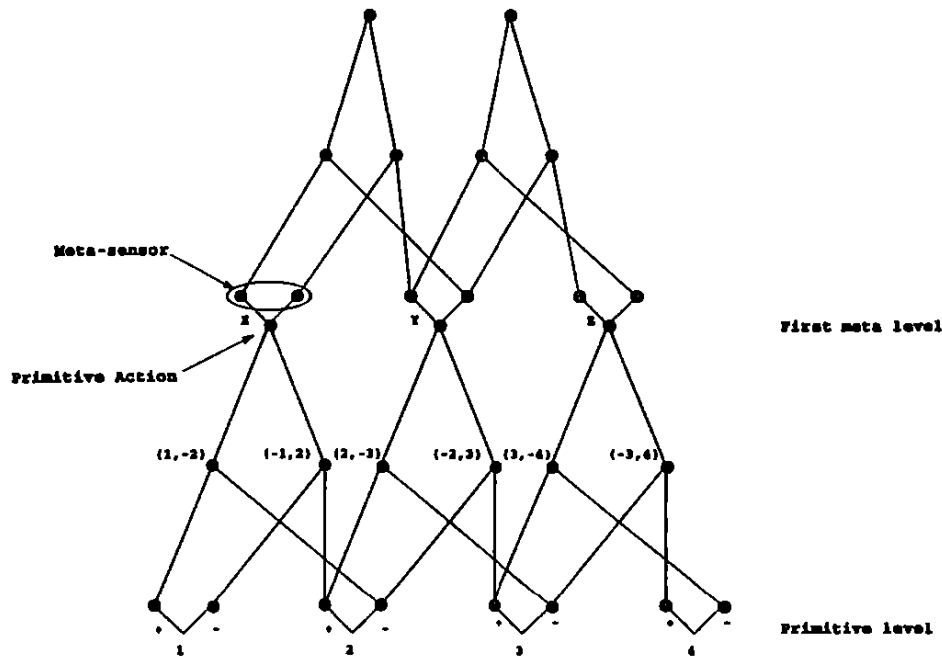


Figure 10: Actions act as meta-sensors.

An action can act as a meta-sensor, but what is a *meta-effector* supposed to do? It cannot just alter the meta-sensor with which it is (necessarily) associated directly when it discovers a goal to do so, since this would leave us with an inconsistent web where the meta-sensors would not reflect the relevance of their founding actions at the level below. Instead a meta-effector translates meta-goals to lower level goals which (hopefully) end up causing the given meta-sensor to change to the desired state. Each meta-sensor has two meta-effectors associated with it⁶, one trying to activate the meta-sensor, and the other one to deactivate it. For example, when a meta-goal ($X \rightarrow \bar{X}$) is issued to change meta-sensor X , the latter's meta-effector will issue sub-goals which should end up fulfilling this goal. If the associated action $((1, \bar{2}) \leftrightarrow (\bar{1}, 2))$ were in state $(1, \bar{2})$, the meta-effector would issue the sub-goals $(1 \rightarrow \bar{1})$ and $(\bar{2} \rightarrow 2)$ in order to enter

⁶One can draw an analogy here with the fact that there are, quite naturally, *two* primitive effectors - *grasp* and *release* - associated with a single primitive sensor - the hand's contents.

the opposite state, $(\bar{1}, 2)$. The other meta-effector would do the opposite: attempt $(\bar{1}, 2) \rightarrow (1, \bar{2})$ by issuing $(\bar{1} \rightarrow 1)$ and $(2 \rightarrow \bar{2})$.

Notice however that if *both* these goals were to be fulfilled, the action would change to its opposite state and thereby still be relevant, leaving the meta-goal unfulfilled! It is therefore desirable that only one of the issued goals be fulfilled. This will make the corresponding action irrelevant and invert ('deactivate') the meta-sensor. Both goals are therefore retracted by the meta-effector when and if *one* of them is fulfilled.

A *meta-sensor* represents the knowledge contained in its sub-parts, but in a more abstract way: it expresses a property of the constituent co-occurrences that they cannot express/contain individually. Thus the 'abstraction' itself is the emergent property of the whole it creates. This property/abstraction is two-valued: either it is present/satisfied, or else is not, which translates to the relevance, or lack thereof, of the action at the level below, of which it is the abstraction.

For example, meta-sensor X in figure 10 knows not only about sensors 1 and 2, but also *and* more importantly, their relationship with each other. Meta-sensor X makes explicit a relationship which is only implicit at the primitive level. It is namely able to state whether *either* sensor 1 *or* sensor 2 is activated, and the very fact that it exists states that (from its point of view) *both* cannot be activated at the same time.

This leads to a final point: an action built over co-occurrences of n changing sensors will in general exist in 2^{n-1} forms, called *duals*. For example (cf. Table 2), the action AB can exist in two forms: $((A, \bar{B}) \leftrightarrow (\bar{A}, B))$ and $((A, B) \leftrightarrow (\bar{A}, \bar{B}))$. We have discussed the first of these already: it captures the fact that a single block can either be on A or B . The dual captures the fact that blocks can appear and disappear vis a vis platforms A and B . Which forms of a given action TOPSY creates depend entirely on the behavior exhibited by the environment: not all forms will necessarily appear, i.e. they are not meaningful.

One can also view this paradigmatically: the PHASE WEB paradigm says that a *useful* way to organize information is in terms of *complementary* co-occurrences, because if you do so, then the same structure can be used both for classification *and* to achieve globally coherent behavior on the basis of local (i.e. distributed) decisions (i.e. actions). The latter obtains because actions formed from complementary co-occurrences encode *mutual exclusion* of the corresponding processes. This is the ultimate reason for why a transition such as $(A, B) \leftrightarrow (\bar{A}, B)$, where there is only one change, is 'uninteresting': there is no *mutual exclusion* in operation.

On the other hand, when there are at least two changes, say $((A, \bar{B}) \leftrightarrow (A, \bar{B}))$, then the following reasoning applies: A excludes $\bar{A}$ and $\bar{B}$ excludes B , so therefore $(A, \bar{B})$ excludes $(\bar{A}, B)$. This we call the *co-exclusion* principle, and it has the effect of encoding the detailed changes to A and B into a single state-exclusion (cf. the meta-sensor associated with the action) at a higher level of abstraction. The ability to create arbitrary numbers of meta-levels with the same abstraction operation (co-exclusion) is a principle source of the PHASE WEB's power.

This concludes our walk-through of the basic concepts of the PHASE WEB and TOPSY.

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 - [9] Software implementing the Phase Web paradigm is currently not available (June, 1995); inquire via <http://www.iesd.auc.dk/general/DS/index.html> for the theses mentioned above, and [ftp.iesd.auc.dk/pub/reports/papers/](ftp://ftp.iesd.auc.dk/pub/reports/papers/) manthey:X where X = PhysComp94.ps.Z for [5] and PhaseWeb_Software.README for software status and patent licensing information. If/when someone writes a paper referencing this one or the ideas contained herein, we would appreciate their sending a (paper) copy to the first author.

MEASUREMENT ACCURACY, BIT-STRINGS MANTHEY'S QUATERNIONS, and RRQM*

H. Pierre Noyes

Stanford Linear Accelerator Center
Stanford University, Stanford California 94309

Abstract

We continue the discussion started last year. By now three potentially divergent research programs have surfaced in ANPA: (1) the Bastin-Kilmister understanding of the *combinatorial hierarchy* (Clive's "Menshevik" position); (2) my bit-string "Theory of Everything" (which Clive has dubbed "Bolshevik"); (3) Manthey's cycle hierarchy based on *co-occurrence* and *mutual exclusion* that Clive helped him map onto quaternions (an as yet unnamed heresy?). Unless we can find a common objective, these three points of view will continue to diverge. We suggest the reconstruction of relativistic quantum mechanics (RRQM) as a reasonable, and attainable, goal that might aid convergence rather than divergence.

1. INTRODUCTION

So far, ANPA has thrived without making a specific research program with a stated objective our main reason for existence. In a general sense, we are interested in providing a forum for *coherent* presentations of foundational theories. In our statement of purpose we use as an example a code word for research arising from the Bastin-Kilmister program of the 50's^[1-5] which started from an examination of Eddington's FUNDAMENTAL THEORY, the discovery of the *combinatorial hierarchy* by Fredrick Parker-Rhodes in 1961,^[6,7] and the grounding of his construction on *discriminately closed sets* by John Amson in 1965.^[8,9] Other than this, a

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vague consensus that a new scientific revolution is in the air and that we wish to encourage it has sufficed.

I once thought that the core research, and objective, were so clear that what was needed to advance the revolution was a more specific focus and presented my proposals in two papers whose titles used the English translation of two polemics by Lenin.^(10,11) My temerity was gently labeled "Bolshevik" by Clive. I assume his intended implication was that my Bolshevik (which means majority in Russian) approach in fact did not command a numerical majority acceptance in our ANPA community. Historically, Lenin seized an occasion when his faction had a majority on the Central Committee of the Second International to make his policies dominant. Probably many (most?) members of the organization did not agree with him; yet from then on those who did not follow his "party line" were *defined* as Menshevik, which means the "minority". So when Clive called his position "Menshevik", he implied that in fact it was much closer to the center of gravity of the ANPA membership than mine.

I still find it remarkable that in an organization like ours which espouses radical viewpoints, a debate on what should be the foundational ideas of our enterprise has taken so long to emerge. In fact, Clive once told me that he was wary of looking too closely at the foundations of the *combinatorial hierarchy* because of a fear that they might dissolve under critical examination. By now I am sure he agrees both that the combinatorial hierarchy has firm foundations and that we now have a solid enough organization to survive internal criticism and self-criticism.

Naturally, when it comes to details, individuals in ANPA may fall outside or in between the three main groups I discuss. There is also controversy within them. For example, Ted (Bastin) and Clive (Kilmister) disagree as to the importance of the sequence $2^2, 4^2, 16^2, 256^2$ compared to the sequence $3, 10, 137, 2^{127} + 136$ which we all aim at understanding. David McGoveran insists that without both sequences, the construction is too general to be applied to physics, as do I. Yet he also insists⁽¹²⁾ that my detailed application of his corrections to coupling constants

and mass ratios is *illegitimate* because I am not working in the *ordering operator calculus* context in which they were derived. I have noted his objections in a recent paper.^[13] Clive started out last year^[14] from a remark of Tony Deakin's at ANPA 14 that Mike Manthey had provided the mathematical theory for Alison Watson's metaphysics. Yet he ended up concluding that there are detailed mathematical connections between Manthey's construction and the original Parker-Rhodes construction (P-R), and detailed philosophical connections between P-R and Alison's thesis, but *not* between Mike Manthey and Alison Watson. And so on.

In this paper I attempt to spell out some of the critical differences underlying this debate, and propose a way to allow us to still have a common objective.

2. The Traditional ("Menshevik") Position

Fortunately, a book presenting the traditional position will be available shortly.^[15] I will defer detailed criticism of the ideas presented there until the printed version is available to all of us. The earlier versions of this text I have seen still left me puzzled as to how the work presented is supposed to be related *in detail* to the actual practice of laboratory physics and observational cosmology.

Here I will respond to Ted Bastin's remarks at ANPA 15.^[16] I agree with Ted that — in contrast to Parker-Rhodes — all the current protagonists of core positions are committed in some sense to a "process" and "constructive" point of view. But I immediately part company with Ted's view that "...our picture is inevitably that of a particular observer. We have no right to think of a construction which would be common to *all* [italics supplied] observers until we have explicitly constructed it. I would be happy with the second sentence if "all" were replaced by "most". This, for me, would carry the implication that our construction has to be satisfactory for most people who practice particle physics and physical cosmology. I would extend this implication to those in other fields who agree that in order to find a common ground for precise statements, it is mandatory to base their constructions on "NO-YES events". My understanding of the meaning of such

events is spelled out for particle physics in the next chapter. But I know that Ted would be unhappy with this change *because* of the implied methodology of relating our construction back to the *practice* of a group "observers". In fact, he remarks that "...when I hear the world 'methodology' I [want to] reach for my revolver."

Here a way out of the difficulty might lie in Etter's *prelogic*^[17] in which even "truth" and "falsity" in the boolean sense depend on the "point of view" of the (still singular?) observer. To avoid the need for a singular observer, we may need the type of distributed computation *without* a central processing unit (CPU) advocated by Manthey (see below).

As one of the physicists who would be upset by replacing the word "observer" by "perceiving mind", I join Ted in looking for a way to restore objectivity without making an *ontological* commitment to mentalism. My way is to use a common *neo-mechanistic* (to use Manthey's term)^[18] explanatory framework for physics and biology, *including* conscious and observing brains, namely selection for heritable stability in the presence of an arbitrary background. I have long viewed *Program Universe* (PU) as providing such a model. Unless one accepts Parker-Rhodes "inevitable" postulates^[19,20] that something exists but that this statement conveys no information, I know of no way to claim that PU or any other ANPA "universe" is self-generating. I do claim that (if recoded carefully) PU is obviously "self-organizing". But there are deeper difficulties, which are related to those mentioned by Ted.

One basic difficulty is that any published description of PU would allow it to be implemented on a Turing machine with a finite tape. The finite tape, which may be a loop, goes part way toward meeting the McGoveran requirement that before any calculation is started we must name a "largest integer", a requirement that I also adopt. If one drops the finite tape restriction (which may even be irrelevant to the points at issue), one immediately encounters two "theorems" usually accepted by computer scientists. The first is that adding a random component to a Turing machine does not increase its computational power; perhaps this was the objection

McGoveran had in mind that Ted mentions on p.8 of his talk. The second is that parallel processing using a number of Turing machines can increase the speed of computation but, again, not the computational power. The validity of this second theorem is explicitly denied by Manthey in Ref. 18. We examine briefly, in Chapter 4, his claim to know how to construct a genuine learning and goal-seeking computer which is *not* a Turing machine. Here we note that if *Topsy* works as advertised, and PU can be implemented on it, Ted will have to re-examine his objections.

However, even within the framework of PU as it now exists as a sequential program, one is guaranteed a finite number (*not* an “indefinite” number, as Ted says) of examples of different levels of the hierarchy construction existing and interacting “concurrently”. Nevertheless, he is correct in assuming that the step from this to a spatially distributed universe is not an easy one. I admit that I have been too cavalier in making that assumption in the past. What my recent work with Kauffman, discussed in the next chapter, has established is that the “space” we arrive at is *non-commutative* at a fine grained but finite level, yet implicates the Maxwell and Einstein fields as representing a well-defined *approximation* to the forces on a single test-particle under appropriate restrictions.

As to whether my neo-Bridgmanian “operationalism” would have been legitimated or denied by Bridgman, neither Ted nor I know. My claim to inherit a small fold of Bridgman’s mantle is presented elsewhere.^[21] When it comes to whether or not I can make contact with the current practice of physicists, however, I think I am on firm ground in the particle physics community, or at least the experimental wing of it. “All” I need to do is to present them with a computer algorithm that will, using the same notation and observables they are accustomed to use in relating cross sections computed from Feynman diagrams to the digital results of their experiments, make a *different* or *more easily tested* prediction than currently accepted theories, and they will be just as happy trying to shoot me down as they are any other theorist. At their level of practice, there will be no problem communicating once I have given my theory the precision I, myself, require. Of course, I cannot expect many *theorists* to take me seriously until after I succeed where they

fail. But I insist that my language of “counts in detectors”, Feynman diagrams, and cross sections is common with that used by current practitioners of particle physics, and understood by non-negligible numbers of theorists. In particular, a recent communication^[22] summarizes Tini Veltman’s position as

“... the Feynman rules and Feynman diagrams are the theory because quantum field theory has failed in the end to produce them, and is itself inconsistent. That is THE Veltman.”

Next Ted talks about “quantum objects” and “reality”. Although Stein thinks he knows what he means by a “quantum object”,^[23] for me the term is an oxymoron. I never use that term and also avoid talking about “reality” if at all possible. My laboratory “spatial relationships” are defined by standard metrological practice. This includes measurement accuracy bounded from below by finite space and time *intervals*, specified in advance and in context. Generalizing Chew and Heisenberg, I am *not* allowed to extrapolate them down below where scale invariance is broken at $\hbar/2m_e$, either directly or by inference from observable effects. So I am not allowed “... all sorts of spatial relationships which go with a conjectural ‘particle’ which is associated with those counts.” Like most practicing physicists, I take short cuts in talking about particles within a community where this will not get me into trouble. I accept the criticism that I am not always careful to drop this cavalier attitude when I engage in ANPA discussions. I hope in the next chapter will be more acceptable on that score.

3. The Radical ("Bolshevik") Position

3.1 PARTICLES, NO-YES EVENTS AND MEASUREMENT ACCURACY

My conceptual foundations for reconstructing relativistic quantum mechanics and physical cosmology are the coupled concepts of *particle*, *event* and *conserved quantum number*. I join them together in the following way:

A particle is a conceptual carrier of conserved quantum numbers between events.

An event is a finite spacial region which particles enter and leave during a finite time interval. Both the spacial dimensions and the time interval are fixed in the context of a particular application of the definition.

The algebraic sum of each type of quantum number carried into the region by the entering particles is equal to the algebraic sum of that type of quantum number carried out of the region by the leaving particles. This statement defines a conserved quantum number. Note that the number of particles entering the region need not equal the number of particles leaving the region; in other words, particle number is not necessarily conserved.

The paradigm for an event we have in mind is a *counter firing* in which a counter of relevant spacial size Δx at a specified location in the laboratory does *not* fire during a time interval Δt , which we call a *NO-event*, or *does* fire during that time interval, which we call a *YES-event*.

We further assume that these NO-YES events can be *recorded*, using a clock at the counter (or calibrated in such a way that it can be thought of as "in" the counter) which has been synchronized to the laboratory clock using the Einstein *convention* in relation to spacial coordinates of the counter position *fixed* relative to the position of the laboratory clock ("origin") and three *fixed*, independent (i.e. non-coplanar) *directions*.

This allows us to represent the record made by a single counter as an ordered sequence of two distinct symbols such as "0" and "1". When we have specified how

two such ordered sequences of symbols of the same length combine, we will call them *bit-strings*. A general representation of our bit-strings is given in Appendix I.

We take as our paradigm for *measurement accuracy* the smallest counter size Δx and time resolution Δt which we can either construct, or infer from the theory we are in the process of constructing.

This is a very powerful and restrictive definition, because it prohibits us from considering *fractional* space and time intervals. Once we have developed the theory far enough to give meaning to *interference*, as in optical interferometry, this assumption of a minimum distance *also* implies a maximum distance and time, which we can call the *event horizon*.

Up to this point we have treated length and time measurement as distinct. But the *System International*, employed universally by physicists in reporting the results of measurement, and establishing the meaning of "fundamental constants"^[24] takes time measurement to be primary and defines the unit of length:

"The meter is defined to be the length of path traveled by light in vacuum in 1/299 792 458 s[econds]. See B.W.Petley, *Nature*, **303**, 373 (1983)."

Thus, following current practice, we are no longer allowed to define Δx and Δt separately when specifying our lowest bound on measurement accuracy. In fact, we must make the *scale invariant* statement that

$$\frac{\Delta x}{c\Delta t} = 1 \quad (3.1)$$

in *any* system of units which allows us to talk about NO-YES events in a precise way.

We can summarize the content of this section by the phrase:

PHYSICS IS COUNTING

3.2 POSTULATES FOR THE FEYNMAN-DYSON-TANIMURA-KAUFFMAN PROOF

The derivation of Maxwell's Equation's using the discrete ordered calculus (DOC) of Etter and Kauffman^[25] has been presented elsewhere.^[26] My version of the *physics* underlying this piece of mathematical physics was presented at ANPA 15,^[27] and discussed again more recently.^[28] My ANPA presentation was uncharitably called a "South Sea Bubble" by Clive, a derogatory characterization more appropriately applied to an enterpeneurial pitch than to a Bolshevik platform. Nevertheless, he has subsequently vetted the most rigorous piece of the work (Ref.26) for submission to the *Proceedings of the Royal Society A*. Lou (Kauffman) and I are most grateful to him for this informal refereeing; his comments undoubtedly enabled us to tighten up the argument.

We are now on firm ground in claiming that the postulates

$$1.[X_i, X_j] = 0; \quad 2. [X_i, \dot{X}_j] = \kappa\delta_{ij}$$

and the assumption that the acceleration of a test charge is related to E and H by the Lorentz law lead to the conclusion that

$$\Sigma_l \nabla_l H_l = 0; \quad \frac{\partial H}{\partial t} + \epsilon_{ijk} \nabla_j E_k = 0 \quad (3.2)$$

in the context of the DOC. Skeptics can consult Appendix II and purists Ref. 26. We concentrate in this section on understanding the postulates in the context of measurement accuracy bounded from below (i.e. $X = n_X \Delta x$, $T = n_T \Delta t$ with n_X, n_T integer and $\Delta x = c\Delta t$). We explore some of the implications of the proof in the next section.

In our context, we can think of $2K_{max} + 1$ macroscopic counters of size Δx lined up in some direction. Take the "origin" as the central counter in the array, $X^{(0)}$, and define

$$X^{(k)} \equiv k\Delta x; \quad k \in -K_{max}, -K_{max} + 1, \dots, +K_{max} - 1, +K_{max} \quad (3.3)$$

Since the recording clocks associated with these counters are synchronized using

the Einstein convention, any pattern of NO-YES events in these counters defines a pattern which can be associated with bit-strings, the 1's representing, for example, YES events and 0's representing NO events. This association can be made in a number of ways.

We defer the examination of Lorentz boosts and rotations of the array (within a larger context) until we have introduced more structure. Here this array is a fixed (one dimensional) spacial coordinate system, and we can define a *simultaneous firing pattern* $F(K_{max}; k, n)$ relative to tick n on the clock at $X^{(0)}$ as the pattern of firings or non-firings of the counters located at grid position k at tick n . Note that to *examine* this data *locally*, we will have to wait *at least* $(K_{max} + 1)\Delta t$ seconds to collect it all in one place. To restrict the maximum size of this finite and discrete model of "space-time" symmetrically, we require that

$$n \in -K_{max}, -K_{max} + 1, \dots, +K_{max} - 1, +K_{max} \quad (3.4)$$

Once the data are collected, we can map a single firing pattern onto a *bit-string* (see Appendix I for notation) by

$$F(K_{max}; k, n) \Rightarrow F(S; f, n); S = 2K_{max} + 1; s = k + K_{max} + 1 \quad (3.5)$$

where

$$f_s(n) = 1 \text{ if } X^{(k)}(n) \text{ fires, else } f_s = 0; f(n) = \sum_{s=1}^S f_s(n) \quad (3.6)$$

In the absence of further information, this block of data could easily have been generated by PU. We call a single firing pattern $f_s(n)$ a *measurement*, and a sequence of firing patterns parameterized by a sequence of ordered ticks n_i

$$-K_{max} \leq n_1 < n_2 \dots \leq +K_{max} \quad (3.7)$$

a *sequence of measurements*.

This model is still too general for our current purpose. We restrict ourselves to *single particle trajectories*, which have one and only one bit for any firing pattern ($f(n) = 1$ for all n), and which pass through the origin (i.e. $X^{(0)}(0) = 0$, or stated another way $f_{K_{max}+1}(0) = 1$). We further require them to be “piecewise continuous” by imposing the constraints

$$\begin{aligned} & \text{if } f_s(n) = 1 \text{ then } f_{s+1}(n+1) = 1 \text{ or } f_{s-1}(n+1) = 1 \text{ but not both} \\ & \text{else } f_s(n+1) = 0 \end{aligned} \quad (3.8)$$

In the absence of further information, we have modeled a “random walk”.

In order to restrict ourselves to “particles” ($-c < v < +c$) and exclude “photons” we require that at the initial time the initial firing does not lie at either of the extreme values of X and similarly for the final firing. Assume that we make only these three measurements, which we call $X^{(-)}(-T)$, $X^{(0)}(0)$, and $X^{(+)}(+T)$. These three measurements then specify two average velocities:

$$V^{(-)} \equiv \frac{X^{(0)}(0) - X^{(-)}(-T)}{T}; \quad V^{(+)} \equiv \frac{X^{(+)}(+T) - X^{(0)}(0)}{T} \quad (3.9)$$

and a change in average velocity:

$$\Delta V = V^{(+)} - V^{(-)} = \frac{X^{(-)}(-T) + X^{(+)}(+T) - 2X^{(0)}(0)}{T} \quad (3.10)$$

If we now extend our counter array by any number of blocks of counters of length $(K_{max} + 1)\Delta x$, run a piecewise continuous single particle trajectory through them all, and define

$$X \equiv X^{(-)}(-T); \quad X' \equiv X^{(0)}(0); \quad X'' \equiv X^{(+)}(+T); \quad X''' \equiv X(2T); \quad \dots \quad (3.11)$$

we have now provided a preliminary bit-string and measurement accuracy model for what I will call a *Kauffman trajectory*.

In his preliminary remarks, Kauffman points out that postulate 2 (which is formally equivalent to Feynman's, if $\kappa = -i\hbar/m$) looks like quantum mechanics. In fact Feynman's proof cannot refer to quantum mechanics because X and $\dot{X}$ are subsequently treated as continuous functions of t , and hence are defined at the *same time*; this is incompatible with the uncertainty principle. Our derivation does not fall into this trap because Kauffman introduces a new symbol X' which means X shifted by one time step, which he takes to be 1 and in the model articulated above is obviously T . He further interprets the symbol XX' as the instruction, "first measure X , then measure X' ". This means that "velocity", however introduced, is *not* measured at the same time as X and further that the symbol $X'X$ is meaningless as it stands. We are therefore able to invest it with meaning, if we use care to do so consistently. Then (Ref. 7, p. 3) making the hypothesis that

$$X\dot{X} - \dot{X}X = \kappa$$

"is regarded as a hypothesis about the structure of their non-commutativity".

In the model given above, all we can say about κ so far is that dimensionally it is an area per unit time, and hence in a broader measurement context can be related to Kepler's second law. We have discussed this in references given here and cited in them, but an axiomatic treatment is still lacking. For the purposes of the Dyson-Feynman-Tanimura- Kauffman proof, nothing prevents us from fixing κ by the scale invariant definition

$$\frac{\Delta x^2}{\kappa \Delta t} = 2\pi \quad (3.12)$$

The mathematical step next taken is to introduce a "shift operator" U defined by $X' = UX$ and treat U as an algebraic element of the same algebraic type as the sequence of X 's we already have. If we now assume three *independent* directions i, j, k , postulate 1 simply asserts their independent measurability, and is consistent with setting up a three dimensional version of our counter array. We also must

define

$$\frac{\partial X_i}{\partial X_j} \equiv \delta_{ij}; \quad \nabla_l \equiv \frac{\partial}{\partial X_l} \quad (3.13)$$

For details, see Ref. 26, and for subsequent steps in the actual proof, see Appendix II.

3.3 SOME IMPLICATIONS

Asserting that the Maxwell Equations specify a *necessary* connectivity between a piecewise continuous trajectory and the “field” which specifies the acceleration (change in velocity) of a “particle” passing through the events (of volume $\approx \Delta x^3 \Delta t$) where (in a punctiform language) the changes occur to be a consequence of accepting finite and discrete measurement accuracy bounded from below is a powerful conclusion. But it does not mean that we have “derived” classical fields from measurement accuracy” for a number of reasons.

One of the problems is that classical fields have ontological existence, and are not supposed to change no matter how many “test-particles” pass through the space-time region in which they exist. But our model contains only *one* particle which “exists” in the sense of having demonstrable properties only when it produces YES events. Further, we can only state that it interacts with some electromagnetic field when a sequence of at least three YES events (at time intervals T) show that its velocity changes. To show that these fields “propagate”, which is implied in the usual classical interpretation of Maxwell’s Equations, will take a lot more work.

A second problem is that the “fields” so derived do not commute. This is actually to be expected. In 1933 Bohr and Rosenfeld^[29] derived the uncertainty principle version of the E, H commutation relations from the restrictions on measurability imposed by the *non-relativistic* uncertainty principle applied to the measuring apparatus. That we have been able to arrive at a (non-commutative, finite and discrete) version of the Maxwell Equations by postulating fixed measurement accuracy is consistent with their result.^[30] How this works out in detail might be worth exploring.

A third problem is that we can take the field as given and compute the trajectory, or the trajectory as given and compute the field, but not both at once. Further, once we introduce momentum conservation, we can treat the particle as either a source or sink of the field, but not both at once. This may be a virtue in disguise, because this “self-energy” problem has proved to be insoluble in classical theory, and intractable in a rigorous, mathematical sense in QED. We return to this issue below.

One way to get off the ground and start moving toward the many particle problem is to consider a closed trajectory which is a regular polygon, implying a “field” directed toward the center acting at the corners where the direction but not the velocity of the particle changes. This is a scale invariant version of the bit-string “Bohr atom” that McGoveran and I used to discuss the fine structure of hydrogen.^[31] Extended to a polygonal approximation of an elliptical orbit, it is reminiscent of diagrams in the *Principia*, and can be extended to hyperbolic orbits if finite and discrete boundary conditions are supplied. Further, by making step-lengths inversely proportional to masses, we could replace this “motion around a center” by a well defined solution of the two body problem.

In contrast to the classical equations in the usual framework, which render these orbits unstable due to “radiation”, they are perfectly acceptable solutions to the “trajectory-field” equations we have derived and *do not radiate*. So we have a *scale invariant* version of the generalized Bohr-Sommerfeld two body system “derived” from measurement bounded from below! Interchanges of energy between two such systems would be quantized. If there are no other sources or sinks, this would extend our “coherence” to at least some four-body systems.

The differences between gravitation and electromagnetism in this context should prove to be of interest. At least if Tanimura’s extension is any guide, gravitation will require closure conditions, even for a single orbit and massive center, which will depend on the area of the orbit, and hence go beyond the quasi-local “trajectory-field” interaction we have examined in this paper.

Returning to the self-energy problem, it will be seen that our underlying “random walk” model could be attributed to a “background radiation” and in “free space” required to yield the finite and discrete version of the Dirac equation which McGoveran, Karmanov, Stein and I kicked around half a decade ago. Consistency between this and our quantized Maxwell Equations might even lead to a solution of the basic problem in the relativistic quantum theory of fields and particles. This speculation could well prove to be analagous to the “South Sea Bubble”, so I offer no stock for sale.

4. Manthey's *coexistence and mutual exclusion*

Mike (Manthey) did an excellent job at ANPA 15 in making clear the connection between his computational model and the Parker-Rhodes construction (*not* the current Kilmister construction) of the combinatorial hierarchy.^[32] The fact that “There is a ‘phase difference’ of one level between the two constructions, as revealed by the syntactic match of $\{a, b, a|b\}$ with $\{1, \bar{1}, 1|\bar{1}\}$, versus its semantic match with s_1s_2 which appears one level later” is undoubtedly significant. It may be connected with the fact that the computational approach uses “ ϕ ” as well as “0” as a basic symbol. Note that Parker-Rhodes makes essentially the same distinction in getting his “inevitable universe” to start up. The fact that Manthey has this new symbol, and negative as well as positive elements makes it easier for him to demonstrate that he has constructed quaternions than it is using only discrimination and the Parker-Rhodes matrix mapping. Clive and Mike did some work together exploring this connection, but more work along this line might prove to be fruitful. Similarly, exploring what it would take to get to the same formalism using discrimination and concatenation as basic would tighten connections to the PU approach.

Mike notes that in his approach, as in some versions of the Menshevik program, the second Parker-Rhodes sequence does not appear. This is a genuine problem if we wish to make contact with particle physics and weak-electromagnetic unification using the first three levels, gravitation at the fourth level and physical cosmology

using the Parker-Rhodes closure to both bring particle physics into contact with gravitation *and* fix the baryon and lepton number of the universe in rough agreement with observation. Until quantitative contact is made with experience by either program in this sense, each will remain speculative metaphysics in my evaluation. In contrast the Bit-String, PU approach leads to a detailed modeling of the standard model of quarks and leptons, and results similar to those obtained in the standard "big bang" cosmology, in both cases with much less effort (see Ref. 13).

The computational model itself was described by Manthey at ANPA 14, and more recently in Ref. 18. Here Mike's work has importance for quite a different reason. He claims, and I believe with considerable cogency, that a von-Neumann computer with a CPU, or its abstraction as a Turing machine, can deal with mathematical problems based on set theory and functional composition, but not with the critical concepts of *mutual exclusion* and *concurrency* used in his cycle hierarchy. In particular, he claims that the "synchronization sticks" which occur when one couples two wait-signal nodes from the Hewett actor model in a specific way conceal a bit which is not a "bit of information" in the Turing machine sense. I suspect he is right, but reserve judgment until he can make a *formal* argument that is understandable by, for example, Tom Etter.

A lot of contemporary discussion of "AI" and consciousness hinges on whether or not a computer can model consciousness, or quantum mechanics in the sense of EPR, let alone "be conscious", whatever that means. I am almost prepared to accept the arguments that claim that a Turing machine cannot be conscious, but Mike Manthey's "Topsy" may be another matter. So I hope that Mike can use Topsy to both model EPR and a concurrent version of PU in a way that satisfies both him and David McGoveran. I am trying hard to do EPR in my own fashion, but am not there yet.

5. CONCLUSION

All three approaches produce the first Parker-Rhodes sequence. A better understanding of what makes this necessary or contingent will help all three programs. I have argued above that the second Parker-Rhodes sequence is needed for particle physics and physical cosmology, so continued attention as to whether this also emerges “naturally” in the Menshevik and Topsy programs is clearly a matter of great importance.

As second area of tension between the three programs arises in the use of bit-strings. For Manthey they are the interface between his hierarchical computer program and the “external world”. For me they can be “firing patterns” of counters, with essentially the same sort of interpretation. So bringing later steps in the construction into congruence should be vigorously pursued. The Menshevik program is more abstract, and only arrives at bit-strings as a possible representation at a fairly advanced stage of the construction. Here I urge its protagonists to show us more explicitly how they view their strings as relating to “experience”.

I think it is clear that *one* possible way to bring the three programs together is to concentrate on the reconstruction of relativistic quantum mechanics (RRQM). But, so far, this has not been a priority for others. I suggest for a topic at ANPA 17 a discussion of (a) *whether* it is even desirable for the three programs to have a common goal and (b) if so, what it should be. Alternatives to RRQM would certainly be of interest to me.

With regard to my own research program, we believe that the discussion started last year of the derivation of the classical relativistic field equations from scale invariance bounded from below and Kepler’s Second Law is achieving the status of mathematical rigor in an appropriately limited context. We believe that to use this as a basis for both establishing a “correspondence limit” for relativistic quantum mechanics and some sort of finite and discrete “quantum gravity” is now only a matter of time. We have made progress in nailing down the bit-string framework for the finite and discrete transformation laws which keep $E(E+1) - p^2 = m^2$ and

$j(j+1) - j_z^2 = j_x^2 + j_y^2$ invariant under Lorentz boosts and rotations, respectively. No surprises have showed up, and closure should not lie too far in the future. These are, of course, formulated in terms of discrimination between bit-string *states*. Results may be available for ANPA 17. By then we could also relate these states to the two positions occupied by no, one, or two blocks used as the basis for Manthey's construction of quaternions. With these tools in hand, we believe that the time would be ripe for the reconstruction of relativistic quantum mechanics (RRQM) which has long been our goal.

6. APPENDIX I: Bit-string Basics

Specify a *bit-string* $a(S)$ by its S ordered elements a_s :

$$a_s \in 0, 1; \quad s \in 1, 2, 3, \dots, S \quad (6.1)$$

If we interpret the symbols "0" and "1" in the strings as *integers*, we can calculate the norm, or Hamming measure, $a(S)$ by the formula

$$a \equiv \sum_{s=1}^S a_s = |a(S)| = a(S) \quad (6.2)$$

Because we interpret the symbols "0" and "1" as *integers* rather than bits, we can define the operator XOR, which combines two strings to form a third and is symbolized by " $\oplus$ ", in terms of the elements of the resulting string:

$$(a \oplus b)_s \equiv (a_s - b_s)^2 \quad (6.3)$$

This is isomorphic to the usual meaning of XOR, addition *mod 2* or boolean symmetric difference in the sense that the element is 1 if a_s and b_s differ, and 0 if they are the same.

We introduce the *null string* $0(S)$ with elements $0_s = 0$, the *anti-null string* $I(S)$ with elements $I_s = 1$, and the *complement* to a defined by $\bar{a} \equiv I \oplus a$; clearly this string is a with the "0" 's and "1" 's interchanged. We note that

$$a \oplus a = 0; \quad a \oplus \bar{a} \oplus I = 0 \quad (6.4)$$

We introduce a second bit-string operation called *concatenation*, symbolized by "||" and defined by

$$e_k^{a||b} \equiv a_k, \quad k \in 1, 2, \dots, S_a; \quad e_k^{a||b} \equiv b_j, \quad j \in 1, 2, \dots, S_b, \quad k = S_a + j \quad (6.5)$$

7. APPENDIX II: Formal derivation of finite and discrete Maxwell Equations

When I recently showed Ref. 26 to my colleague, M. Peskin, he noted that the "shift operator J " defined by Kauffman is, in our context of a single particle, isomorphic to the operator $U = \exp(-iHT)$ representing a finite time shift in the Heisenberg representation. Then the formal steps in Kauffman's rigorous version of Feynman-Dyson-Tanimura "proof" go through easily. The difficulty with adopting Peskin's approach is that what *operational* context the Heisenberg formalism fits into is by no means obvious. So, for mathematical and physical clarity, one needs to invoke the DOC and discuss the relationship between measurement accuracy and the DOC. I am indebted to Peskin^[33] for allowing me to quote his shortened version of the Kauffman proof below.

Define

$$\dot{X} = XU - UX = [X, U] \quad (7.1)$$

where U is the time shift operator from X to X' in time Δt (eg $U = e^{-iH\Delta t}$).

Notice that

$$(AB)' = [AB, U] = [A, U]B + A[B, U] = \dot{A}B + A\dot{B} \quad (7.2)$$

as required.

Postulate:

$$1. [X_i, X_j] = 0; \quad 2. [X_i, \dot{X}_j] = \kappa \delta_{ij}$$

Rewrite 2 as

$$[X_i, [X_j, U]] = -[X_j, [U, X_i]] - [U, [X_i, X_j]] \quad (7.3)$$

and noting that $[U, [X_i, X_j]] = [U, 0] = 0$ we find that

$$\kappa \delta_{ij} = [X_i, [X_j, U]] \text{ symmetric in } i, j \quad (7.4)$$

Now define

$$H_l = \frac{1}{2\kappa} \epsilon_{jkl} [\dot{X}_j, \dot{X}_k] \quad (7.5)$$

Then

$$\nabla_l H_l = \frac{1}{2\kappa} \epsilon_{jkl} [[\dot{X}_j, \dot{X}_k], \dot{X}_l] \quad (7.6)$$

But this cyclic sum vanishes by the Jacobi identity. Thus

$$\nabla_l H_l = 0 \quad (7.7)$$

which is one of the two Maxwell equations we set out to derive.

Finally, define

$$E_i = \ddot{X}_i - \epsilon_{ijk} H_k \quad (7.8)$$

We wish to prove that

$$\frac{\partial H_i}{\partial t} + \epsilon_{ijk} \nabla_j E_k = 0 \quad (7.9)$$

First we need to define $\partial/\partial t$ by

$$\dot{H} = \frac{d}{dt} H = \frac{\partial H}{\partial t} + (\dot{X} \cdot \nabla) H \quad (7.10)$$

Then

$$\begin{aligned} \frac{\partial H_i}{\partial t} &= \dot{H}_i - \dot{X}_j \nabla_j H_i \\ &= \frac{1}{2\kappa} \epsilon_{ikl} ([\dot{X}_k, \dot{X}_l]) - \dot{X}_j \frac{1}{\kappa} [\frac{\epsilon_{ikl}}{2\kappa} [\dot{X}_k, \dot{X}_l], \dot{X}_j] \\ &= \frac{1}{\kappa} \epsilon_{ikl} [\dot{X}_k, \ddot{X}_l] - \frac{1}{2\kappa^2} \dot{X}_j \epsilon_{ikl} [[\dot{X}_k, \dot{X}_l], \dot{X}_j] \end{aligned} \quad (7.11)$$

$$\begin{aligned} \epsilon_{ijk} \nabla_j E_k &= \epsilon_{ijk} \frac{1}{\kappa} \left[(\ddot{X}_k - \epsilon_{klm} \dot{X}_l H_m), \dot{X}_j \right] \\ &= \frac{1}{\kappa} \epsilon_{ijk} [\dot{X}_j \ddot{X}_k] \cdot (-1) - \epsilon_{ijk} \epsilon_{klm} \epsilon_{mab} \frac{1}{2\kappa^2} [\dot{X}_l [\dot{X}_a, \dot{X}_b], \dot{X}_j] \\ &= -\frac{1}{\kappa} \epsilon_{ijk} [\dot{X}_j, \ddot{X}_k] \\ &\quad - (\delta^{il} \delta^{jm} - \delta^{im} \delta^{jl}) \epsilon_{mab} \frac{1}{2\kappa^2} ([\dot{X}_l, \dot{X}_j] [\dot{X}_a, \dot{X}_b] + \dot{X}_l [[\dot{X}_a, \dot{X}_b], \dot{X}_j]) \\ &= -\frac{1}{\kappa} \epsilon_{ijk} [\dot{X}_j \ddot{X}_k] + \frac{1}{2\kappa^2} \epsilon_{iab} X_j [[\dot{X}_a, \dot{X}_b], \dot{X}_j] \\ &\quad - \epsilon_{jab} \frac{1}{2\kappa^2} [\dot{X}_i, \dot{X}_j] [\dot{X}_a, \dot{X}_b] \end{aligned} \quad (7.12)$$

now

$$\begin{aligned} \epsilon_{jab} [\dot{X}_i, \dot{X}_j] [\dot{X}_a, \dot{X}_b] &= [\dot{X}_i, X_1] [X_2, X_3] \\ &+ [\dot{X}_i, \dot{X}_2] [\dot{X}_3, \dot{X}_1] + [\dot{X}_i, \dot{X}_3] [\dot{X}_1, \dot{X}_2] \end{aligned} \quad (7.13)$$

for $i = 1$, eg

$$= [\dot{X}_1, \dot{X}_2] [\dot{X}_3, \dot{X}_1] + [\dot{X}_1, \dot{X}_3] [\dot{X}_1, \dot{X}_2] = 0 \quad (7.14)$$

so

$$\begin{aligned} \epsilon_{ijk} \nabla_j E_k &= -\frac{1}{\kappa} \epsilon_{ijk} [\dot{X}_j, \ddot{X}_k] + \frac{1}{2\kappa^2} \epsilon_{iab} X_j [[\dot{X}_a, \dot{X}_b] \dot{X}_j] \\ &= -\frac{\partial H}{\partial t} \quad QED. \end{aligned} \quad (7.15)$$

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Physical Computation and Parallelism (Constructive Postmodern Physics)

Keith Bowden (25th August 1994, DRAFT 4.2)

Computer Centre, University of East London,
Longbridge Rd, Dagenham, Essex RM8 2AS, UK.

There is increasing evidence that information may be the basic stuff of the Universe. We consider this proposition in the light of Bohm and Hiley's Quantum Potential, the work of the ANPA group on the Combinatorial Hierarchy, and the Natural Philosophies of Gabriel Kron and Maurice Jessel. We compare and contrast the philosophical backgrounds of both these and the more conventional Copenhagen interpretation. In conclusion we suggest that our approach should be termed Constructive Postmodern Physics.

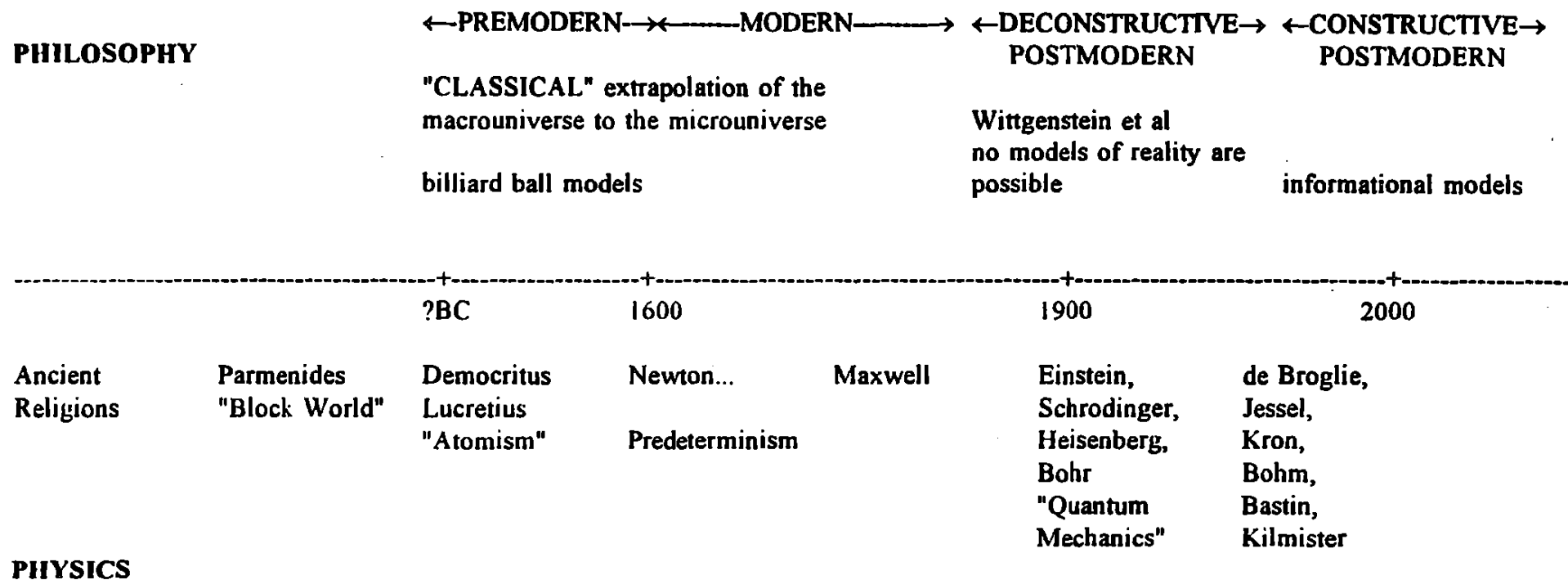
Philosophy is the study of physical paradigms, ethical paradigms and belief systems. It can be classified into four historical periods, ancient, pre-modern, modern and postmodern (Fig 1). It is remarkable the extent to which the prevalent underlying philosophy of a period influences and predates both ethics and physics. For instance it is well known that the Great Machine Theory of Newtonian mechanics coincided with the philosophy of predeterminism in the Roman Catholic Church. It is less well known that Bergson predicted, and encouraged the search for, indeterminacy in physics *from purely philosophical arguments*.

Philosophy began with the ancient religions, the ethical arguments of the Greeks and the block world of

Parmenides. The inadequacies of the latter led to the atomism of Democritus and the pre-modern period, followed by the great age of Western scientific discovery starting in the 17th Century with the mechanics and optics of Newton and culminating in the electromagnetic theory of Maxwell. The philosophical complacency and universality of the modern period was overturned by the discovery of quantum uncertainty and relativity and the Copenhagen Interpretation of Quantum Mechanics in the early part of the 20th century. Philosophy then bifurcated into two schools of thought.

Physics at the particle level shows peculiar nonNewtonian quantised behaviour. Quantum Mechanics is a set of procedures for predicting the evolution of these microscopic phenomena. It is not an ontology, or physical theory, explaining them. Various physical theories do exist. The conventional and generally accepted theory amongst the majority of laboratory physicists, educational establishments and the media, is the so called Copenhagen Interpretation of Quantum Mechanics. It essentially says that no (globally consistent) models of reality can be built. The world can only be described by locally consistent patches of theory which cannot be fitted together without global contradictions. Quantum Mechanics itself is not compatible with Relativity. Indeed Quantum Mechanics is not compatible with Newtonian Mechanics. These

Fig (I) Physics and Philosophy



problems are known as the measurement paradoxes of Quantum Mechanics.

This corresponds to the philosophical stance known as *Deconstructive Postmodernism*, initiated by Nietzsche, Heidegger, Wittgenstein (Logical Positivism), Derrida and others, that all phenomena are just surface phenomena and that there is no deep underlying reality (or, for Wittgenstein, that we have no means of finding out what it may be). Deconstructive postmodernism is all pervasive. Its influence can be seen in contemporary literature, music, art, science, law and politics. It has been seen by some as beneficially revolutionary, by others as dangerous in that it provides an excuse for the dismantling of constitutional systems on the grounds that there are no absolute truths.

The alternative philosophical stance is known as *Constructive Postmodernism* [Griffin, 1993]. It is appalled by a philosophy that allows built in contradictions. In Physics it was spearheaded by David Bohm in that he provided (in 1952) an ontological model (that is one which includes a "physical" explanation), called the Quantum Potential, that reproduced, exactly *all* of the statistical predictions of quantum theory, thus refuting a so called proof of von Neumann that this was impossible. (Von Neumann made assumptions about contextuality that were too strong.) Bohm's fascinating theory, although almost unknown to the general public, has never been proved wrong. We will say no more about it here except that **it is based on a purely informational field that does not necessarily decay with distance**. Constructive postmodernism accepts the incorrectness of the standard Newtonian model but not the impossibility of an alternative deep reality. Note that a third reaction to the failure of modernism is known as *Antimodernism* and was typified by the Luddites.

There are a number of different schools of constructive postmodernism, but like the Quantum Potential people, **they generally consider information to be fundamental**. Many of the founders of constructive postmodern philosophy, C S Pierce, William James, Bergson, Whitehead and Hartshorne, are panexperientialists, that is, like the strong AI people, they believe in the existence of the material world, but in order to do so require that all material objects have a degree of sentience or intelligence. (Contrast a "conventional" approach due to Roger Penrose at Oxford University (who is very strongly anti strong AI) who proposes a model called quantum gravity to resolve the measurement paradoxes of quantum mechanics.) An alternative view, taken by this author, by Pierre Noyes at SLAC, Mike Manthey at the University of Aalborg and others, is that all we actually know about is information (that is sense data, memory and imagination) and the communication of information. In this view of the world **there is no distinction between ontology and epistemology**, that is, what exists is what we know. On the surface this view does not seem too far from Wittgenstein's, however the difference is that he saw all questions of ontology as meaningless.

An extreme version of this view is solipsism, that until proven otherwise all one knows about is one's self and (maybe) our interaction with the outside world. This view is actually all that is necessary in order to undertake the analyses of Manthey, and Bastin and Kilmister, described below. Manthey's analysis results in the same group structure as particle physics. Bastin and Kilmister's work, a four level hierarchical structure related by four constants with very similar values to the dimensionless coupling constants of (Grand) Unified Field Theory. This is an important difference between Constructive Postmodern Physics and modern physics. Constructive Postmodern

Physics calculates fundamental numbers such as the coupling constants, the charge and mass ratios of the elementary particles etc. directly. Conventional physics only ever calculates numbers in terms of other (measured or calculated) numbers. It is really not a quantitative theory at all in this sense but only a qualitative theory. (At least it is relative rather than absolute.) Bastin and Kilmister's Process of Discovery is not only solipsist but also stoical in the sense that there is no element of causality, that is it is simply an analysis of the process of observation.

Many postmodernist physicists are members of a research group called ANPA based at Cambridge and Stanford Universities. The main program undertaken by these workers is to try to build a bridge between Information Theory and Physics. This work was initiated, in the 1940's, by Ted Bastin and Clive Kilmister who

decided that to get information from dimensional physical structures there must be a hierarchy of levels in which the elements of each new level is formed from the operators of the previous level. Together with Gordon Pask and John Amson they experimented with computer models. Later, the late Frederick Parker-Rhodes discovered the mathematics for these notions using binary algebra and a matrix mapping between levels. He came up with a simple, unique, four level, Boolean construction, now known as the Combinatorial Hierarchy, which has a number series, associated with the basis vectors, under exclusive-or, at each of the four levels of this Hierarchy, which takes the form 3, 10, 137, 1.7×10^{38} . This series gives the number of different ways that information can interact at each of the four different levels of the hierarchy. It takes very similar values to the four coupling constants of the Standard Model of Physics, which are

Fig (2) Two four-level information structures

(GRAND) UNIFIED FIELD THEORY

A four level informational structure.

Associated with the four levels are four dimensionless "empirical" numbers, called the *coupling constants*, taking the values $O(1)$, $O(1)$, 137 and 1.7×10^{38} .

The first two are related to the strengths of the weak and strong nuclear forces and the last two give the strengths of the electromagnetic and gravitational forces.

The strengths of these forces are believed to be given by the number of different ways their associated "messenger particles" can interact. Following Eddington, Pierre Noyes has defined a particle as a "conceptual carrier of information (conserved quantum numbers) between events (collisions)".

COMBINATORIAL HIERARCHY

A four level informational structure. It is unique and minimal.

Associated with the four levels are four numbers taking the values 3, 10, 137 and 1.7×10^{38} .

The hierarchy is based on the "exclusive-or" operator, $\oplus$ on bit strings. Exclusive-or can be shown to be the unique comparison operator on bit strings.

These numbers give the number of different ways that entities at each level of the hierarchy can interact.

The entities concerned are bit strings which have been associated with the process of observation by Bastin and Kilmister.

believed to give *the number of different ways* that particles can interact at each of the four levels of the theory (weak nuclear, strong nuclear, electromagnetic and gravitational). The number of different modes of interaction is considered to be responsible for the strengths of the corresponding fields (Fig 2). In his two books Parker-Rhodes developed an ontological theory of the universe based on information theory. Unfortunately much of this is very obscure.

In their forthcoming book, Ted Bastin and Clive Kilmister are attempting to bridge this same gap by looking at Physics as a process of discovery or innovation. From this they construct the Hierarchy and relate it to Physics with a much greater degree of clarity than Parker-Rhodes achieved. Pierre Noyes (Stanford) is trying to directly relate particle physics to bit string algebra. Following the work of Sir Arthur Eddington who, even before Parker-Rhodes, was addressing the same issues, Noyes defines a particle as "**a conceptual carrier of information** (conserved quantum numbers) between events (or collisions)". This, he claims, is all we can ever know about a particle. Anything else is metaphor or speculation or religion. Thus we see the beginnings of a Physics based upon a theory of local parallel processing with the speed of light as the maximum velocity of information propagation.

My colleague Peter Marcer was very much influenced by the work of the late Maurice Jessel, a doctoral student of the physicist Louis de Broglie in the sixties in Paris. (de Broglie is famous for wave-particle duality and the pilot wave theory which led directly to David Bohm's Quantum Potential.) Jessel was interested in holography but was persuaded by de Broglie to go back to first principles and derive a more general theory. Jessel went all the way back to the pioneering work on light

propagation of Christian Huygens in the seventeenth century, the beginning of the modern period as defined earlier. Translating some of Huygens' material from the original old Dutch, Jessel found that modern interpretations of Huygens' work were not at the time all that accurate. Jessel restated Huygens Principle thus "The perturbation that goes out through a closed surface S that contains a wave (or field) source is identical to the perturbation that can be obtained by cutting off the source and replacing it by appropriate sources distributed on the surface S " (Fig 3). He further developed this as a mathematical formula from which he found that he could not only rederive Gabor's work on holography but also some exciting new results indicating amongst other things that it should be possible to produce a wave field to cancel any given field in real time. Thus active acoustic attenuation or even "black light" should be possible.

Marcer was struck by the fact that Huygens' Principle, although considered to be part of Physics, described the **evolution only of information**. He strongly believed that there should be a connection between this local parallel computational process and the Boolean exclusive-or operation defined by the Combinatorial Hierarchy. He coined the phrase "Huygens' Machine" to describe such a system. He was, about this time, (1985) introduced to my work on Kron's Method of Tearing by the journalist Tony Durham, and noticed the strong resemblance to a theory of General Systems he was developing with a King's College based research group that included Maurice Jessel. Peter also introduced me to ANPA where I presented a paper I had written which was inspired by Peter's observation.

Gabriel Kron's Method of Tearing or Diakoptics, as he called it, is both a computational technique and a Natural Philosophy. It has been rediscovered recently by the

FIG (3) Huygens Principle

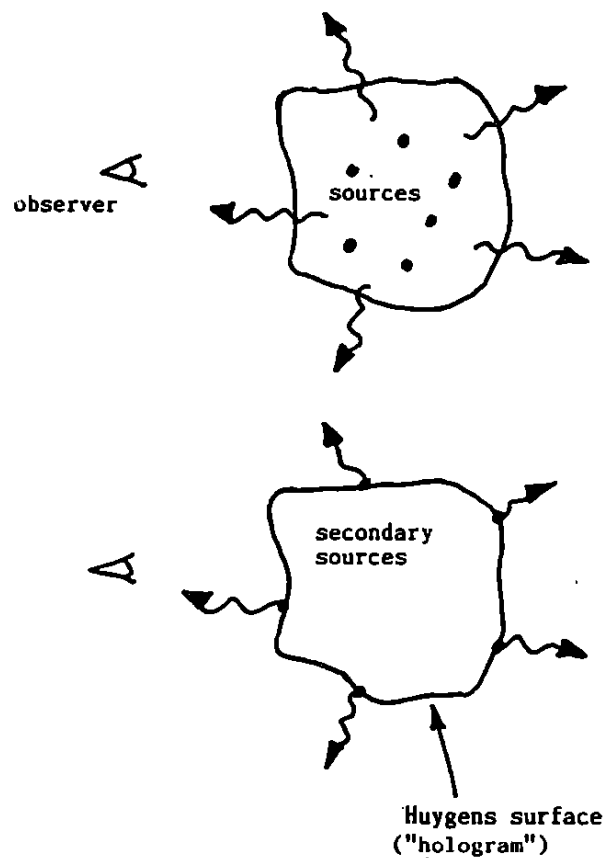


FIG (4) Kron's method

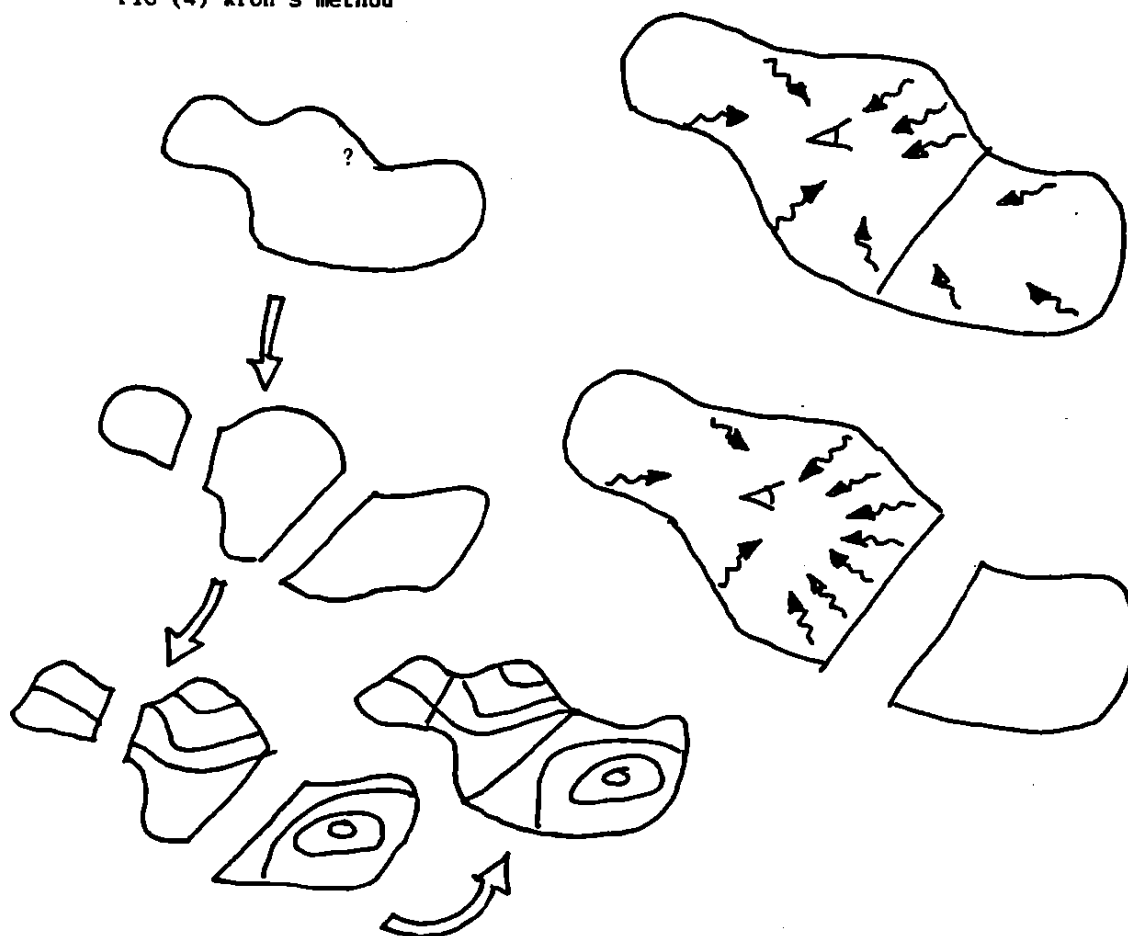
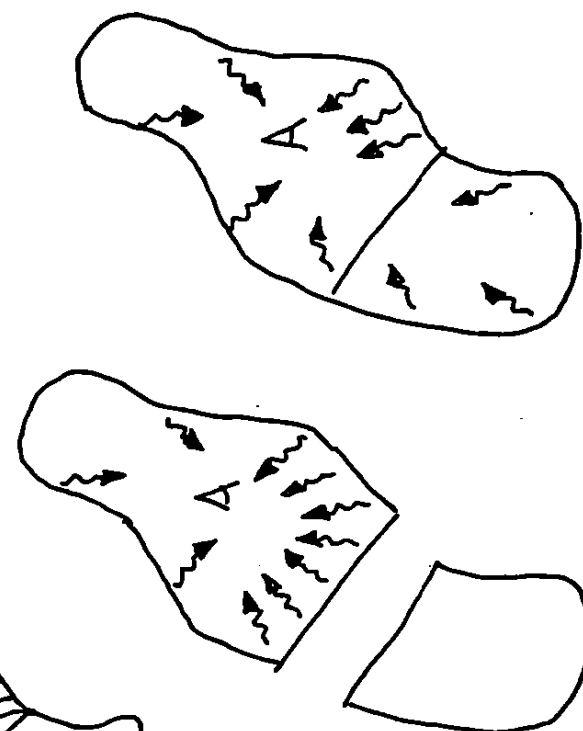


FIG (5) Kron's Method from Huygens' Principle



parallel processing community where it goes under the name of "domain decomposition". It is a technique of taking a physical problem, splitting it up topologically into subproblems, solving each subproblem, and then recombining the subsolutions into an exact overall solution. Even on a single sequential processor this method of solution is very much faster than classical approaches (such as matrix inversion). It is ideal for parallel processing in that each subproblem can be solved in parallel on a different processor. It is unique among decomposition techniques in that the extra information - the correction - needed to make the combined solution an exact one, is obtained from the "intersection layer" or boundary between the subproblems (Fig 4). As in Bohm's holomovement, information about every part of the system is stored everywhere. Kron was undoubtedly searching for an ontology of Engineering.

In the fifties, when Kron's ideas were first introduced, controversy raged over their validity. Clive Kilmister remembers arguments in the meetings of the British Society for the Philosophy of Science. Eventually the issue was resolved in the mid sixties when Sun Ichi Amari, then a student at Tokyo University produced a proof of the correctness of Kron's Method based on some ideas of the mathematician J Paul Roth in Homology Theory or Algebraic Topology. The basic tool of homology theory is the *exact sequence*, a sequence of mappings called boundary operators, between successively higher dimensional spaces. The idea is that the boundary of a boundary is zero. Roth took the unusual approach of defining a *twisted isomorphism* between two dual exact sequences. Homology theory is *difficult*; later, in the seventies, my doctoral supervisor, Harry Nicholson at Sheffield, produced a simpler analysis based on *scattering theory*. Scattering is defined as a collision of two

informational processes.

My first contribution to all this was to produce a third derivation of Kron's Method based on Jessel's formulation of Huygens' Principle. Imagine Jessel's scenario inside out (Fig 5). The area of interest is surrounded by a set of sources representing the boundary conditions of a problem. Then that set of sources can be replaced by a set of sources on a smaller boundary within the original one and we have torn the problem into two subproblems separated by an internal boundary or intersection layer. The information distribution on this internal boundary is then a hologram of the original source distribution. The technique can be applied again in order to reduce the problem still further.

My second contribution was to derive a hierarchical version of Kron's method and to show that the information flow within this system is (in a sense) optimal and that it is the computational equivalent of a physical paradigm called the *holomovement* due to David Bohm. The holomovement is a very general idea that has the quantum potential as a special case. Information about every event in the universe is holographically enfolded within the fields at every other point in the universe. Hierarchical tearing gives a vivid visual picture of this. The problem with Kron's method is that, for very big problems, tearing the system up into too many pieces increases the size of the total subsystem boundaries, or intersection layer, to a size where its solution becomes more computationally intense than that of the subsystems. My solution to this problem was to tear the original system up into a small number of subsystems and then to tear the subsystems up into subsystems and so on, recursively. The size of the intersection layer at any level of tearing is then relatively small. It turns out that for real problems there is an optimal depth of tearing.

The major problem with classical matrix inversion of large problems on modern fast processors is not computation time but storage of the matrix inverse. The original matrix may be sparse but the inverse in general is not. In the hierarchical tearing algorithm normal matrix multiplication is replaced by a function. Matrix inversion is then replaced by an inverse function which is recursively defined in terms of a set of similar "smaller" functions. The leaves of this tree involve real matrix multiplication by a set of small (typically five by five) matrices. The total storage required is of a similar order to that for the original matrix.

My current work, like that of most of the others involved, involves trying to cross the bridge between Information Theory and Physics. In particular to try to make more clear what it is that Peter Marcer refers to as a Huygens' Machine. Note that I am not talking about the Information Theory of Shannon and Weaver here. Their's was a theory of communication. As a number of people have observed recently there isn't yet a coherent theory of information. Similarly, Brian May of Inmos recently pointed out that there is no paradigm for parallel processing equivalent to that of the Turing Machine. If I can cross the particular bridge that I'm aiming for I will be able to identify Jessel's formulation of Huygens' Principle, or maybe a further generalisation of it, as a paradigm for Parallel Processing. Huygens' Principle is adept at elevating interesting concepts in Physics. It is possible that there could be some exciting implications for parallel processing but we shall see. Further, I will have to start with a suitable definition of information.

I am attempting to analyse a system in which all that is assumed is that one is communicating with a set of other entities. This analysis will immediately apply to a set of interconnected parallel processors. Huygens' Principle

must apply to the information crossing the boundary around any connected subset of the processors. The "sources" to which it will apply consist of the set of data within the memory of the processors in the subset, at the start of the analysis, plus any subsequent data input interactively in the duration. Clive Kilmister has suggested looking at the homology of the system. Scattering theory may equally be relevant. Any analysis of solipsism will also be applicable to each of the individual entities. Thus each entity is undertaking Bastin and Kilmister's process of discovery and I can immediately import the Combinatorial Hierarchy. In Manthey's approach each entity is accepting "co-occurring" input from (and sending output to) a number of asynchronous information streams. It is this, combined with a mutual exclusion on certain events, that leads to the quantum mechanical group structure (Clifford algebra) mentioned above. This analysis must also be relevant.

The crucial building block needed to proceed with this work is a definition of information. These seem to fall into two camps. The first consists of "Computer Sciencey" definitions typified by Parker-Rhodes definition of the information content of a statement as "the number of yes/no questions" needed to arrive there. This is a context dependent or relative definition, of what I would prefer to refer to as *knowledge*. Thus it also describes *new* information, and is what must be described by Bastin and Kilmister's Process of Discovery. The second camp, due to Stonier and Scarrot, defines (absolute) information as that which is contained within the structure of an organised system. An organised system is defined recursively and hierarchically in terms of a set of other organised systems. This clearly defines that which is described in David Bohm's holomovement (he referred to "active information") or the hierarchical version of Gabriel

Kron's natural philosophy. All data, whether information or knowledge or garbage, is measured in *bits*. Thus we have transformed the job of building a bridge between the classical or general systems approach to Physics and the Information Theory approach, to a bridge between two kinds of information. In this model time and space are requirements of communication and information respectively.

I believe we are reaching the end of the deconstructive postmodern period and are about to enter an age of constructive postmodern philosophy. Natural laws of all sorts, scientific, political and artistic, will be rebuilt based on rules about information, observation and knowledge. We will no longer think of a billiard ball world but an information age in a very fundamental sense. Not only will Information Theory tell us much about our knowledge of the world but Physics will teach us new things about how to build computers. For instance it is known that there are only two means of sending information through space without distortion. One relies on waves generated by Huygens' operators in a linear medium. It can be shown that this is only possible in even dimensional space-times with dimension greater than three. The other relies on stable particle-like pulses called solitons travelling in a nonlinear medium. Light soliton transmission through optical fibres the equivalent of 12,000 miles long, without a repeater, has recently been demonstrated. (Light) solitons also have the property that they can pass through each other with no effect other than a phase change. This provides the means for a simple computational element. Gabriel Kron in the sixties did some work on what he called a Crystal Computer. Light solitons in crystals may provide the basis for his dream to come true.

Acknowledgements

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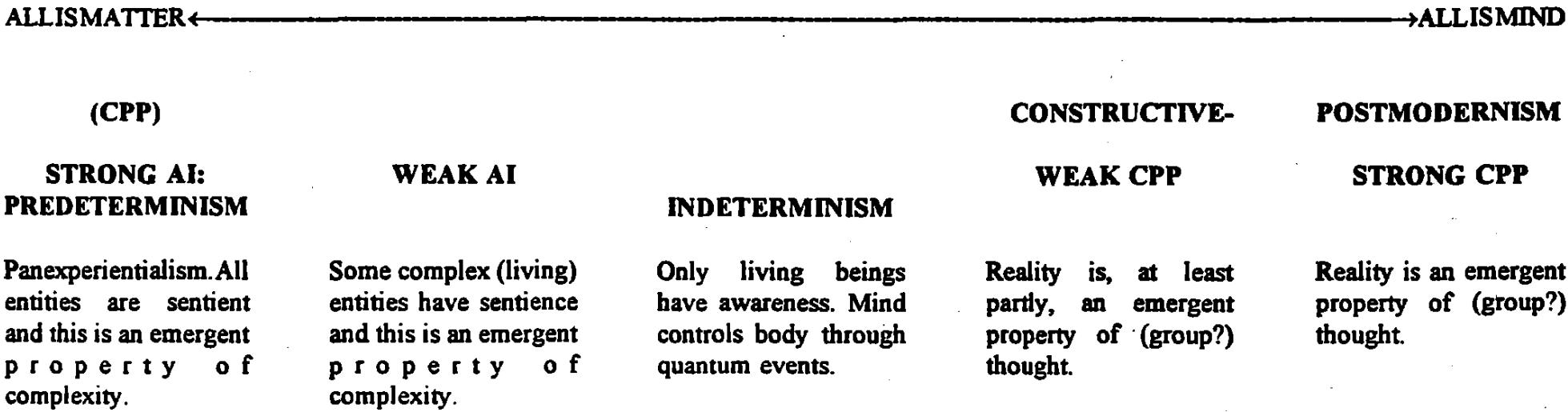
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Fig (4) Cartesian Spectrum



Alternatives: Proceedings of ANPA16

BOOLEAN GEOMETRY and NON-BOOLEAN CHANGE, PART I.

by Tom Etter
112 Blackburn Ave.
Menlo Park, CA 94025, USA
E-mail: tometter@aol.com
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ABSTRACT.

Von Neumann showed that quantum observables with eigenvalues 0 and 1 can be interpreted as propositions about the outcome of measurement. When two such observables commute, their product as operators is their conjunction as propositions, i.e. PQ means $(P \text{ AND } Q)$. However, since $(P \text{ AND } Q) \neq (Q \text{ AND } P)$, this cannot be true if P and Q don't commute. For such propositions, von Neumann defined AND in a new way, which led to new non-Boolean laws for AND, OR and NOT; the resulting non-Boolean "logic" was called *quantum logic*.

Quantum logic was a dismal flop, and is all but forgotten today. But the logical issues raised by von Neumann's deep insight into the meaning of eigenvalues 0 and 1 are as alive today as ever. What are we to make of propositions that don't commute? To put it another way, why is it that sometimes we can't say "P and Q", taking "and" in its usual sense? Though these question arose in physics, they don't *belong* to physics; they're not about matter in motion but about *propositions*.

Non-commuting quantum propositions are always asserted from different "viewpoints", i.e. their eigenvectors belong to different bases in Hilbert space. When we can't say "P and Q", it's because P is true or false *here*, while Q can only be true or false after we move to *there*. Taken at face value, this tells us not that Boolean logic is wrong but that it is *relative*. "AND" only jumps the Boolean track when we move our logical vantage point. The adjective "non-Boolean" is misapplied to logic – what it really applies to is *change*!

What, if anything, is invariant under non-Boolean change? In the present paper I explore the thesis that, however we may *experience* this constancy, mathematically speaking it is the *connectivity* of the Boolean lattice stripped of its arrows. This mathematical structure, which I call *Boole space*, is isomorphic to the undirected edge graph of the Euclidean hypercube. Given Pascal's logical definition of probability as the number of favorable cases divided by the total number of cases, this weakening of Boolean algebra to Boolean geometry turns out to be mathematically

equivalent to generalizing probability so that it can go negative as well as positive. The result is a hidden variable theory that specializes to quantum mechanics as a simple large-number case. Of course the hidden variables here are highly non-classical; their invisibility is not just de-facto but *logical*, and they are not only hidden from the classical observer but from each other!

Part I will concentrate on the mathematics of Boolean geometry while part II will develop the concept of amplitude and show how it specializes to quantum mechanics.

CHAPTER 1. ILLOGIC, PRE-LOGIC and LOGIC.

Early in the twentieth century, at a time when scientific idols were toppling right and left, even logic itself began to totter. "If Euclidean geometry has fallen, which according to Kant is so built into human reason that it's humanly impossible to rationally doubt it, then why is Boolean logic still standing?" So asked the spirit of the times, and so asked von Neumann when in the 1930's, in trying to clarify Bohr's notion of complementarity, he proposed his so-called *quantum logic*.

Quantum logic at first attracted an enthusiastic and distinguished following. But, some 60 lackluster years later, even its best-known advocate has declared it to be a flop. Why did quantum logic fail? There were no mistakes in von Neumann's mathematics, but it turned out to be strangely sterile. It produced not a single empirical prediction, and wasn't even helpful in making calculations. Not surprisingly, most physicists have turned away from logic altogether.

This is unfortunate. The powerful winds of change that were felt by pioneers like Bohr and Pauli were not just about calculating the radiation spectra of atoms. The really new thing in quantum mechanics is a very general idea, *superposition*, and superposition makes sense in any context whatsoever that presents us with a range of alternatives, never mind alternatives for what. Physicists, though they may claim to disdain logic, make unabashed use of this generality. For instance, they assume without hesitation that it makes sense to speak of the superposition of alternative topologies. But what would you call the theory that tells them they can do that? I don't know its name, but I'd certainly call it some kind of logic.

Among those of us who still do call it some kind of logic, the common wisdom is that we must continue the search for alternatives to Boolean logic. I believe that this is wrong and that the common wisdom here has overlooked the obvious.

There's nothing at all odd or non-Boolean about logic in quantum mechanics so long as we stay within a context where one measurement doesn't disturb another, i.e. within a single set of commuting observables. We can also freely move our ordinary Boolean logic to any other such context. It's only when we try to combine statements from different contexts that problems arise. *Context sensitivity* is of course very familiar in everyday life – think of statements about left and right. What the quantum logicians seem to have overlooked is the possibility that it's the context sensitivity of logic that is causing all the trouble. Why do we need a new kind of logic? Perhaps ordinary logic is not wrong, but just relative!

How do we explore this hypothesis? The approach that works well for spatial relativity is to start with relative descriptions and extract from them a certain absolute or *invariant* part. For instance, you can start with "X is to the left of Y and Y is to the left of Z" and extract the weaker invariant statement "Y is between X and Z", a statement that remains true under reversal of left and right. That's close to the sort of thing we're going to do here. However, in one respect our enterprise has no precedent. In all pre-quantum theories of relativity the job has been to find a system of invariant *statements*. But we are looking for something a little different, which is an invariant way to *logically combine* statements.

Actually, the same thing could be said about von Neumann's quantum logic. How the present approach diverges from quantum logic, to put it in a nutshell, is that it does not seek a *competitor* to Boolean logic with *different* laws, but an *objectification* of Boolean logic with *weaker* laws. I shall call the first *illogic*, the second *pre-logic*.

The particular pre-logic that I shall describe here is what I call Boolean geometry. Von Neumann compared his non-Boolean logic to non-Euclidean geometry. By way of contrast, the present approach can be more accurately compared to Euclidean geometry. To see what this means, let's indulge in a fantasy.

Imagine that it was not Euclid but Descartes who in 300 BC invented the definitive mathematics of space. Since Descartes was an egocentric

CHAPTER 2. BOOLEAN LOGIC.

2.1. Boolean algebras.

In this paper I will be treating Boolean geometry as something abstracted from Boolean algebra; as mentioned, this is like treating Euclidean geometry as something abstracted from a system of Cartesian coordinates. For space it seems more natural to go the other way, since our everyday experience of space involves a constantly moving origin. But for logic, I don't see how we can go the other way. What *is* our everyday experience of a moving Boolean origin, of a moving *nothingness*?

This is actually a fascinating question, and one that can start you reflecting about all sorts of things: creation and annihilation, virtuality, Bergson's duration, the Hegelian dialectic between being and not-being, Jacob Boehme's un-ground, Heraclitus vs. Parmenides – there's a call of the wild here that echos down through the ages.

Unfortunately we haven't yet found the concepts that can connect this kind of speculative reflection to empirical science, and so I believe it's better to begin with concepts that have securely made this connection, namely with AND, OR and NOT. In this chapter I shall set the stage for Boolean geometry by reviewing some familiar aspects of Boolean algebra and introducing some others that may not be so familiar.

A Boolean algebra is a collection of objects, its *elements*, on which there are certain operators AND, OR, NOT etc. that satisfy certain rules. It's usual to introduce these rules by means of certain axioms. That would be irrelevant here, though, since we are only concerned with finite Boolean algebras, and the mathematical structure of a finite Boolean algebra is quite transparent to common sense; it is simply the structure of the set of all subsets of a finite set. We will use this fact to freely go back and forth between logical and set-theoretic terminology, which will make it easier to visualize some of our new concepts. Let's remind ourselves of how the two kinds of terminology correspond:

The INTERSECTION of x and y is the subset of all things that are both in x AND in y . We'll abbreviate INTERSECTION / AND by "&".

The UNION of x and y is the set of all things that are either in x OR in y .

fellow, Cartesian geometry was centered on his own person, and all points of space were designated by their distance from his navel taken in three directions: left/right, front/ back, and above/below. This was a wonderfully practical system when Descartes was sedentary, but it got a bit confusing when he was moving about. The problem seemed to be solved by his death, but grave robbers kept reviving it. Nevertheless, the system persisted for almost two thousand years until Euclid came up with his great theory of *relativity*. This theory solved once and for all the problem of Descartes' peregrinations by completely doing away with the idea of a Cartesian center, putting a Cartesian clone at every point of space! Note that Euclid's is not an alternative geometry. It doesn't contradict the viewpoint of the wandering Descartes, but *weakens* it by abstracting only what it shares with its clones.

For Descartes substitute Boole. Our new logical geometry is to Boolean algebra what Euclidean geometry is to Cartesian geometry. Indeed, as we shall see, a Boolean logic is literally a *coordinate system* on a Boolean geometry. Starting with Boolean logic, we can define Boolean geometry as the invariant structure under a new group of transformations that *translate* the Boolean origin (Boolean 0). In geometry a translation is a congruence transformation that takes lines into parallel lines. We shall define the concept of *parallel* in Boolean algebra by saying that the line x,y is parallel to the line x',y' iff $(x \text{ XOR } y) = (x' \text{ XOR } y')$, where XOR is exclusive OR. Given this definition, we can move the concept of geometric translation into logic word-for-word! All this will become clear in chapters 3 and 4; for now I just want to stress again how different Boolean geometry is from quantum logic, whose symmetry group bears an entirely different relationship to Boolean algebra.

To summarize: The laws of logic are not wrong. Indeed, without these laws, these *Boolean* laws, it would make no sense to speak of laws of any kind. The problem is that we have been using Boolean logic too *egocentrically*. It is only after we become aware that there is more than one Boolean viewpoint and begin to study *transformations* of viewpoint that the fundamental meaning of quantum superposition becomes clear.

This may sound like a soothing message: there's a technical fix for all this weird logic stuff that turns it into science as usual. However, let me end here with a word of warning: *When you mess around with logic, you mess around with how you think!* Lobotomy may be a routine procedure for a brain surgeon, *but not when he performs it on himself!*

We'll abbreviate UNION / OR by " $\vee$ ".

The COMPLEMENT of x is the set of all things that are NOT in x . We'll abbreviate COMPLEMENT by " $\neg$ ".

Most of the time we'll be dealing with Boolean algebras whose elements are subsets of some explicitly given finite set S . The members of S are called the *atoms* of that Boolean algebra, and the number of these atoms is called the *dimension* of the Boolean algebra. Here, as in everyday life, we won't distinguish a set with one member from that member itself, so atoms, as one-member subsets of S , are also elements of the Boolean algebra. S itself is of course an element; it's called the *universal* element and is abbreviated 1. The null set is also an element, abbreviated 0.

2.2. Boolean logics.

A Boolean *logic*, as I shall be using the term, is defined as the Boolean algebra of subsets of a set S of mutually exclusive possibilities, i.e. of *cases*. Think of S as a *menu*. It's usual in the restaurant business to number the items in a menu so we can *point* to them by their indices: "Hey, one #5 special coming up!" Let i be a menu index that ranges, say, from 1 to 10. Let S be the set of all items on the menu. Then, roughly speaking, the Boolean logic of S is the set of all the things we can say about i , for instance " $i > 3$ ".

This last statement needs to be carefully qualified. Taken out of context, " $i > 3$ " could mean almost anything. It could be about the ratio of the circumference to the diameter of a circle, or about the number of dimensions of space-time, or it could tell us that the customer is not ordering Hamburger Supreme or Heavenly Chicken or Fisherman's Delight. To discriminate among these possible messages, we must first know the answers to two questions: What values does i take? and what alternatives do these values point to? Given this essential background, it makes sense to ask what *information* does " $i > 3$ " supply?

The elements of a Boolean logic are often represented by sentences or sets of indices, but what they are is *items of information*, taking that term in Shannon's sense as the narrowing of a range of possibilities. My use of the word "logic", which is also von Neumann's, is rather different from what you find in most textbooks on logic, which are largely concerned with

formalizing the science of inference. Logic in this textbook sense has almost nothing to do with our present subject matter, and a case could be made for our using some other term such as "Boolean informational structure". However, "logic" is a pretty flexible word, spanning the gamut from Hegel's dialectic to logic gates, and since von Neumann's use of it has already taken root in the foundations of physics community, we'll stick with "Boolean logics".

To recapitulate: An *item of information* is defined as a selected subset of a fixed set C of cases. A *Boolean logic* is defined as the set of all items of information on C structured by the set operators INTERSECTION, UNION and COMPLEMENT etc.

2.3. Projections.

Information has another aspect which is not captured by Shannon's definition: It *accumulates*, and as it accumulates, the act of *acquiring* each new item of information alters all the others. Consider our example of the item $i > 3$. Taken by itself, this places i in the range 4,5,6,7,8,9,10. But suppose we had already learned that $i < 8$. Then in Shannon's terms, $i > 3$ is a different item of information, since now it confines i to the range 4,5,6,7 against a background of an S that includes only the first eight members of the original S .

To put it another way, an item of information is not just a subset, it is an *operator* on its Boolean logic. The item of information p , as an operator, takes every element x into $p \& x$. We'll adopt the convention of using capital letters for operators and small letters for their operands, so we can write this as $P(x) = p \& x$. P is a *projection* operator in the sense that it is idempotent ($PP = P$) and it preserves a certain algebraic structure – we'll see just what this structure is later. This projective character of information is important to us here for two interrelated reasons: First, it tells us something about why propositions are represented by projections in quantum mechanics, and second, it makes it possible to extend the definition of information so that it still makes sense in Boolean geometry, as we'll see in Chapter 3.

In everything we do we make in one way or another an important distinction between information of two kinds: first there is information that applies only to a particular occasion or event, and then there is information that applies to a whole group of occasions, or is a fixed aspect of a

changing object. There are many different words for this contrast. In natural science we speak of data vs. regularities, of boundary conditions vs. laws. In computer science it's input and memory vs. program. In everyday life we have events vs. rules, activity vs. condition or status, accident vs. order etc. The concept of "state" straddles the boundary; a state is something that tends to persist unless it is "forced" or "induced" to change by something outside of itself.

The concept of projection most naturally applies to the second kind of information. Typically when we encounter an object we imagine a large range of nominal possibilities for it, most of which are not realistic. Narrowing down this nominal set S to a realistic set C is the kind of information that we call a *principle*. Since a new item of data is most commonly expressed in terms of S , it can be very useful to understand how a principle projects data onto C , since this tells us something about how changing data bears on the state of the object as a whole. Indeed, understanding such a projection is just what we ordinarily mean when we say we *understand the principle* of the thing. We'll pick up this train of thought again in section 7.

2.4. The Boolean lattice.

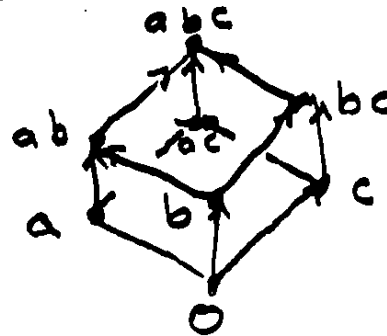
There are a number of ways to characterize the structure of a finite Boolean algebra. We've done it here by giving that structure a canonical representation, so-to-speak, as the set of all subsets of a finite set. A useful variation on this is to identify the Boolean elements with bit strings which represent the characteristic functions on these subsets. There is a third quite different kind of representation, though, which is important for studying Boolean geometry, and that is the *Boolean lattice*.

Thinking of the Boolean elements as sets, the Boolean lattice is the partial ordering of these sets by inclusion. We'll write this relation as $x < y$, meaning that every element of x is an element of y . In logic, if all x 's are y 's we say that x *implies* y , so the logical name for $<$ is *implication*. We must be careful not to confuse this relation of implication with the Boolean operator $\neg x \vee y$ which is sometimes called *material implication*. The two are closely related, though, since $x < y$ iff $\neg x \vee y = 1$. Also we must not confuse it with the concept of deducibility, which is a metaconcept that occurs in the study of formal languages.

Here is a picture of the relation $>$ for a 3-atom Boolean logic; $x < y$ if

you can follow the arrows from x to y .

Fig 2.4.1
The 3-atom
Boolean Lattice



Note that we can define inclusion in terms of $\&$: x is included in y means that x is the intersection of x and y . We can also go backwards from $<$ to $\&$: The intersection of x and y is the largest set included in both x and y , i.e. the g.l.b. (greatest lower bound) of x and y under the partial ordering $<$.

A less obvious fact is that we can define NOT in terms of $<$. First we define 0 as the element that is included in all others; 0 is of course the null set. Next, we define " x and y are disjoint" to mean that $x \& y = 0$ (recall that we have already seen how to define $\&$ in terms of $<$). Finally we define $\bar{x}$ to be the element that is disjoint from x and that includes every other element that is disjoint from x ; clearly $\bar{x}$ is the complement of x . (This last step only works for Boolean lattices. In non-Boolean lattices like quantum logic, there is more than one maximal disjoint element, and to define negation requires additional structure.)

Here's something that may come as a surprise. We've seen that we can define $>$ in terms of AND, and NOT in terms of $<$, but this means that we can define NOT in terms of AND! Sounds impossible? That's because we're used to *algebraically generating* the other Boolean operators from AND and NOT, and we know it can't be done with AND alone. What we've done above, though, is something quite different, which is to define NOT as an aspect of the whole structure of the AND operator.

To summarize: The Boolean lattice is a partial ordering of the elements of a Boolean algebra in terms of which all of the Boolean operators can be defined, and conversely, which itself can be defined in terms of the Boolean operators; it is thus equivalent to Boolean algebra in the sense that it characterizes the same abstract structure.

2.5. The Boolean graph.

In fig. 2.4.1 the Boolean lattice is pictured as an oriented graph, where $x < y$ means you can follow a path of arrows from x to y . Let's now look at this graph as a relation in its own right, which we'll call arrow. We'll write $x \rightarrow y$ to mean that there's an arrow from x to y . In the language of sets, $x \rightarrow y$ says that y is the result of adding another member to x . We can define $x \rightarrow y$ in terms of $<$ to mean that $x < y$ and there's nothing in between, i.e. for any z such that $x < z$ and $z < y$, either $z = x$ or $z = y$. Conversely, we can define $<$ as the *ancestral* of arrow, i.e. the smallest transitive relation containing arrow – just what this fancy language means becomes pretty obvious when you look at the picture.

Since we can use it to define the Boolean lattice, the Boolean graph is another way to give the structure of a Boolean algebra. But far more important, it immediately leads to a simple definition of the basic object in Boolean geometry:

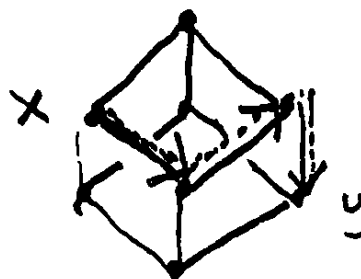
Boole space: The un-oriented graph that results from stripping a Boolean graph of its arrows.

We'll leave the arrows in place for the rest of this chapter, but we'll concentrate on those concepts that still remain important after we remove them. One of these is the concept of a path, which is a series of steps in the Boolean graph.

Step: An ordered pair of elements x, y such that either $x \rightarrow y$ or $y \rightarrow x$; in the first case we call it a step up or a positive step, in the second, a step down or a negative step.

Path: A sequence of elements whose adjacent pairs are steps. A path from x to y will be notated $x..y$. Here's a path in the three-atom graph, shown by the dotted line:

Fig 2.5.1
Path from
 x to y



By the *length* of a path we mean the number of steps in it. A

geodesic is defined as a path from x to y of minimum length, and this length is called the *Boolean distance* between x and y . It's easy to see that Boolean distance is a metric in the sense that $D(x,x) = 0$, $D(x,y) = D(y,x)$, and it satisfies the triangle inequality. Giving this metric is another way to define Boole space, and in fact that's how we will start off defining it in chapter 3. Here is an important theorem: The Boolean metric $D(x,y)$ together with the Boolean origin 0 determine the structure of Boolean algebra. This will be proved in Ch. 4.

A step up adds a new member to an element, while a step down removes a member. Thus if a path starts from 0 , we can determine the cardinality of its endpoint by taking the number of steps up and subtracting the number of steps down. In the language of finance, the net gain for someone traversing a certain path is his income along the way minus his outgo. It may help us remember what we are doing to use such words as technical terms:

Income: The number of positive steps in a path.

Outgo: The number of negative steps in a path.

Net gain: Income minus Outgo, abbreviated $\text{net}(x..y)$

Theorem: The net gain of any path $x..y$ from x to y is the cardinality of y minus the cardinality of x . More briefly, $\text{net}(x..y) = \text{card}(y) - \text{card}(x)$

Proof: We've seen that $\text{net}(0..x) = \text{card}(x)$ and $\text{net}(0..y) = \text{card}(y)$. Now consider a path $0..y$ from 0 to y which results from splicing $x..y$ onto the end of any path $0..x$ from 0 to x . Clearly the net of a path is the sum of the nets of its consecutive parts, so $\text{net}(0..y) = \text{net}(0..x) + \text{net}(x..y)$ and hence $\text{card}(y) = \text{card}(x) + \text{net}(x..y)$, i.e. $\text{net}(x..y) = \text{card}(y) - \text{card}(x)$. QED.

Definition: This theorem shows that we can write $\text{net}(x,y)$ for $\text{net}(x..y)$.

We'll say that a path is *ascending* if all its steps are positive, *descending* if they are all negative. A path that is either ascending or descending will be called *monotone*. A monotone path is always a geodesic. A geodesic needn't be monotone, however, unless it starts from 0 . The geodesics from 0 have a special place in Boolean algebra, since their lengths are the cardinalities of their upper endpoints.

2.6. Probability.

The above discussion of paths has been part of our preparation for a definition of amplitude modelled on Pascalian probability. Recall that Pascal defined probability as the number of favorable cases divided by the total number of cases. In our current terminology, the probability of x is $\text{card}(x)/\text{card}(1)$. In the language of graphs it's the net gain from 0 to x over the net gain from 0 to 1, and it's also the distance from 0 to x over the distance from 0 to 1. This last statement is purely geometric except for singling out a point called 0, so let's adopt it as the definition of probability.

Probability: $\text{prob}(x) = D(x,0) / D_{\max}$, where $D_{\max}$ is the greatest distance between any two points. (note that $D_{\max}$ is $D(1,0)$, which shows that 1 is the unique *antipode* of 0. $D_{\max}$ is also what we called the dimension of the Boolean algebra, and it will turn out literally to be the dimension of the corresponding Boole space.

Pascal's definition of probability is a purely logical definition, and in fact it has its uses in logic proper. Perhaps the most important of these is to give us an easy way to define what it means for two items of information to be logically separate or *independent*:

x is *independent* of y means that $\text{prob}(x \& y) = \text{prob}(x)\text{prob}(y)$.

We'll see in a little while how to define independence in terms of Boolean factorization. The concept of independence is of course one of the cornerstones of science as we know it. Will it still make sense after we geometrize logic? Will science as we know it still be possible? To find out, tune in again in chapter 4.

2.7. Sublogics, factors and independence.

Generally speaking, a *sub-structure* of a mathematical structure is a subset of its elements together with the operators and relations that define the structure of the whole. Here is the basic Boolean sub-structure:

Subalgebra: A subset of a Boolean algebra closed under AND and NOT.

Theorem 2.7.1: The atoms of a subalgebra form a partition of the atoms of the algebra.

Proof: Let B_1 be a subalgebra of B . If B_1 includes x and y , it includes $\neg x$ and $x \& y$. Therefore it includes $0 = x \& \neg x$ and $1 = x \vee \neg x$ and $x - y = x \& \neg y$. Suppose x and y are atoms of B_1 . Then x and y must be disjoint, for otherwise one of $x \& y$ or $x - y$ or $y - x$ would be smaller than either x or y , contradicting the assumption that x and y are atoms. A similar train of reasoning shows that every element of B_1 is a union of atoms of B_1 . But since 1 is an element of B_1 , we conclude that every atom of B is in some atom of B_1 . QED.

Sublogic: A subalgebra of a logic.

If the state of a (classical) physical object is described by several variables, each of these variables ranges over the case set of a sublogic of the state logic. More generally, any exhaustive set of mutually exclusive properties of the state defines a sublogic. The relationship of sublogic to logic captures much of what in everyday life we think of as the relationship of part to whole.

Since Boolean lattices, Boolean graphs, Boolean rings, etc. are all equivalent to Boolean algebras, it would be reasonable to suppose that sub-lattices, sub-rings, sub-graphs etc. are also subalgebras. Oddly enough, this is not true! Every subalgebra is a sub-ring (defined as a set closed under AND and exclusive OR) and every subring is a sub-lattice. However, not every sub-lattice is a sub-ring, nor is every sub-ring a subalgebra. An important substructure that is not a subalgebra is the set S' of elements of the form $p \& x$ that results from a projection P . S' is closed under OR (union) so, unless $P=1$, it does not include the negations (complements) of its elements, since $x \vee \neg x = 1$, while $P \& 1 = P$. S' is a subring, however, namely that generated by OR from all the atoms of S' .

How do we characterize the logical relationship between two objects that have nothing to do with each other? In order to say anything at all about it, we must conceptually bring these objects into the same universe, which means that we must see them as sublogics of the same logic. Then what? There is a clear way to proceed if they together generate all the elements of this common logic:

Generation: We say that a set A of elements *generates* a Boolean algebra B if we can obtain every element of B by applying AND and NOT to the members of A . For instance S , the set of atoms, generates its Boolean algebra.

Spanning: Suppose that B_1 and B_2 are sublogics of B such that all of their elements together generate B ; we then say that they *span* B . If B_1 and B_2 are any two sublogics of B there is a sublogic of B which we'll call $B_1 \& B_2$ that is spanned by B_1 and B_2 .

Factors: We say that B_1 and B_2 are *factors* of B if they span B and if $s_1 \& s_2$ is never 0, where s_1 is an atom of B_1 and s_2 is an atom of B_2 . More generally, sublogics $B_1, B_2 \dots B_i \dots$ are factors of B if for any B_i , B_i and B' are factors, where B' is the sublogic spanned by all the other sublogics.

The concept of factoring captures what it means to break something into a "heap" of parts, assuming that this is possible. The converse operation, bringing parts together into a heap, will be known as:

Boolean multiplication: Given Boolean logics B_1 and B_2 over case sets S_1 and S_2 , we define their *product* $B_1.B_2$ to be the Boolean logic over the Cartesian product of S_1 and S_2 .

Theorem 6.1. Given a product $B_1.B_2$, there are natural isomorphisms of B_1 and B_2 onto factors B_1' and B_2' of the product.

proof: The atoms of the product are the ordered pairs $\langle x_i, y_j \rangle$, where x_i is any atom of B_1 and y_j is any atom of B_2 . Define B_1' as the sublogic whose atoms x_i' are of the form $\langle x_i, y_1 \rangle \vee \langle x_i, y_2 \rangle \vee \langle x_i, y_3 \rangle \dots$, and similarly B_2' with atoms y_j' . Clearly the atoms of B_1' and B_2' correspond to those of B_1 and B_2 , all these atoms together span B , and $x_i \& y_j$ is never 0, so B_1' and B_2' are factors.

Because of these obvious natural isomorphisms, we'll regard multiplying and factoring as inverse operations, and we'll speak of a logic as the product of its factors. The dot notation $B_1.B_2$ is a close relative of the dot notation in computer science for separating fields in labels or addresses (think of an Internet address). If B_1 and B_2 are factors of B , we'll allow ourselves to write $B = B_1.B_2$; in such a case we have $B_1.B_2 = B_1 \& B_2$.

Now we come to a crucial theorem. Recall that we defined independence to mean $\text{prob}(x \& y) = \text{prob}(x)\text{prob}(y)$.

Theorem 6.2. x and y are independent in B if and only if B can be factored into two subalgebras one of which contains x , the other y .

It's easy to show that elements in different factors are independent; indeed, this is an immediate corollary of the fact that the cardinality of a Cartesian product is the product of the cardinality of its factors. Proving the converse is harder, though, and since the details of the proof are not relevant to what we're doing here, we won't go into them.

If the elements of one sublogic are independent of the elements of another, we say that the sublogics are independent. A necessary and sufficient condition for this is that the atoms of one are independent of the atoms of the other. This is the logical meaning of independent variables. That is, to say that two variables are independent means that they range over the case sets of independent sublogics.

Independent sublogics are factors of the sublogic that they span, but they need not be factors of the whole logic. For a sublogic A to qualify as a factor of a logic B, the atoms of A must be equiprobable in B. A sublogic that meets this condition will be called *separable*. Note that if A is separable, the probabilities defined in B for the elements of A are the same as those defined in A alone, and if A is all we care about, we can leave B out of the picture. If A is not separable, however, we cannot use Pascal's definition on A alone but must also take B into account. One way to do this without mentioning B explicitly is to describe the effect of B in terms of a *probability measure*.

A *measure* on a Boolean algebra will be defined as a numerical function on its elements that adds for mutually exclusive cases. Some definitions of measure also includes the requirement that the numbers be non-negative, but we'll omit this requirement since we'll soon be studying *amplitude measures* that can go negative and complex. A probability measure is a real non-negative measure that is 1 for Boolean 1. Pascal's definition of probability applied to B defines a probability measure on each of its sublogics.

The relative frequency interpretation of probability is often presented as a competitor of Pascalian probability. However, it can be brought under the Pascalian umbrella by treating a series of trials as a set of possibilities for *this* trial. The series then becomes the set of cases for the logic B of all statements about which trial is this one, and relative frequency becomes a Pascalian measure on a sublogic A whose cases are the possible outcomes of the trials. If the outcomes are equally frequent, as with a fair coin toss, then A is separable.

It may seem that all this business about factors is laboring the obvious. After all, we all know what it means for things to have nothing to do with each other – why all the fuss? At this point I can only ask the reader to be patient a little longer. We really do need a rather abstract approach to familiar ideas like separateness, connectedness and equality, since our commonsense intuition about such things turns out to be a poor guide in the strange new realm of Boolean geometry.

CHAPTER 3. BOOLEAN GEOMETRY.

3.1. Boole space.

In section 2.6 we defined Boole space in terms of the Boolean graph; here we'll start with the Boolean metric.

Metric space: A set of points on which there is a distance function $D(x,y)$ satisfying three axioms: First, $D(x,x) = 0$, second $D(x,y) = D(y,x)$ and third, $D(x,y) + D(y,z)$ is greater than or equal to $D(x,z)$ (the triangle inequality.)

Boolean Distance: The *distance* $D(x,y)$ between two elements x and y of a Boolean algebra is defined as $\text{card}(x+y)$, i.e. the cardinality of $x+y$, where $+$ means exclusive OR.

Exclusive OR, or XOR for short, is central to Boolean geometry, so it's important to be clear about its basic properties. First, let's be clear about its definition:

$x \text{ XOR } y$, abbreviated $x+y$ means $(xvy) \& \neg(x\&y)$

Unlike inclusive OR, exclusive OR is a group operator. Applied to bit strings, it is bit-by-bit addition mod 2, which justifies, or at least excuses, the symbol $+$ for it. Boolean 0 is the identity of the XOR group, and every element is its own inverse; the latter property alone characterizes a group as isomorphic to a XOR group. If we define scalar multiplication by 0 and 1 by the rules $0x=0$ and $1x = x$, the XOR group becomes a vector space over the binary field; we'll call this vector space XOR space. AND distributes through XOR, so AND and XOR together form a ring, the so-called Boolean ring. The dual of XOR is IFF, defined as $(x\&y) \vee (\neg x\&\neg y)$.

Theorem 3.1.1. Boolean distance is a metric.

proof. Since $x+x = 0$, $D(x,x) = 0$. Since $x+y = y+x$, $D(x,y) = D(y,x)$. To prove the triangle inequality, first note that $D(x,y)$ is a maximum when x and y are mutually exclusive, in which case it is $\text{card}(x)+\text{card}(y)$. Then note that since $y+y = 0$, we have $x+z = (x+y)+(y+z)$, showing that $D(x,z) = \text{card}(x+z)$ is at most $\text{card}(x+y)+\text{card}(y+z) = D(x,y)+D(y,z)$, which is the triangle inequality.

There are two basic theorems that launch Boolean geometry. Let's now turn to the first, which is that that Boole space is homogeneous. To understand what this means and how to prove it, we need the concepts of congruence, symmetry and displacement.

Congruence: A *congruence* between two subsets of a metric space is a 1-1 correspondence between them that preserves distance.

Symmetry: A self-congruence of a subset is called a *symmetry*.

Homogeneity: We say that a metric space is *homogeneous* if for any two points x and y there is a symmetry of the whole space taking x into y .

Displacement: A transformation on Boole space which for some fixed element d takes every element x into $d+x$. Note that this resembles a vector displacement in ordinary space, and is in fact literally a vector displacement of the linear algebra we called XOR space.

Theorem 3.1.2. Displacements are symmetries of Boole space.

proof: $D(d+x,d+y) = \text{card}(x+d+d+y) = \text{card}(x+y) = D(x,y)$

Theorem 3.1.3. Boole space is homogeneous.

proof: Given any two elements d and e , we have $(d+e)+d = e$, so the displacement by $d+e$ takes d into e

The second big theorem that starts things off is that you can get from the Boole space of a Boolean algebra back to the Boolean algebra itself simply by saying which point is 0. Since Boole space is homogeneous, you can choose any other point to be 0 and get another Boolean algebra. The relativity of Boolean logic with respect to the choice of origin is the

essential novelty of Boolean geometry, and we'll see in Part II how it leads to the relativity of logic in quantum mechanics.

At this point it will be helpful to consider Boole space in terms of the Boolean graph as we did in see section 2.5. Recall that we defined Boole space there to be the Boolean graph stripped of its arrows. More formally, it is the structure defined by the set of all unordered pairs of neighboring points in the graph. Referring to fig. 2.4.1, we see that such neighbors are the endpoints of the straight lines in the Boolean cube. This is no accident, and it will turn out to be a good move to define straight lines in our geometry to be neighboring pairs. The definition now will be algebraic:

Line. A *straight line*, or simply a *line*, in a Boolean algebra is a two-element set $\{x, y\}$ such that $x+y$ is an atom.

We can see that this is clearly the case for the lines in fig. 2.4.1. The logical meaning there of an arrow $x \rightarrow y$ is that y results from adding one more member to x . To remove the arrowhead means asserting the weaker relationship $x \leftrightarrow y$ or $y \leftrightarrow x$, which doesn't say which of x and y is included in the other but merely that they differ by one atom, i.e., that $x+y$ is an atom. Thus we see that:

Theorem 3.1.4. The two points on a line are neighboring points on the graph, which means that the structure of the unoriented graph is given by specifying the set of lines.

Theorem 3.1.5. A line is a pair of points whose distance apart is 1.

proof: If $x+y$ is an atom then $D(x,y) = \text{card}(x+y) = 1$. The point of stating this obvious theorem is to make it clear that the concept of line is purely geometric, i.e. it depends only on the metric and not on other features of the Boolean algebra.

In non-Euclidean geometry the role of straight lines is taken over by geodesics. Now we have both straight lines and geodesics, which in section 2.5 were defined as edge paths containing a minimal number of steps. We must now see what this means algebraically:

Path: A sequence of connected lines, i.e. a sequence points x_i such that $\{x_i, x_{i+1}\}$ is a line. Path length is the number of points minus one.

Geodesic: A shortest path between two points.

Theorem 3.1.6. The length of a geodesic between x and y is $D(x,y)$.

proof: Consider first the case where $x=0$. Since $0+y = y$, $D(0,y) = \text{card}(y)$. We saw in 2.5 that $\text{card}(y)$ is the length of any geodesic from 0 to y , so the theorem is true for $x=0$. But now suppose we apply a displacement d , turning our interval into $d,d+y$. We saw (theorem 3.1.2) that displacements are geometric symmetries, so $D(d,d+y) = D(0,y)$. But we also saw that lines and hence paths are geometric concepts, so the shortest path between d and $d+y$ has the same length as the shortest path between 0 and y . We can choose d arbitrarily. By letting $y = d+z$ for arbitrary z , we can also choose $d+y = z$ arbitrarily. Thus the theorem holds for any x and y QED.

We now see that our two ways of defining Boole space agree. If we know the metric $D(x,y)$ we know the geodesic distance on the graph and hence the structure of the (unoriented) graph itself. Conversely, if we know the graph, we know its graph distance and hence $D(x,y)$.

Theorem 3.1.7. Given any point x , and any path, every step forward in that path either increases the distance from x by 1 or decreases the distance from x by 1, i.e. there are no side steps.

Proof: The theorem is true for $x=0$, since distance from 0 is cardinality. It is true of any other point since the metric is homogeneous.

Theorem 3.1.8. The structure of a Boolean algebra is given by its metric together with its origin (Boolean 0).

proof. The metric defines the unoriented graph while the origin defines the arrow as the direction of increasing distance from 0.

As mentioned, it is theorems 3.1.3 and 3.1.8 that really get us going. These theorems tell us that a Boolean algebra is a Boole space on which we have singled out an origin, and that the points all look alike so any point will do. Theorem 3.1.7 is also very important, since, as we shall see, it plays a crucial part in our definition of amplitude.

We started this chapter by defining the Boole space metric as the number of atoms in $x+y$. This of course presupposes a Boolean algebra in

which atoms and $+$ are defined. We then found that by applying a geometric symmetry we can displace the origin to any other element and obtain a new Boolean algebra in which this new origin is 0. Since the atoms are the neighbors of 0, this new 0 defines a new set of atoms, different from those we counted in defining the distance between x and y . In fact, $+$ in the new Boolean algebra is also a different operator from $+$ in the old one. Nevertheless, since the origin was shifted by a symmetry of the metric, we know that the new atom count is the same as the old count. Shifting the origin not only relativizes atoms and $+$, it relativizes all the familiar Boolean operators except NOT, and it also relativizes inclusion and mutual exclusion. Nevertheless, a surprisingly large part of Boolean structure remains invariant, and describing this invariant structure will be our next job.

3.2. Geometric invariants.

What is the full symmetry group of Boole space? It includes the displacement group, and it of course includes the symmetry group of Boolean algebra, which I shall call the *logic group*.

Theorem 3.2.1 The logic group of a finite Boolean algebra consists of all transformations that result from permuting the atoms.

proof: A finite Boolean algebra is isomorphic to the set of all subsets of its atoms, whose intersections and complements obviously don't depend on how the atoms are arranged, so any permutation of the atoms will generate a symmetry. Since a logical symmetry must preserve the Boolean lattice, it must map neighbors of 0 into neighbors of 0, so the symmetries generated by permutations are the only logical symmetries.

Theorem 3.2.2. The geometric group, i.e. the full symmetry group of Boole space, is generated by the logic group and the displacement group in the sense that every geometric symmetry can be written in the form DL , where D is a displacement and L a logical symmetry.

proof: Let T be any geometric symmetry of a Boolean algebra B . Let $d = T(0)$. Then by theorems 3.1.3 and 3.1.8, T must map B isomorphically onto the Boolean algebra B' whose origin is d . But the displacement $D(x) = d+x$ also maps B isomorphically onto B' . Thus the symmetry $L = DT$ is a logical symmetry on B (recall that D is its own inverse). We thus have $T =$

DL, the product of a displacement and a logical symmetry. QED.

Theorem 3.2.3 The displacement group is a geometric invariant, i.e. it is a normal subgroup of the geometric group.

proof: (note: in order to stay within ASCII we'll write T inverse as $T^{\wedge}$). We must show that for any symmetry T and any displacement D , $T^{\wedge}DT$ is a displacement. We have seen that we can write T in the form EL , where E is a displacement and L is logical. Since $(EL)^{\wedge} = L^{\wedge}E$, we have $T^{\wedge}DT = L^{\wedge}EDEL = L^{\wedge}DL$, so the problem reduces to showing that $L^{\wedge}DL$ is a displacement. We have $L^{\wedge}DL(x) = L^{\wedge}D(L(x)) = L^{\wedge}(d+L(x))$. But since $L^{\wedge}$ is a logical symmetry, it preserves $+$ and we have $L^{\wedge}(d+L(x)) = L^{\wedge}(d)+x$. Thus $T^{\wedge}DT$ is a displacement by $L^{\wedge}(d)$. QED.

Our aim in this section is to see how much of logic carries over into Boolean geometry, i.e. to find the important logical concepts that are geometric invariants. Now of course logical concepts are already invariant under the logic group – they don't depend on any particular arrangement of the atoms. Thus by theorem 3.2.2, to show that a logical concept is geometrically invariant it is sufficient to show that it is invariant under displacement. This reasoning is essentially what underlies the proof of theorem 3.2.3; displacement is a logical concept and the displacement group is invariant under itself.

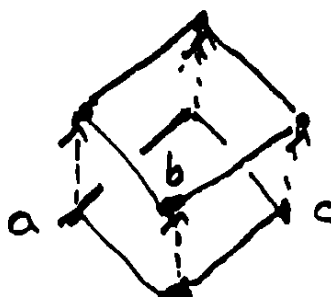
The most familiar geometric invariant: is NOT. NOT is in fact displacement by 1, i.e. $-x = 1+x$, which shows that it is invariant. The negation of an element x is, geometrically speaking, its antipode, i.e. the point furthest away from x . To see why this is so, note that the longest possible geodesic is of length n , where n is dimension, since each step in a geodesic must add or take away a different atom. But a geodesic of length n starting at x must take away all the atoms in x and add all the atoms not in x , since there are no other atoms to add or take away; the result is NOT x . Incidentally, note that the dimension n is a geometric invariant, since n is the number of neighbors of 0, and by homogeneity every point has the same number of neighbors. Let's now move on to some important unfamiliar geometric concepts.

Parallel. Two lines $\{x,y\}$ and $\{z,w\}$ are called parallel if $x+y = z+w$.

Theorem 3.2.4. Parallel is a geometric concept.

proof. Since $+$ is a logical concept, it is sufficient to notice that a displacement D of two parallel lines leaves them parallel, i.e. if $x+y = z+w$ then $d+x+y = d+z+w$.

Fig 3.2.1
Adding atom b
to the lower
square



Recall that a line is an edge in the Boolean cube. The arrow on an edge represents adding an atom to a set. Note that parallel arrows add the same atom, which agrees with our definition above. This is no coincidence. It can be shown that the edge graph of the Euclidean n -cube is the Boolean graph of an n -atom Boolean algebra, and that the Boolean metric is the square of the Euclidean metric on the vertices of the n -cube. The Boolean n -cube is very useful for visualizing definitions, theorems and proofs in Boolean geometry, and its Euclidean geometry can be rigorously incorporate into the mathematics of Boole space, though we won't do so here. However, here is a quick intuitive account of why the two structures coincide:

The set of parallel edges in a certain direction connects together two squares to make up the cube (see fig 3.2.1). The lower square represents the Boolean algebra of all subsets of a two member S , while the upper square represents the new subsets that result from adding a third member to S . If we add a fourth member to S , we connect up our cube to another cube by eight parallel lines in a new dimension get a four-dimensional hypercube. We can keep doing this, which shows that an n -dimensional hypercube is a natural representation for an n -atom Boolean algebra. Note that lines in the cube that are not parallel are orthogonal. This is true also in the n -cube, so it makes sense to define *orthogonality* as not being parallel. It's easy to show that dimension is the maximum number of orthogonal lines.

After this brief side excursion, let's get back to parallel lines. What parallel lines have in common is a particular atom, the atom $x+y$. Though parallelism is an invariant geometric concept, this statement depends on two non-invariant algebraic concepts: atom and $+$. Let's now try to think more geometrically. Suppose we choose a particular origin, call it 0 . Then

an atom can be defined geometrically as a neighbor of that origin.

Theorem 3.2.5. For any point k , every line is parallel to a line of the form $\{k, x\}$, and no two lines of this form are parallel.

proof: Given a line $\{z, w\}$, we have $z + w = k + (k + z + w)$, so $\{k, k + z + w\}$ is a parallel line. If x is unequal to y , then $k + x$ is unequal to $k + y$ by the group property of $+$. QED.

We see from this theorem that for any point k , an equivalence class of parallel lines has a canonical representative as a line connecting k with a neighbor. This is a geometric way of stating that what parallel lines have in common is a *unit displacement*, something that follows immediately from the definition of parallel. Looking at fig 3.2.1, we see that a unit displacement along the dotted lines reverses the two solid squares, keeping the dotted lines fixed. On the n -cube, a unit displacement reverses two $n-1$ cubes, keeping their connecting lines fixed. The unit displacement is such an important concept that we will give it a special name:

Step: A displacement of the form $A(x) = a + x$, where a is an atom.

Theorem 3.2.6. Every displacement is a product of steps in which no step occurs more than once, and the set of steps in that product is unique.

proof. Any element d is a sum of its atoms, so $d + x = a_1 + a_2 \dots + a_i \dots + x$. Thus $D(x) = A_1(a_2 \dots + x) = A_1(A_2(a_3 \dots + x)) = \text{ect.} = A_1(A_2 \dots (A_i(x) \dots))$. Clearly the a_i must include the atoms in d , and any other atom would have to occur at least twice in it. QED.

Steps: Define the set $\text{steps}(D)$ to be the unique set of steps that are the factors of displacement D according to theorem 3.2.6.

Theorem 3.2.6 tells us that the displacement group is in natural 1-1 correspondence with the set of all sets of steps. As the set of all subsets of a set, it is a Boolean algebra under intersection and complement. What makes this Boolean algebra so important is that it is geometrically invariant!

It will be useful to think of this Boolean algebra as a ring, i.e. as a set closed under XOR and AND. Recall that a ring is equivalent to a Boolean

algebra, but a subring need not be a subalgebra.

Displacement ring. The displacement group together with an AND operator defined as follows: $D \& E$ is the displacement such that $\text{steps}(D \& E)$ is the intersection of $\text{steps}(D)$ and $\text{steps}(E)$.

Theorem 3.2.7. The displacement ring of a Boolean algebra is isomorphic to the ring of that algebra itself under the mapping $D \mapsto d$, where $D(x) = d+x$.

proof: $D \mapsto d$ maps steps 1-1 onto atoms, so $\&$ is obviously a corresponding operation on the two rings. $DE(x) = D(e+x) = d+e+x$, which means that $DE \mapsto d+e$. QED. Incidentally, this also shows that the so-called displacement ring actually is a Boolean ring, with $+$ defined as the group product.

With the geometrically invariant displacement ring we have arrived at a way to automatically transform any Boolean algebraic concept into a Boolean geometric concept without having to check it for invariance. What we have done is almost exactly analogous to pulling the normed linear algebra of Euclidean displacements out of Cartesian geometry. In each case we begin by thinking of the points as vectors and define a displacement as the addition of a vector to all points, the only difference being that Boolean vectors are over the binary field rather than over the real field. In each case we get to the full geometric group by combining the displacements with the rotations and reflections. In the Boolean case, the rotations (which only rotate by multiples of 90 degrees) and reflections are the permutations of coordinate axes, i.e. the logic group.

Lifting a Boolean atom from the status of a mere object d to the status of a displacement D is to give it an essentially dynamic quality. A step is an object that is either joining or leaving a set. Which set? That doesn't matter; it's only the bare fact that the object is coming or going that creates a step. Which object? That depends on what other steps have been taken! In the face of a moving 0, only the fusion of the mercurial object with the ephemeral set is something fixed, invariant, *objective*.

I now see the logic of the classical observer in quantum mechanics as a displacement ring on an underlying "hidden" Boolean underworld of incompatible Boolean logics which can only be combined geometrically. It appears that only by dealing directly with logics that change can we find a

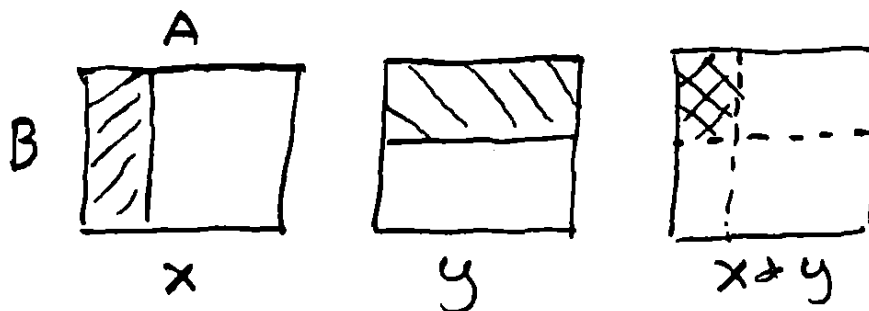
logic that doesn't change, a logic that everyone can agree on and that will serve for the writing of history and the accumulation of facts.

3.4. Independence.

In chapter 2 we asked whether Boolean geometry is compatible with science as we know it. The issue is whether, given non-logical geometric change, it still makes sense to isolate parts of the world from the general flux. In our present terms, the question is whether we can find a geometrically invariant concept of separation that does the same job for some new science that logical separation, i.e. independence, does for present day science.

Logics A and B are independent if taken together they form a *product logic* $A.B$ whose atoms are ordered pairs of atoms from A and B. A good way to visualize this is to think of the atoms of A being arranged horizontally and those of B vertically so that their ordered pairs form a *rectangular set*.

Fig. 3.4.1
The separable element $x \& y$



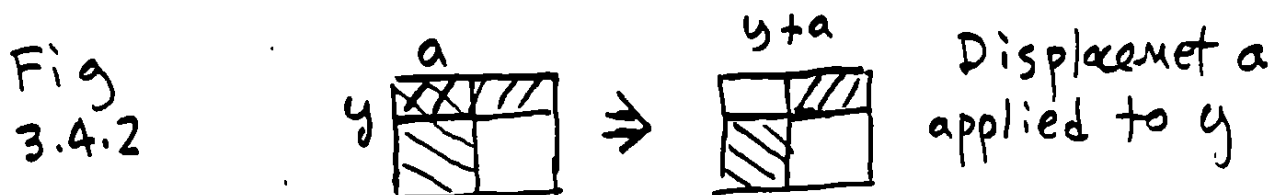
Every region of this rectangle is an element of $A.B$. However, the elements of A and the elements of B are regions of a special kind. An element of A is a vertical stripe, or more exactly, a set of atoms that can be turned into a vertical stripe by rearranging the columns. An element of B is a horizontal stripe in the same sense. An element of the form $x \& y$ with x in A and y in B is a rectangular region, i.e. a region that can be turned into a rectangle by rearranging rows and columns; in particular, $1 \& 1$ is the whole rectangle. If an element of $A.B$ is not a rectangle, i.e. if it cannot be separated into an element of A and an element of B, we'll borrow a term from quantum mechanics and speak of it as *entangled*.

Let's now consider what happens when we apply a geometric transformation $G(x)$ to $A.B$.

First let's assume that G is logical, meaning that it permutes the joint atoms in the rectangle. To say that G only applies to A means that it only permutes the columns. This has no effect on the set of atoms in a given row, so the atoms of B are unaffected by G . More generally, a n.a.s.c for G to preserve the separability of separable elements is that it only rearranges rows and columns, i.e. that it is a product of a logical transformation on A and a logical transformation on B . This is just what common sense would expect: if two things are independent, changing them separately can't make them correlated.

But now suppose that G is a displacement. If G applies to only one of the components, we shouldn't expect it to affect the other, right? Let $G(x) = a+x$, where a is in A . If we look only at what G does to the elements of A , i.e. to the vertical stripes, then it displaces them just as if B didn't exist. B could be on another planet, in another universe, as far as A is concerned. Thus it seems to be OK to isolate a Boole space from the rest of the world as an object of study. So far, Boolean geometry is still just another step in the cheerful march of scientific progress.

But wait just a minute, stop the band! A messenger has just arrived from planet B reporting that something very odd has happened to the elements on his planet, which is that they have all become entangled with the elements on ours! What has happened? Our geometric displacement G , which seemed to be confined to our A logic alone, has actually zapped his planet and turned every element y into the inseparable element $y+a$!



There is no way to analyze a Boole space into separate geometric parts. Separation is simply not a geometric concept. Unlike the action of a logical transformation or the action of a projection, the action of a displacement cannot be broken down into distinct actions on independent factors. The reason for this is that any "rectangular" separation of possibilities still leaves all the parts with a common null set, a common 0, so a shift in the 0 of one part is a shift in the 0 of all!

But before you take off for a Tibetan monastery or banish Boolean geometry to some mystical netherworld, remember the displacement algebra. Though it's a geometric invariant, it's also a Boolean *algebra* and as such is factorable like any other Boolean algebra. Even though the underlying geometry has no objective parts, there is at least an objective way to take apart an aspect of this geometry. Furthermore, if the geometry acquires a 0, the factorization of the displacement algebra can be as-it-were projected onto it. All is not lost to science after all.

Of course if the geometry acquires a fixed origin it simple turns into logic, and the displacement algebra as such becomes irrelevant. What we're really interested in is the laws governing a moving origin, which is the likely source of non-Boolean change in quantum mechanics. The conceptual framework within which we shall formulate and study these laws is the displacement algebra, and our main tool in this study will be the concept of *amplitude*, which will be the focus of Part II.

A DISCRIMINATION SYSTEM

J. C. Amson

31 August 1965

I DISCRIMINATION SYSTEM

1. DEFINITION The distinct (ie not-identical) elements of the Discrimination System are 0 and 1.

2. DEFINITION The elements of the Discrimination System are called discriminators.

3. REMARK Identical copies of the elements of the Discrimination System are not distinguishable from the elements themselves. Consequently identical copies are also called discriminators.

4. DEFINITION An n -column or column of length n , is an ordered set of n ($n \geq 2$) discriminators. Thus if $d_1, d_2, \dots, d_n$ are any n discriminators, then

$$\begin{pmatrix} d_1 \\ d_2 \\ \vdots \\ d_n \end{pmatrix}$$

is an n -column. We sometimes speak of an n -column simply as a column, when its length is not important in the context. For an n -column we write c_n , or simply c when no confusion is likely. To index n -columns we write $c_n^1, c_n^2, \dots$, or simply $c^1, c^2, \dots$

5. DEFINITION The discriminators $d_1, d_2, \dots, d_n$ of an n -column are called the 1st, 2nd, ..., n th components respectively of the n -column. When their order is not important in the context, we may speak of simply the components of the column. We say the n -column contains the components.

6. DEFINITION Two n -columns $\begin{pmatrix} d_{11} \\ \vdots \\ d_{1n} \end{pmatrix}, \begin{pmatrix} d_{21} \\ \vdots \\ d_{2n} \end{pmatrix}$, for any $n \geq 2$,

are said to be identical iff $d_{1k} = d_{2k}$ for each $k=1,2,\dots,n$; otherwise they are said to be not-identical.

7. REMARK For each $n \geq 2$ there are evidently 2^n not-identical columns of length n , one & only one of which is the n -column for which $d_1 = d_2 = \dots = d_n = 0$, the remaining $2^n - 1$ of which are such that each of them contains at least one component equal to 1, and one & only one of them is the n -column for which $d_1 = d_2 = \dots = d_n = 1$.

8. DEFINITION For each $n \geq 2$, the n -column for which $d_1 = d_2 = \dots = d_n = 0$ is called the null n -column or null column of length n and written Θ_n or simply Θ . Each of the other $2^n - 1$ n -columns that contain at least one component equal to 1 are severally called monic n -columns or monic columns of length n , and collectively called the monic set of n -columns or monic set of columns of length n and written I_n or simply I . The monic n -column for which $d_1 = d_2 = \dots = d_n = 1$ is called the unitary n -column or unitary column of length n and written U_n or simply U . Finally the set of all 2^n columns of length n is denoted by E_n or simply E .

9. COMMENT The use of the term monic n -column to include the special case of a unitary n -column clearly abandons the symmetry that exists between the elements 0 and 1 in favour of a special emphasis on the element 0. Such an asymmetry (or its dual in which the element 1 is emphasised) appears to be unavoidable in the subsequent use to which the notions of the null column and the monic set are put (of sections V, VI).

10. REMARK In keeping with the definitions in 8 above, we shall sometimes call the discriminators 0 and 1 the null and the unitary discriminators respectively.

11. We shall write $/S/$ for the cardinal of a set S .

II OPERATIONS IN THE DISCRIMINATION SYSTEM

1. There are three separate operations in the Discrimination System :-

- A. a binary operation on discriminators,
- B. a binary operation on n -columns,
- C. a unary operation on n -columns.

Alternatives: Proceedings of ANPA16

2. DEFINITION The binary operation A acts on any two discriminators; the result^{ant} of the operation A is again a discriminator. If d_1, d_2, d_3 are discriminators, then we write $A(d_1, d_2) = d_3$.

3. DEFINITION The binary operation B acts on any two n-columns of the same length; the resultant of the operation B is again an n-column of the same length as the operands. If c^1, c^2, c^3 are columns of length n then we write $B(c^1, c^2) = c^3$. If c^1, c^2 are columns of different lengths, then B is not defined on them.

4. DEFINITION The unary operation C acts on any n-column; the resultant of the operation C is a discriminator. If c is a column, and d is a discriminator, we write $C(c) = d$.

5. DEFINITION The operation of first performing operation B on a pair of n-columns and then performing operation C on the resultant n-column, is defined as the compound operation CB. For convenience we call the operation CB the operation D. Thus if c^1, c^2 are columns of length n then

$$D(c^1, c^2) = (CB)(c^1, c^2) = C(B(c^1, c^2)).$$

III OPERATION RELATIONSHIPS

The operators A, B, C, D, in the Discrimination System are related as follows.

1. DEFINITION The operation B consists of operation A applied severally to each pair of component discriminators of any pair of columns of length n, in the following sense.

If $\begin{pmatrix} d_{11} \\ d_{12} \\ \vdots \\ d_{1n} \end{pmatrix}, \begin{pmatrix} d_{21} \\ d_{22} \\ \vdots \\ d_{2n} \end{pmatrix}$, are two columns of length n, then

$$B \left(\begin{pmatrix} d_{11} \\ d_{12} \\ \vdots \\ d_{1n} \end{pmatrix}, \begin{pmatrix} d_{21} \\ d_{22} \\ \vdots \\ d_{2n} \end{pmatrix} \right) = \begin{pmatrix} d_{31} \\ d_{32} \\ \vdots \\ d_{3n} \end{pmatrix},$$

where $d_{31} = A(d_{11}, d_{21})$, $d_{32} = A(d_{12}, d_{22})$, ..., $d_{3n} = A(d_{1n}, d_{2n})$, for any $n \geq 2$.

2. REMARK The operation B can conveniently be considered as reducing to the operation A in the special case where $n = 1$ and the single discriminator component d_1 can be regarded as a 1-column or column of length 1. (This remark allows us to regard the operation A as a special case of the operation B on the one hand, or the operation B as an extension of the operation A to ordered sets consisting of more than just a single element, on the other hand.)
3. REMARK The binary operation B can be regarded as a $2n$ -ary operation, comprised of n separate binary operations, whose resultant is an n -column.
4. REMARK The unary operation C can be regarded as an n -ary operation on ordered sets of n discriminators, whose resultant is again a discriminator.
5. REMARK The binary operation D can be regarded as a $2n$ -ary operation on ordered sets of $2n$ discriminators, whose resultant is again a discriminator.

IV PARTICULAR FORMS OF THE DISCRIMINATION SYSTEM OPERATIONS

1. So far we have not specified the particular forms of the operations in the Discrimination System. This we now do.
2. REMARK By Def.II-2 the operation A acts on any two discriminators. Since the number of not-identical discriminators is finite (2), the number of not-identical pairs of operand discriminators is also finite (4). Hence we can specify the operation A by actually specifying the resultant discriminator associated by A with each of its four pairs of operand discriminators. As a consequence we have the following assertion.
3. ASSERTION The operation A can take any one of the following sixteen forms :

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
$A(00)$	0	1	0	0	0	1	1	1	0	0	0	1	1	1	0	1
$A(01)$	0	0	1	0	0	1	0	0	1	1	0	1	1	0	1	1
$A(10)$	0	0	0	1	0	0	1	0	1	0	1	1	0	1	1	1
$A(11)$	0	0	0	0	1	0	0	1	0	1	1	0	1	1	1	1

For convenience we write A_k for A when A is defined by choice k ($1 \leq k \leq 16$) in this table.

4. REMARK By Def.III-1, any one of the sixteen available choices for operation A will now specify the operation B. Hence there are also sixteen available choices for operation B, which again we write as B_k ($1 \leq k \leq 16$). It is clear that the length of the columns on which B acts does not affect the choice of the operation B.

5. REMARK Nothing in the definition (II-4) of operation C makes its form dependent on the forms of the operations A or B. Consequently we can freely choose the form of operation C; we do as follows.

6. DEFINITION The operation C is specified by the relations

$$C(o^0) = 0, \quad C(o^1) = 1$$
 iff o^0 is the null n-column and o^1 is any monic n-column, for any value of $n \geq 2$.

V DISCRIMINATION

1. In section I (Def.I-2) we called the elements of the Discrimination System discriminators. We now give purpose for the choice of this name.

2. DEFINITION A binary operation on a set S that contains at least two elements is said to be a weak discrimination in S iff the resultant of the operation, whenever its two operands are identical, is not-identical to the resultant whenever its two operands are not-identical. It is said to be a strong discrimination iff the resultant of the operation is the discriminator 0 resp. 1 whenever its two operands are identical resp. not-identical. We sometimes refer simply to a discrimination when no confusion is likely.

3. REMARK A strong discrimination always implies a weak discrimination, but not conversely. Moreover an operation cannot be a strong discrimination if its resultants are not discriminators. (For example, since B has n-columns for its resultants, B cannot be a strong discrimination.)

4. **ASSERTION** A necessary and sufficient condition for operation A to be a weak discrimination (strong discrimination) is that $A = A_8$ or A_9 ($A = A_9$ alone).

Proof of sufficiency: Let $A = A_9$, (the argument is similar for $A = A_8$ in the case of weak discrimination). The resultant of A whenever its two operands are identical (ie are 00 or 11) is 0; the resultant of A whenever its two operands are not-identical (ie are 01 or 10) is 1; these resultants are not-identical. Hence by definition A is a weak discrimination when $A = A_8$ or A_9 , and a strong discrimination when $A = A_9$. qed

Proof of necessity: (i) Let A be a weak discrimination, ie the resultant of A whenever its operands are 00 or 11 is not-identical to the resultant of A whenever its operands are 01 or 10. If $A(00) \neq A(11)$ then either $A(00) = A(01)$ or $A(10)$ or both. Since there are no other possibilities, we have contradicted the hypothesis that A is a discrimination. Hence $A(00) = A(11)$. Similarly $A(01) = A(10)$. Consequently, by Table IV-3, $A = A_1, A_8, A_9$, or A_{16} . But $A(00) \neq A(01)$ by hypothesis. Thus the choice for A is restricted to just A_8 or A_9 . qed

(ii) Let A be a strong discrimination. Then by definition $A(00) = A(11) = 0$, $A(01) = A(10) = 1$, ie $A = A_9$. qed

5. **REMARK** If A is a weak discrimination, then the resultant of A is the discriminator 0 (or 1) whenever its operands are identical discriminators, and the discriminator 1 (or 0) whenever its operands are not-identical discriminators.

6. The effect of A is to discriminate between pairs of identical operands and pairs of not-identical operands. We can extend this notion of discrimination to act on n-columns through the operations B and D.

7. The assertion V-4 above establishes the equivalence between A being a weak discrimination and A being defined as either A_8 or A_9 . The presence of these two alternative choices, rather than a single unique choice for A, is a consequence of the symmetry implicit in the definition of the elements 0 and 1, and in the notion of weak discrimination. However we shall now see that this symmetry does not induce a similar equivalence between the operation B being a weak discrimination and its being defined exclusively through either a single or an alternative choice of operation A.

8. ASSERTION $A = A_8$ or A_9 is a sufficient, but not a necessary condition, for the operation B to be weak discrimination.

Proof : (1) sufficiency. Let $A = A_9$ resp. A_8 . Let c^1, c^2 , be any two columns of length $n = 2$. There are two cases.

(a) $c^1 = c^2$; then $B(c^1, c^2) = \emptyset$ resp. U
(by table IV-3 and hypothesis).

(b) $c^1 \neq c^2$; then $B(c^1, c^2) \neq \emptyset$ resp. U
(by table IV-3 and hypothesis).

Hence by definition, B is a weak discrimination.

qed

(2) not-necessity. Let B be a weak discrimination, ie if c^1, c^2 , are any two identical columns and c^3, c^4 , are any two not-identical columns, all of the same length $n = 2$, then by definition (V-2)

$$B(c^1, c^2) \neq B(c^3, c^4), \quad (*)$$

Clearly the following seven possibilities exhaust condition (*) :-

		$B(c^3, c^4) =$		
		$\emptyset$	monic, $\neq U$	U
$B(c^1, c^2) =$	$\emptyset$	—	i	ii
	monic, $\neq U$	iii	iv	v
	U	vi	vii	—

We shall not investigate all the implications of these seven cases, since it will be enough to consider just cases ii and vi as follows. Clearly

$$\begin{aligned} B(c^1, c^2) = \emptyset & \text{ implies } A(00) = A(11) = 0, \\ \text{and } B(c^3, c^4) = U & \text{ implies } A(01) = A(10) = 1, \end{aligned}$$

which in turn implies $A = A_9$.

Again

$$\begin{aligned} B(c^1, c^2) = U & \text{ implies } A(00) = A(11) = 1, \\ \text{and } B(c^3, c^4) = \emptyset & \text{ implies } A(01) = A(10) = 0, \end{aligned}$$

which implies $A = A_8$.

Hence quite apart from what other implications for A arise from the remaining cases, these cases ii and vi alone show that we have two contradictory choices for A . This means that the assumption that D is a weak discrimination does not imply an exclusive choice for A (and hence for B) or even an alternative pair of exclusive choices. Consequently the condition on A in the assertion's hypothesis fails to be necessary.

qed

9. The second part of assertion 8 above shows that the use of B as a weak discrimination implies no restriction on the choice for B , as in the case of the operation A . We turn now to consider the operation D in the role of a discrimination.

10. REMARK The operation D associates each pair of its column operands with one or other of the discriminators $O, 1$. Consequently we can use the notion of strong discrimination in connection with D .

11. ASSERTION A necessary and sufficient condition for D to be a strong discrimination, is that $A = A_9$. The weaker condition that $A = A_8$ or A_9 , is sufficient but not necessary for D to be a weak discrimination.

Proof : (1) - sufficiency. Let c^1, c^2, c^3 , be columns of the same/length n .

(i) Let $A = A_9$;

$$\begin{aligned} \text{(a) let } c^1 = c^2, \text{ then } D(c^1, c^2) &= C(B(c^1, c^2)) \\ &= C(0) \text{ (by table IV-3)} \\ &= 0 \text{ (by Def IV-6);} \end{aligned}$$

$$\begin{aligned} \text{(b) let } c^1 \neq c^2, \text{ then } D(c^1, c^2) &= C(B(c^1, c^2)) \\ &= C(c^3) \text{ (where } c^3 \text{ is a monic } n\text{-column, by table IV-3)} \\ &= 1 \text{ (by Def IV-6).} \end{aligned}$$

Hence the conditions for D to be a strong (and hence a weak) discrimination are satisfied. qed

(ii) Let $A = A_8$; here a similar argument shows that

(a) $D(c^1, c^2) = 1$ when $c^1 = c^2$, (b) $D(c^1, c^2) = 0$ when $c^1 \neq c^2$, and hence that D is only a weak discrimination. qed

(2) - necessity (for strong discrimination). Let D be a strong discrimination, ie if c^1, c^2 , are any columns of length $n \geq 2$, then

$$\begin{aligned} \text{(a) } D(c^1, c^2) &= 0 \quad (c^1 = c^2) \\ \text{and } \text{(b) } D(c^1, c^2) &= 1 \quad (c^1 \neq c^2). \end{aligned}$$

But (a) implies that $B(c^1, c^2)$ is the null column, which implies that either $A(00) = 0$, or $A(11) = 1$, or both; and (b) implies that $B(c^1, c^2)$ is a monic column, which implies that either $A(01) = 1$, or $A(10) = 1$, or both. Consequently A is defined as A_9 uniquely. qed

(3) - not-necessity (for weak discrimination). Let D be a weak discrimination, ie if c^1, c^2 , are any two identical columns, and c^3, c^4 , are any two not-identical columns, all of the same length $n \geq 2$, then we have

$$\begin{aligned} D(c^1, c^2) &+ D(c^3, c^4), \\ \text{that is } C(B(c^1, c^2)) &+ C(B(c^3, c^4)). \end{aligned}$$

Then by Def IV-6 we have two & only two possibilities :

either (a) $B(c^1, c^2)$ is the null n -column and $B(c^3, c^4)$ is a monic n -column, or (b) $B(c^1, c^2)$ is a monic n -column and $B(c^3, c^4)$ is the null n -column.

Case (a): $B(c^1, c^2)$ is the null n -column and $c^1 = c^2$, hence
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either $A(00) = 0$, or $A(11) = 0$, or both. (*1)

$B(c^3, c^4)$ is a monic n -column and $c^3 \neq c^4$, hence either $A(01) = 1$, or $A(10) = 1$, or both. (*2)

Hence by table IV-3 the only choice for A that satisfies all six conditions (*1), (*2), is the choice $A = A_9$.

Case (b) : $B(c^1, c^2)$ is a monic n -column and $c^1 = c^2$. Hence either $A(00) = 1$, or $A(11) = 1$, or both. (*3)

The associated choices for A are then A_8, A_3, A_{14} or A_{16} .

$B(c^3, c^4)$ is the null n -column and $c^3 \neq c^4$. Here we have seven possible alternatives for the columns c^3 and c^4 :-

$$c^3 = \begin{array}{c|c|c|c} & \overbrace{\begin{array}{c} \theta \\ \text{monic, } \neq U \\ U \end{array}}^{c^4 =} & \begin{array}{c} \theta \\ \text{monic, } \neq U \\ U \end{array} & \begin{array}{c} \text{monic, } \neq U \\ U \end{array} \\ \hline \begin{array}{c} \theta \\ \text{monic, } \neq U \\ U \end{array} & \begin{array}{c} \text{---} \\ iii \\ vi \end{array} & \begin{array}{c} i \\ iv \\ vii \end{array} & \begin{array}{c} ii \\ v \\ \text{---} \end{array} \end{array}$$

These alternatives have the following implications for the components of the null column $B(c^3, c^4)$:

i, ii $A(01) = 0$; iii $A(10) = 0$; iv $A(01) = 0$, or $A(10) = 0$, or both ; v $A(01) = 0$, or $A(11) = 0$, or both ; vi $A(10) = 0$; vii $A(10) = 0$, or $A(11) = 0$, or both. (*4)

The associated choices for A that satisfy all thirteen of these last conditions are just A_1 and A_2 .

Hence there is no choice for A that will simultaneously satisfy all the nineteen conditions in (*1), (*2), (*3), (*4). In particular the choice of neither A_8 nor A_9 for A is a necessary condition for D to be a weak discrimination. This completes the proof of the assertion. qed

VI DISCRIMINATELY CLOSED SUBSETS

1. DEFINITION Let S be a set with at least three members. Let S be closed under a binary operation F . Then a proper subset $S' \subset S$ is said to be discriminately closed under F iff for all $x, y, \in S'$ we have

$$x \neq y \iff F(x, y) \in S'.$$

For convenience we use the shorthands " S' is a $dc(F)$ -subset of S ", and " $S' \subset S$ is $dc(F)$ ".

2. REMARK Since $S - S' \neq \emptyset$, then if $S' \subset S$ is $dc(F)$, we have that for all $x, y, \in S'$, $x = y \iff F(x, y) \in S - S'$.

3. **ASSERTION** The monic set of n -columns I_n ($n \geq 2$) is discriminately closed under operation B iff operation $A = A_9$.

Proof : sufficiency. Let $A = A_9$. Since $n \geq 2$ there are at least two members in I_n (cf. Rem I-7). Let $x, y \in I_n$. Then $x = y$ implies $B(x, y)$ is null, ie $B(x, y) \notin I_n$, and $x \neq y$ implies $B(x, y)$ is monic, ie $B(x, y) \in I_n$. Hence by definition I_n is $dc(B)$. qed

Necessity. Let I_n be $dc(B)$, ie there are at least two members of I_n and for all $x, y \in I_n$ we have (a) $x = y$ implies $B(x, y) \notin I_n$, (b) $x \neq y$ implies $B(x, y) \in I_n$. But (a) implies $B(x, y)$ is null, which implies $A(00) = A(11) = 0$; and (b) implies $B(x, y)$ is monic, which implies $A(01) = A(10) = 1$. Hence these two conditions imply that $A = A_9$. qed

4. **COROLLARY** When $A = A_9$, then for all $x, y \in I_n$ such that $x \neq y$, we have $y \neq B(x, y) \neq x$.

Proof : suppose $B(x, y) = x$ for some y ; then either $A(10) = 1$, or $A(01) = 0$, or both. Then $A = A_4, A_8, A_{11}, A_{14}$, ie $A \neq A_9$, which contradicts our hypothesis. Similarly, if $B(x, y) = y$ for some x , then $A \neq A_9$; contradiction. qed

5. **ASSERTION** If any proper subset of I_n is $dc(B_9)$, then (i) $|I_n| \geq 4$, (ii) $n \geq 3$.

Proof : let I'_n be a proper subset of I_n .

(i) By Cor VI-4 above, there are at least three not-identical members of I_n , namely x, y , and $B(x, y)$. There must also be at least three not-identical members in I'_n if I'_n is $dc(B_9)$, for the same reason. Then $3 \leq |I'_n| \leq |I_n| - 1$.

Hence $|I_n| \geq 4$. qed

(ii) Now $|I_n| = 2^n - 1$, hence $3 \leq |I'_n| < |I_n| = 2^n - 1$, ie $2^n > 4$ or $n \geq 3$. qed

6. **COROLLARY** There are no proper subsets of I_2 that are discriminately closed under the operation B_9 .

7. **ASSERTION** For all $n \geq 2$, no subset of E_n that includes the null n -column can be discriminately closed under the operation B_9 .

Proof : Let $E'_n \subset E_n$ and $\theta_n \in E'_n$. Suppose E'_n is $dc(B_9)$. Then in particular $B(\theta_n, \theta_n) = \theta_n \in E'_n$ and hence $\theta_n \neq \theta_n$.

by Def VI-1, which is false. Hence E'_u is not $do(B_9)$. qed

8. COROLLARY No subset of E_2 other than I_2 is discriminately closed under operation B_9 .

Proof : By Cor.VI-6 above, no proper subset of I_2 is $do(B_9)$. Hence the only other subsets of E_2 , not I_2 or a subset of I_2 , include $\emptyset_2$. But by Assn.VI-7 above, these are not $do(B_9)$. qed

THEOREM

To be Proved

A world in which quantization exists must contain a maximum signal velocity, c .

Proof.

Stage I

To show that a theory of measurement sufficiently generalized to include quantization can be adequately represented by a cybernetic model having a hierarchy of levels and a component (the scale-component) at some level which is invariant under the operations in the model.

Note. By the term "quantization" I mean the existence of exact atomic constants defined in terms of objects in the world, and expressed in current quantum theory by introducing discrete numerical magnitudes into the mathematical formation: I do not refer to the actual mathematical techniques by which these discrete magnitudes are introduced - as when one speaks of "first" and "second quantization".

1. Quantization is Necessary for Measurement

I first extend current measurement theory, which became familiar with the appearance of relativity theory and which was discussed particularly by Bridgman ("Logic of Modern Physics", New York 1927) to include quantization as an essential part.

I assert that quantization is necessary for measurement because in a quantized world there exist exact atomically defined (or atomically specified) units which can be taken as naturally occurring standards. I shall say that quantization provides an exact scale for measurement.

Note. It is often thought - mistakenly - that one can erect a theory of measurement in which any convenient object such as a bar of metal can be defined as the standard in terms of whose length the lengths of other objects are stated as a ratio. The current view became familiar at the time of the development of relativity theory, and according to it we attach numbers to physical magnitudes by counting successive placings of a metre stick, and by comparing standard clocks. This type of account (see especially Bridgman, p. 9 et seq.) of the measurement process - if it is to be practical - requires that a large

class of objects exists whose size with respect to the arbitrary standard can be relied upon to remain more or less fixed (as can the size of the crystalline solids at room temperature). The phenomenon of quantization is the hidden factor in the world underlying this widespread fixity with respect to the standard.

I now follow Eddington in assuming that the simplest quantized scale is provided by the hydrogen atom. Current theory of the hydrogen atom provides two numerals (dimensionless numbers) - namely the proton/electron mass-ratio m_p/m_e , and the fine-structure constant $\alpha = e^2/\hbar c$. Either of these will satisfy my requirement for a scale, in virtue of their dimensionless character.

Note. It is vital to the argument to take the numerals themselves as the logically prior quantities out of which we may later - though we cannot yet - construct dimensional quantities. Thus it may be to some extent arbitrary how we split these scale constants up into ratios: it is the scale constants themselves we know we should be able to rely on in establishing communication with a very different kind of being from ourselves (like Hoyle's "Black Cloud"). My procedure here is quite different from that of Eddington who did not undertake a logical reinvestigation of the nature of measurement. I shall again rely on Eddington's intuition, later in the proof, when I identify these scale constants with simple constants arising out of the construction of a cybernetic model - since the model effectively replaces Eddington's algebra. It will then be found that I have avoided the logical objections to any such step that Eddington encountered because I have explicitly avoided assuming both that the scale constants are logically primitive, and that they can be constructed as ratios of dimensional constants measured according to the current theory. I shall then be free to estimate my success in identifying the scale constants with properties of the model merely by considering the success with which the model provides appropriate constants.

2. A Cybernetic Model can provide a Scale if it has Levels, and Bisections within the Levels.

Note. I am concerned at present with the logical properties of cybernetic models: I have not begun to use the restrictive conditions defined by their mechanical properties, though these too have a mathematical character in the sense that they play a part in the proof.

Cybernetic models must have an input. In physics inputs are conceived as operators. Hence the model must be conceived in terms of levels such that the components of one level are in the operator/operand relation with components of some other level. In this case a mechanical scale-component can be defined at some level if and only if there exists a division of the operator-components at some other level into two classes. Such a separation into two classes is called a bisection.

Note. The existence of a scale-component is secured in practice in the model by restricting the number of active components at all lower levels. The construction of the model is such that components at one level can be regarded as operators upon the components at the level above, and therefore to impose invariance upon a component at the level above is to divide the components at the lower level into two classes - active and inactive. (Or in the language of Rosenblatt, N.P.L. Conference 1958, a 0, and a 1 class.)

Because of operator/operand relation between levels, it follows that in any interpretation of the cybernetic model the entities the levels describe must exist simultaneously. This type of model therefore describes different levels of analysis of the physical world, an observer may use, and thus the whole model represents the "conceptual framework" of the observer. There is never a sharp dividing line between the conceptual framework and the world. It is always a matter for the experimenter to decide in what detail he will analyse the phenomena he has to describe. Moreover, he must be free to complicate or to simplify his theory (to extend or to reduce the distinctions he makes). This freedom appears to be an essential concomitant of scientific thought.

A very general mathematical model of a system having the required characteristic that an observer may simplify it so as to include as much or as little of its complexity within his theoretical scheme as he wishes, is described by Ashby. (Introduction to Cybernetics, London, 1956, §§ 6/13 - 6/16.) Ashby uses the inclusion relation defined by a simplification process to represent the possible modification of a closed, single-valued system as a lattice. A hierarchical structure is thus fundamental to the present theory of measurement and measurements are always in terms of the most complex structure the model can describe. The present theory is unusual in this respect, for in

hierarchical theories of - for example - the Braithwaite type⁽¹⁾ simplicity arises through lower-level hypotheses being subsumed under higher. And although in the Braithwaite account lower levels are more complex, his view is quite different from mine because the actual place of the theories in the model is practically reversed. Thus quantum theory is above classical mechanics in Braithwaite's account, and below it in mine.

3. Current Physics can be Interpreted as a set of Levels Logically Related by means of an Invariant Scale.

I can describe the environment of a particle in a series of increasing stages of complexity by means of the number of variates required to specify the behaviour of the particle. Following Eddington I call this number the multiplicity factor of the particle in that environment. The first two such stages are the 4-vector and the second order tensor of 16 components. These have multiplicity 3, and $9 \rightarrow 15$ respectively because both include at least one invariant component. For example if we regard them as momentum vector and energy-momentum-tensor respectively then in both cases the invariant component is the rest mass of the particle. In this interpretation of vectors and tensors I am not allowed to introduce metrical considerations. Hence at Stage I the fourth component is always invariant, and to deal with a non-relativistic situation I must go to the greater complexity allowed by Stage II. However the concept "rest-mass" appears in both stages. Hence these stages are different stages of complexity of the same logical system and can properly be called levels. Moreover they are related by the scale term in the following sense: If we represent the relation of the levels by a homomorphism, then there exists a many-one transformation of a subset of elements (including the rest mass) in level II into the rest mass in level I. Finally it is certainly possible to regard the rest mass as a quantum-specified scale in the sense of § 1 provided we adhere to current thinking as far as units of measurement are concerned. This is certainly legitimate since the whole of the present section is valid within current physics.

(1) Scientific Explanation, Cambridge 1953.

Note. Eddington's writings concerning multiplicity factors mix up (a) arguments derived from current physics and (b) arguments which in my opinion can only properly be based on a cybernetic model. Thus his use of the term multiplicity factor is exceedingly obscure. It appears as (a) the number of dimensions of phase-space required to specify a particle in a given environment or "uranoid"; (b) as the number of symbolic coefficients in the E-frame that operate in the mechanics of the particle; (c) as the number of dimensions of a sort of phase-space; and (d) as the ratio of the energies of "top" and "mean" particles in an environment. I do not think it possible to obtain from these diverse descriptions a consistent definition of a multiplicity factor and C.E.G. Bailey has advised a programme of research in which one considers what are in fact "the minimal number of particles required to deduce any property of one or them", and that this programme should be carried out for a good number of the elementary particles. His proposal has the same phenomenological character as the approach I have taken in this section, and can perhaps be made the basis of a technique for calculating multiplicity factors within the bounds of current physics. It refuses to allow the particle any existence over and above the finite set of quantized magnitudes in terms of which it is defined. It effectively insists that a fresh, and perhaps useful - but at any rate safe - approach to theory could be made by discarding all information that we conventionally bring with us to the study of particles in the language we use about them and the way we are accustomed to theorize about them. His approach is not without analogues in current physics. It has points of resemblance to the technique of the Copenhagen school of quantum physicists who follow Bohr (see, for example, Bohr's essay "Discussion with Einstein", pub. in "Atomic Physics and Human Knowledge", Copenhagen, 1958) and who relate the phenomenon of atomicity to the fact that we are bound to describe experiments on the atomic scale by means of two different mutually exclusive sets of macroscopic apparatus. These physicists, like Bailey, make their argument depend upon a very careful and detailed separation of what could in fact be observed from what can only be more or less distantly inferred. If we define multiplicity factor as the number of test particles necessary to specify a given particle, then Bailey's programme has already been carried out by Eddington in the greatest detail and complexity, though - as I think - in such an obscure manner that without Bailey's clarification it is impossible to see what he was doing. The Eddington procedure makes a logical distinction

between the particle whose descriptor is being specified and the particles necessary to specify it, and this distinction is hinted at in Eddington's distinctions between "top" and "mean" particles ("Fundamental Theory", Cambridge, 1946, p. 28). It seems we ought to think of Bailey's method of specifying particle descriptors with this distinction in mind, too, for really Bailey is working with a single real experimental particle but using a set of "test particles" as a sort of analytic framework. Another important point emerges: the analytic framework can be made as complex or as simple as we wish by introducing more or less test particles. This procedure is equivalent to using a more or less complex level. Thus the multiplicity factor specifies the total experimental conditions necessary to detect the corresponding particle. In Bailey's terms it defines the necessary number of test-particles. In Eddington's terms it specifies the appropriate environment for that particle. Let us test this conclusion in one or two simple cases. First consider a classical particle with no spin or charge and test Bailey's method along Eddington's lines. We shall require one mean - or test - particle to collide with the experimental particle to detect the momentum of the particle in the plane containing the paths of both of them. However, to know which this plane is we should have needed to perform a similar experiment with two other test-particles in planes at right angles to the original plane. This particle will therefore have multiplicity 3 - in Eddington's terminology it is a V_3 . The scalar we can add to a V_3 is its mass, for this is the only quantity related to momentum - i.e. to quantities we have already defined. This would make the particle a V_4 . The justification for making the extension $V_3 \rightarrow V_4$ is that in a Minkowski world we should have had to use another particle. It is only in our space-time geometry that the fourth component is a scalar.

Now let us find out what apparatus we need to assert that a particle is charged. A charged particle must be observed accelerating. (It does not seem to matter whether we attribute the acceleration to interaction with one of the test-particles or to an external field - though I accept Bailey's dictum that the observation has to involve a particle.) We already know that our particle - V_3 - has momentum. Evidence that it is accelerating would clearly be provided if we found that the particle had changed its momentum. Suppose therefore it has momentum in one plane, then exactly as before we can repeat the measurement of momentum by the use of a second particle in the same or in either of two other planes at right angles; and by the

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same argument as before we shall need three "second" test-particles. But the first particle was one of three, therefore in all we need 9 test-particles to specify the experimental particle, which is therefore a V_9 . We add the scalar element by the same argument as we used for the mass making a V_{10} , and our conceptual framework is now rich enough to allow us to define this scalar as the charge, for when a particle is accelerated the interpretation which comes logically first is to regard it as charged and as moving in an electromagnetic field.

4. The Logical Relation of Scale and Levels within a Cybernetic Model can be Identified with the Same Relationship seen to exist Within Current Physics, Following §2 and §3 this identification is direct. It enables us to prove the following
Lemma: A multiplicity factor is the number of components in a cybernetic model active in a given level at a given time.

Note. The derivation of multiplicity factors we can obtain from current physics is very restricted. Eddington thought he could go much further in constructing them than we have been able to go, and gave for his main scheme

<u>Level I</u>	<u>Level II</u>	<u>Level III</u>
3	10	136/137

with many variants for different circumstances. He moreover postulated that the two dimensionless constants mentioned in §1 were of the same logical form as these multiplicity factors, and could be derived from them by simple methods. It in fact appears that all we can obtain from current physics is the scheme:-

<u>Level I</u>	<u>Level II</u>	<u>Level III</u>
3	9 → 15	?

and that current physics gives no support for more, and especially gives no support for the calculation of the two dimensionless constants. For this reason the justification for the identification made in the present section is less strong than we might wish, but it is strong enough to enable us to formulate our interpretative principles for the cybernetic model without ambiguity.

Stage II

To show that Measurements must be represented in the Cybernetic Model by Perturbations.

The object of stage II is to deduce what property of the cybernetic model has to be identified with the physical variables whose value is to be compared with the measurement scale.

5. A Variable to be Measured must be the Input of the Cybernetic Model.

This follows from the obvious requirement that we must never be forced into the position of having to interpret a quantity whose value has been imposed by the machine by the arbitrary nature of its construction. Thus the model must have an output which is linear with respect to input in the sense that ratios of outputs must be proportional to ratios of inputs because if we change the voltages or other mechanical quantities used in the model to represent numbers, it is essential we should not thereby affect the results of the measurement. It follows therefore that no meaning can be attached to an operator with a continuously variable constraint. We cannot for example - ask the meaning of a point half-way up the scale from one binary value (0) of a given operator to the other value (1), because any such interpretation of an intermediate value would imply significance for the arbitrary mechanical means we employed to establish the intermediate range (say by a rheostat in a circuit).

6. A Set of Temporally Discrete States is Necessary to Describe a Variable

because an input is essentially a (1) temporal and (2) finite, process. I shall therefore say that the model works in a sequence of scans. [This term is derived from the way such models have actually been constructed, and implies that a time sufficiently short for the machine's state to remain effectively constant can be taken as the temporal unit, and during it the state of the components of the model can be mechanically assessed and readjusted (scanned).] Each scan must assign to the components of each level of the model a temporal order: it follows from §6 that no level can be closed. I therefore

assert that a variable must be represented by a temporal sequence of orderings of components of at least one level of the model. I shall consider such sequences only at the most complex level of the model because components of this level are in the relation of operator to all other levels and therefore input to the model is through this level.

Note. The model is a machine with input. The input represents the disturbance of the model by the phenomena in the world, and takes place at the lowest (most complex) level. One of the types of phenomenon taking place in the world and represented as input to the model is the measurement process.

I call the most complex level in the model at which input takes place, the measurement level.

7. There Exists a Subset S of the Set of Inputs, that Prescribes Measurements of a Variable [i.e. all inputs can be interpreted as referring to a physical variable (§6): of these the set S represent measurements of that variable]. The only physically interpretable numbers in the model (Stage I) are the multiplicity factors. (These combine the concepts "scale" and "level".) Therefore any attribution of numbers to a variable that is to have physical significance must be determined by a multiplicity factor. A multiplicity factor determines a bisection (Stage I) of a level. Hence physically distinguishable states of the model divide the components of the (most complex) level into two classes. The total number of ways of making this bisection is $S = 2^p$ where p is the number of components in the level.

8. A Measurement of a Variable is an Ordered Sequence of Distinguishable States of the Model Defined by the Scale Bisection.

A certain bisection exists in which operators upon the scale are all inactive and the rest active. The system must be in this state before a measurement and return to it after the measurement. Call the finite sequence of scans during which the measurement lasts $t_1, t_2, t_3, \dots, t_n$ and divide S into (a) the classes of components including the null class that remain throughout the measurement either in the active or in the inactive state, (b) the classes of components (including the null class) that cross over during the time of the measurement either from being in the active

class to being in the inactive class or from being in the inactive class to being in the active class. Let us call members of class (b) U-components (U for unstable). Then a measurement is characterized by the number

$$Q = \sum_{t_1}^{t_n} q_t$$

where q_t is the order of class b during scan t. Q has all integral values from 0 to S, therefore Q defines an ordered sequence in terms of the scale bisection. This sequence is available for assigning a value to a physical variable, and I shall call it the measurement sequence. Since the scale bisection is unique the measurement sequence is unique.

9. A Measurement corresponds to a Perturbation of the Cybernetic System. By this statement I mean that there exists a quantity - call it the "perturbation" - that is zero at beginning and end of the measurement and that can be regarded as giving the magnitude of the disturbance to the system caused by the measurement. I prove the statement by observing that I can take Q as the magnitude of the perturbation.

Note. All measurements involve a perturbation of the model, and I therefore regard the ideally simple measurement as the assignment of a number to a perturbation. Hence we get the following correspondences

- (1) measurement = observation + assignment of number
- (2) observation = 1 input to machine
- (3) assignment of number = output of machine.

The view of the essential nature of measurement which arises from the foregoing theory is more sophisticated than the one current in physics, and the former includes the latter as a special case. Measurement, according to the former, is essentially a process of enumerating distinguishable states of a system, and on this basis we can regard measurement as depending on the following physical principles.

I. Measurement is essentially a process of successive approximation in which the degree of approximation attainable is determined by the number of distinct machine states available for assigning a number to the measurement. We can think of these distinct states as each serving to label one step in the approximation process.

II. Higher degrees of approximation involve higher energies, because we are making a general identification of the strength

of the perturbation of the model with the energy involved in the corresponding disturbance in the physical world.

III. The measurement process can be assumed to leave the organization of the model undisturbed only for small energies (i.e. roughly for macroscopic system)

I shall not attempt to describe high energy measurement in which the scale bisection is no longer a possible approximation and where new quasi-stable configurations of the model (to be identified if possible with unstable particles) have to take the place of the scale I have described. I shall however show how the three principles I have stated permit typical low energy measurements (say the range $0 \rightarrow 1\text{eV}$) to be described. Consider the measurement of a wavelength of light in the optical range to an accuracy of say $1 \text{ \AA}$. An instrument like an echelon grating could make the measurement in absolute terms - i.e. in terms of the geometrical constants of the instrument. However, standard practice would certainly be to use such a high resolving power instrument in conjunction with a spectrum (say of iron) which contains a large number of standards, and then to interpolate to find the required wavelength. Details of the interpolation procedure, and measurement of the standard iron lines in terms of the ultimate standard - the cadmium red line - bring up no points of principle and it is sufficient to consider the determination of the ultimate standard. For this we recall the classical work of Michelson, whose technique was essentially to "step off" the cadmium red wavelength against the standard Paris metre, and count the times this had to be done. This determination clearly falls under principle III for the energy involved is small. Condition II is satisfied if we assume the Heisenberg relation (as we are free to do in an example). If the smallest distinguishable wavelength is to be $\Delta\lambda$ then the minimum energy has to be

$$\Delta E = \frac{h}{\Delta\lambda}.$$

It is less clear that a process of successive approximation is involved in the Michelson experiment, because the ideally simple form of the stepping off process - in which nothing in the apparatus changes except the position of a mirror at each step - obscures the application of principle I. The fact that the apparatus has this simple form justifies us in regarding the steps as equal, but logically - as far as our model is concerned - when we have made one step we have only a very coarse grid to our measurement scale, and each subsequent step refines the grid and hence allows a higher degree of approximation in measurement.

Stage III

To Deduce the Existence of a Limiting Signal Velocity in the Physical World.

9. In Correlating Physical Phenomena with the Cybernetic Model, Exact Separation of Levels in the Physical World is Impossible.

We now notice an essential limitation on the interpretation of our model. This limitation becomes apparent when we consider the abstract definition of a level in a model. (It is necessary to consider in the abstract how we distinguish levels since in the physical world - to which the model is applied - we cannot discern connexions existing between mechanical components. I assert that to define a level we must class two components of the model into a single level if we find that the only connexion between them takes place through a third component (which will of course be itself in a different level). This statement is to be interpreted as saying that if we observe two components and find that their behaviour is uncorrelated if we render some third component inactive then those components will be elements of the same level. (It is of assistance in imagining this model to remember that it cannot be a model in which the connexions are provided by mere switching processes; there will always be a time lag, provided, for example, by integrating devices.)

It now follows that since measurement requires an exact scale, the separation of the levels can only be approximate (i.e. there must always be a residual small uncertainty in knowing to which level a component belongs). The scale term at - say - the top level is determined by particular bisections at lower levels, and we have seen that in order to use these bisections to define a measurement process we must have a slow change in the scan order of the measurement-level components. This change in order however, however slow, constitutes a weak direct interaction within a single level, and this is inconsistent with an exact definition of level. Hence exact separation of levels is impossible.

Note. A related problem to mine (of the exact separability of levels) has been discussed in an unpublished work-paper by

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Newell & Simon. They considered "almost decomposable stochastic matrices in which all the components outside a set of diagonal squares were very small - in the range ϵ where $\epsilon \gg \alpha \gg 0$. for ϵ very small. Such a matrix has certain resemblances to models with distinct levels if we take the diagonal squares as the elements of a higher level. The analysis of Newell & Simon did not - unfortunately - proceed very far.

	ϵ	ϵ
ϵ		ϵ
ϵ	ϵ	

Note. The present stage in my argument plays a similar part to that played by the Copenhagen interpretation of the Heisenberg uncertainty principle in current quantum theory. According to the latter, experiments designed to measure canonically conjugate quantities exactly, are mutually exclusive and cannot be carried out simultaneously. There is no exact correspondence, however, between stages in the theories, for in spite of the efforts of the Copenhagen school there remains an ad hoc element in the introduction of the Heisenberg principle in current theory which is eliminated in the present theory.

10. A Constant of the Model can be constructed which Specifies the Greatest Exactness Attainable in Separating Levels in the Physical World. Call it the Measurement Constant.

Let us associate a relaxation time T to the scan process. This can be done in many ways - for example by noticing how long a time elapses between successive appearances of a particular component of a level in a particular place in the scan order. Let us denote the time taken by one scan by τ . Then form the dimensionless ratio T/τ which will be a constant of the system. We should expect without logical error to be able to identify T/τ with some corresponding constant of the physical system of which we are constructing a model. I call T/τ the measurement constant.

11. The Measurement Constant Introduces the "Light-Cone" into a Coordinate System.

The limitation on exact separation of levels specified by the measurement constant is equivalent to the condition that the operator/operand distinction can never be exact. We can give a precise meaning to this condition: we interpret the approximate

character of the operator/operand distinction as an uncertainty in the application of symbols.

(I.e. that there is a finite chance of mixing up operators and operands which are expressed as a set of symbols in a list

$$A(a_1, a_2 \dots a_n) \quad 11.1$$

where the a_i include both operators and operands). Moreover we know that the constant T/τ has to represent the value of this finite chance. We have now to use the identification of levels provided by §3 to interpret operators and operands and the measurement constant, and in fact an application of the operator/operand relationship exists in the interpretation of the elements of the top two levels in the model as coordinates and rotations of these coordinates. However the vectors and tensors discussed in §3 are abstractions from the usual idea of vectors and tensors in which - as was explained - metrical ideas have been eliminated, and therefore it is quite impossible to proceed (as we normally should) straight from this physical interpretation to an interpretation in terms of rotations of coordinate systems.

Note. Arnold Coslow (personal communication 1959) has discussed some of the stages of progressive generalization of the current mathematical idea of a rotation of a coordinate system. He has shown that - starting from the real and imaginary rotations of relativity theory and expressing them in terms of "clumps" (Needham and Parker-Rhodes) a great many mathematical restrictions can be discarded and a generalized notion of rotation can be constructed. This generalized form is then analogous to the extremely general form I claim to be represented by the cybernetic model, because the bisections in the model essentially establish a simple clumping among the components of a level. Thus the model represents an abstract form of the dimensional structure underlying physics, and its use presupposes that this structure has an existence independently of its particular appearance in coordinate systems and rotations of them.

The difficulty I have described - that to interpret levels in terms of abstract dimensional structures is not equivalent to interpreting them in terms of coordinate systems arises particularly over the limitation on the operator/operand distinction.

This distinction has no obvious meaning in terms of coordinate systems and their rotations. Accordingly we therefore have to discover what physical effect will correspond in the field of coordinate systems and rotations, to the limitation on exactness of the operator/operand distinction. I wish to regard the quantity A as the set of symbols describing an event in space and time outside me. Then the state of uncertainty regarding the application of the symbols can only be what is normally expressed by placing the event outside my light cone. The light cone divides events into two classes, and for the events inside the light cone I write

$$A = A(a_1, a_2, a_3, t) \quad 11.2$$

I formally extend the same formula to events outside the light cone by regarding the latter class as those from which we can never receive messages. In the special case where the assumptions of special relativity are satisfied I can interpret my relation as observer to the event A as the distance S_A from me to A and write

$$S_A^2 = a_1^2 + a_2^2 + a_3^2 - c^2 t^2. \quad 11.3$$

In this case the finite signal velocity is the constant c.

12. The Measurement Constant is the Limiting Signal Velocity - the Velocity of Light.

Comparing 10.1 and 11.3 we see that a function of ct in 11.3 has replaced the whole set of operators and left the whole set of operands in 10.1. Accordingly we can identify c with the measurement constant in so far as both are concerned with the relation of operators to operands. Moreover the constant c determines a maximum signal velocity in 11.3, and combining this with the fact that the measurement constant specifies the maximum value of a set of possible measurements we can write

$$c = f(T/\tau) \quad 11.4$$

where f is an undetermined function.

All the arguments I have put forward concerning the constant T/τ would - individually - be equally true of $f(T/\tau)$ where f is any given function. In fact I select $f = 1$, without any loss of generality

because no way exists operationally of distinguishing - say - $(T/\tau)^2$ and $\log_e T/\tau$. As I showed in §3, to make such a distinction would require an independent scale from that which it is the purpose of the theorem to describe. Moreover, I adopt the view that to select any value of f other than $f = 1$ would be a mistake, because we have to identify a quantity which has appeared in the progressive elaboration of our theory, and to give it more complex identification than its nature demands would be to indicate that its identification had taken place at a different stage in the elaboration of the theory.

Note. This process of identification appeared in the writings of Eddington very frequently where it was extremely puzzling: it is in fact characteristic of theories of symbolism in any field which assume that the experimental field can be described with varying fineness of detail according to how indeterminate the symbols are taken to be. Some light is thrown on the identification process by R.B. Braithwaite (Axiomatizing a Scientific System by Axioms in the Form of Identifications: Berkeley Symposium 1958) and by D.J. Newman, (e.g. Entity Structure, Proc. Roy. Irish. Acad. 1958).

I therefore write

$$c = \frac{T}{\tau} \quad 11.5$$

and this concludes the proof.

Note. The physicist will immediately object that T/τ is dimensionless whereas c has dimensions L/T . However these considerations of the introduction of characteristic constants and their identification are, from the present viewpoint, logically prior to the introduction of length and time dimensions. Moreover this viewpoint is not unique. Milne's method is to introduce c as a pure number for equivalent observers. Each such observer defines distance as half the time interval between sending (t_1) and receiving (t_3) a signal at A by A's clock, multiplied by c . This is the distance of B: then the time of reflection of the signal at B by B's clock is defined to be $1/2(t_1 + t_3)$.

Part 2: Variations

The Lingering Death of Western Dualism

A Digest of Discussions at the 'Blue Anchor' Pub On the Gower Peninsula, 1994

I would like to examine, here, and then discuss with you, the strange compulsion we have in our theories of physics to talk about 'the velocity of light' as though it were a fact of nature that light travels in space at a finite and constant speed, c . Now I'm not disputing either the constancy of c or that it is one of the most meticulously measured constants in physics. I simply want to point out (or reiterate, for those who have heard me before) that there is no logical *necessity* to think of c as a speed and that our compulsion to interpret it as such is no more than the troublesome relic of a now moribund yet strangely recalcitrant philosophical dogma called dualism. Let me explain.

Every physicist, however hard-nosed and illustrious, was, of course, once a child and like every child in every culture he learns to distinguish *himself* (his system of arms, legs, thoughts, feelings, and so on) from the general background consisting of other entities, some like himself, such as other members of his family and community; and others unlike himself, such as the sun, moon and stars, animals, rocks, trees, and so on.

As he grows he learns not only to construct more and more of these concepts but also to sort them into various groups and kinds, such as animal, vegetable and mineral, concrete, abstract, material, mental, and so on. Different cultures may differ in the sounds and other signs by which members signal to one another their recognitions of those same concepts and concept-categories. They may also, however, differ far more radically, in the ways in which they form the concepts and categories themselves. Eskimos, for instance, have different names for many kinds of what we call 'snow'. These various arrangements of classes and divisions of experience, communicated by the spoken and written word, bodily behaviour and so on, are what in its broadest sense philosophers call *language*.

There are, nevertheless, common factors in all languages, otherwise those languages could never be interpretable to one another. What culture, for instance, fails to distinguish day and night or up and down? Thus we may talk of a *sense* of things which is common to all cultures and which we may take as the basic meaning of 'commonsense'.

Accordingly, let us call that globally common way of looking at the world the Normal or Commonsense way. But now we come to that culture which is founded on the traditions of our Western science. Here, the child begins in the commonsense manner of all cultures, by classifying and categorising his forms of experience in a communicable and socially acceptable way. However, as he grows he imbibes, in one way or another, the idea that the things he perceives as 'other than himself' are not what they seem; that they are no more than sensory representations, or *impressions*, which he constructs in his mind out of little bits of energy given off by the only truly real things, *atoms* (or, as physicists now say, 'fundamental physical

particles'). And modern physics tells him that the fastest possible speed at which that energy can be transacted is the 'speed of light'.

His perceptions are therefore always what scientists call *localised*; that is, always to some extent or other remote in space and time from the actual reality of physical things, which are also localised, or isolated in the same way from one another. What things *really* are or how they are 'in themselves' is thus, if he thinks about it, a complete mystery. All he can ever do, at best, is to guess what they are from his own sense-reconstructions out of whatever bits of information those things may happen to throw off into space and which, after travelling for aeons in some cases, may just happen to impinge on his sense-organs or scientific instruments. And since there is no way of knowing those things as they are 'in themselves' other than through those intermediary processes and end-impressions, then how can he ever know whether those impressions are true or false? Thus, at his first flush of intellectual awareness he is confronted with a great problem which is endemic in our whole Western way of thinking and which philosophers call the *Problem of Knowledge*.

This, it needs to be stressed, is no mere academic problem. It means that in our society we all suffer, in one way or another, from an institutionalised schizophrenia in our attitudes towards 'reality'. For a symptom of this malaise we need look no further than at the way in which our educational institutions traditionally distinguish, in an entirely polarised way, between Arts and Science, between, on the one hand, subjects like Philosophy, Psychology and Theology, and, on the other hand, subjects like Physics, Chemistry, Mechanics, and so on, as though that split reflected some real, radical divide in nature. Indeed, our very language has evolved around this same dualistic assumption, with its category distinctions between 'mind' and 'matter', 'body' and 'soul' and so on. This 'double-talk' in which we direct and organise our thoughts and actions signifies that right at the very root of our Western society there is a built-in duplicity which makes us think, speak and theorise, however inadvertently, 'with forked tongue'.

There are all sorts of social problems arising from this, not least of which is the question of whether to put our faith in 'the appearances' (the 'mental' world) and go for the Arts, as I say (or Humanities, as it is now more often called) or to believe in the underlying atomic sources of those appearances (the 'world of matter') and go for what, by implication might be called the *In-Humanities*. If we go for the Humanities, then those Sciences which are modelled on Physics are inimical to us, since they are, to us, so innately 'mindless and materialistic'. And if we go for Science, then all talk of humanitarian (i.e., 'spiritual') values, such as justice, morality and – needless to say – religion become no more than psychological or social 'conventions' – meaning that in what we implicitly regard as the 'real world' of stars and atoms none of these things signifies, or that they signify nowhere but 'in our minds. So the only 'God' the Science-sophisticate can contemplate, if any, is some great and utterly detached 'Design-Engineer' of the mechanical scheme of things; and the best that remains of 'morality' for him is to remain cynical or stoical in the face of a beautifully ordered but uncaring universe. The more popular this despairing sort of 'realism' becomes the more the premiums fall, especially in the young, either on philosophical indifference or on escapism by whatever means is available – in some form of religious or political dogma, perhaps, or in 'wine', as Omar Khayyám advocated – or drugs, as is nowadays more and more commonly the case.

The scandal is that in the two thousand years or so of the formation of our present culture, and despite the fact that practically all of our academic institutions of philosophy have been devoted to solving it, there has never been any satisfactory, authoritative solution to that Problem of Knowledge – nor, needless to say, to all the social and intellectual confusion this Problem has generated. Doubtless, this is why practically-minded people like physicists, tend to avoid the subject of Philosophy like the plague – because studying it, as everybody knows, 'gets us nowhere'. However, that mind-bending 'Problem' which has for so long enervated our philosophical institutions – not to say our whole society – is, as it transpires, really no more than a conventional, self-imposed logical trap, a conundrum. The reason, as it turns out, is astonishingly simple. If we say there is a 'veil of perception' preventing us from knowing things as they really are, then how can we claim, in the same breath, to *know* that there is some problem about knowing them? In other words, how can there possibly be a 'Problem of Knowledge' concerning things that cannot possibly be known?

Realising this, some modern philosophers have completely changed tack. Instead of perpetuating the vain academic task of seeking to *solve* that insoluble problem they have sought to *dis-solve* it, declaring it to be what the philosopher Wittgenstein called a *Scheinproblem*. In taking that different course, however, these philosophers have had to break with the traditions of what they call the 'scientism' which creates and sustains that problem with its ideas about how our perceptions of things are separated by a vacuum and mediated by light. Accordingly, they have cast off all connection with that Western tradition of dualism and reverted to the alternative way of thinking identified at the start as the Commonsense way. Unfortunately for these new 'Commonsense' philosophers, so prestigious has that 'scientism' now become and so endemic in Western culture is its idea that the light by which we perceive things travels in space, that in going out on a limb against it, these new Commonsense philosophers have seemed 'unscientific' – that is, at best irrelevant and at worst ridiculous.

But now things are definitely beginning to change. Since the discovery of *relativity* and the *quantum* each new discovery nudges modern science more and more in that new philosophical direction. That is to say, among scientists the realisation is gradually dawning that our ultimate observational interrelations with external objects are not mediated in the way we have customarily supposed, by light-waves or light-particles ('photons') starting out from atoms at one instant in universal time and finishing up in our nerve-endings or sensing-instruments at another. A little-known chemist, Gilbert Lewis, showed in 1926 that in what relativists call 'proper-time', these 'photons' are not travelling particles but quantum-events happening at the same instant to both object and observer. In other words, he showed, in effect, that *there is no longer any scientific justification for thinking of the physical world and the perceived world as inexorably separated*. At the most basic level common to all perceptions and physical processes – that is, at the fundamental quantum level – those 'two worlds' are now seen to be, logically, one and the same. [Demonstrate. See OHP.1]

The philosophical consequences of this radical shift in scientific thinking are profound – some find it even disturbing. Perhaps it is fortunate, then, that the realisation of these

consequences, even in science, is slow in coming. However, for anyone with the temerity to consider them, these consequences are as follows.

In classical physics, the ways in which things and collections of things configure as *wholes* were confined entirely to perception and were therefore, in comparison with 'physical reality', illusory. So if all perceivers disappeared, then all that would remain, in some way which it is impossible to describe without equivocation, would be the ultimately reduced and further irreducible *sources* of our perceptions; that is, atoms, floating in a self-sufficient void, as mindless of one another as of the absence or presence of ourselves. In modern physics that complete, dualistic dissociation between 'the world of wholes' and 'the world of parts' disappears and, as soon as ever we come to realise it, along with it goes our old schizophrenic view of reality. The wholes and the parts then come together in the one and only real world that it makes sense to speak of, the world that stands right there before us.

What some find so disturbing about this is that since only perception can interrelate one mindless particular and another, this new emphasis on interrelations among things, which we call *relativism*, seems, to them, to 'mentalise' the world, reducing everything to perception, which we are accustomed to think of as a world of illusion. However, if the old dichotomy between 'mind' and 'matter' is false, then to deny that everything is matter no more proves that everything is mind than denying that a man is Welsh proves that he is English.

By the same token, 'humanising' science in this way by no means reduces the world to human proportions, any more than 'relativising' it reduces it to the perceptions of a single observer (i.e., oneself). In relativity, 'an observer' may be anything from a scientist or a scientific instrument to the smallest and simplest object there is. What qualifies something to be an 'observer', no matter how complex or rudimentary, is simply its capacity to *relate* to something other than itself in the context of the whole interrelational network. An atom, for instance exists insofar as it is a rudimentary 'observer' that can communicate its existence to (i.e., interrelate with) another atom in some holistic, observational/experimental context – for example, in transacting optical energy-blips of an identifying spectral signature or, at the very least, in contributing to the overall balance of angular momentum of the stars, planets and so on. The *world*, according to modern science, is therefore a *communicational* system of indeterminate quantum-transactions, as different from the old 'mechanical universe' as a computer is from a steam-engine.

In being forced, in this way, to become at least as much the study of systems of interrelations (wholes) as of atomic relata (ultimate parts), relativistic physics has become what commentators refer to as *holistic*, as opposed to the partistic, or *reductionist* character of earlier Physics. In other words, in this new holistic approach, the emphasis in the scientific search for reality shifts away from reducing everything to 'elements' (i.e., fundamental particles, numbers, or whatever) towards discovering what things are and how they function, first and foremost, as integrated and interrelated wholes. This result of the combined relativising and quantising of modern Physics has therefore made the subject fall more and more into line with the basic Commonsense form of realism described at the beginning.

The main philosophical consequence of this scientific 'sea-change' is that in becoming relativistic or relationist, modern physics now accepts, as natural objects of serious scientific study, many of the things and situations formerly regarded as capable of existing only in the human 'psyche'. Thus, as other sciences like biology and zoology have already been forced to concede that *intelligence* is no longer an attribute solely of human behaviour but that it extends also to animals and even vegetables, so physics has now had to follow suit in attributing intelligence (holistically, that is) to the last remaining category, that of *minerals*. Thus, intelligence, under the new neutralised name of *information*, is now, a universal attribute in which *all* natural processes, physical and mechanical as well as biological, partake to a greater or lesser extent. The fact that it seems nonsense to attribute intelligence to minerals – as someone said to me 'Does that mean that we can expect there to be conferences among flat-irons?' – merely illustrates the extent to which our dualistic 'double-talk' ill-prepares us for such logical developments.

Now some might say that a 'universal intelligence' is, by definition, a deity. If so (and that inference, of course, whilst logically permissible is by no means logically obligatory), then any deification of Nature or cosmism according to this 'new deal' in science would have to be what theologians distinguish as a *theistic* rather than a *deistic* conception: that is, a *communicating, information-transacting* deity, not a machine. Moreover, with the removal of mechanical certainty the essence of *morality* is restored as a principle of nature in the *responsibility* this places on organisms capable of choosing between one course of action and another, for carving out their own futures – in the same way that being free to operate the keys on my word-processor makes me responsible for whatever communicational triumphs or disasters that instrument produces. By the same token, principles like justice, right and wrong, good and evil and so on, cease to be what science has so long regarded them, as mere ideological noises made by priests and politicians and become, once again, all part and parcel of the evolving global Commonsense ontology. That is, they complement the laws of physics, mechanics, medicine and so on, as factors in the same holistic (or, in terms now regarded as archaic, 'holy') equation.

This promise of a reconciliation between modern science and what we customarily regard as 'mysticism' is, of course, disquieting to Western traditionalists – especially since some physicists seem to have gone to what those Western traditionalists regard as mystical (usually Eastern) extremes. Such rapid innovation, however, inevitably produces polarisation into a radical Left and a reactionary Right, with all sorts of shades of difference and indifference in between – indeed, the 'don't knows' and 'don't cares' are doubtless well in the majority at present. However, when all this settles, as sooner or later it must, then perhaps we just *might* witness what some foresee as the dawn of a New Age of true understanding, when the collapsed philosophical underpinnings of Western politics are renewed, when ordinary commonsense *wisdom* catches up with the expansion of scientific and technical knowledge and global *communication* replaces the now cynically accepted self-centredness and strife.

N.V. Pope, 'Llys Alaw', 10 West End, Penclawdd, Swansea, West Glamorgan, SA4 3YX, United Kingdom.
(Philosophy Research Associate of the Department of Mathematics, University of Keele, Keele, Staffordshire.)

The Language of 'Light Velocity'

by

N. V. Pope

The following is a Transcript of a tape-recorded discussion at the sixteenth meeting of ANPA, at Wesley College, Cambridge (September, 1994). My paper was to have been 'The Lingering Death of Western Dualism'. However, due to an exigency to be described, this talk was delivered *extempore* and is now entitled as above.

'Ladies and Gentlemen – Surprising how few ladies, in fact are here!'

Standing before the rostrum, he takes the paper out of his briefcase and, as he prepares to read it, suddenly crumples it and tosses it aside.

'To hell with it! I've just come from London after reading a paper on this subject of "light-velocity" at Imperial College and I have to confess that its reception has left me feeling very disgruntled. I had a wild thought, just now, that I might avail myself of the precedent set by our founder-member here, the illustrious Professor Kilmister, for relaxing into the vernacular in order to describe that feeling and the reason for it. But I have talked to too many nice people over coffee and my intentions in that respect are now somewhat muted.

'You see, I am a philosopher. Let me remind you what that means. Socrates was a philosopher and someone once said to him, "The Delphic oracle has said that you are the wisest man in Athens. Do you agree?" "Yes", replied Socrates, simply. His inquisitors were appalled at what seemed to them sheer arrogance. "How can you say that?" they asked him. "Because," said Socrates, "we are all of us ignorant; and since I seem to be the only one who knows it, then to that extent I am the wisest man!"

'Now whether or not that is true is not the point. The point is that it defines the true spirit of philosophy. The philosopher, which is what I am, is a professional ignoramus. He is the sceptic, if you like, whose aim it is to seek out and destroy all mere *pretences* at knowledge.

'Okay, so let's see why I'm so cross.' *Placing a blank transparency on the OHP he scrawls*

The speed of light in vacuo

'Now just look at this: "The speed of light *in vacuo*." That is taken by just about everyone as a sensible factual statement of experimental physics. Indeed, Pierre (Prof. Noyes) and I have been discussing this at PIRT, and he has announced that I have got my wires crossed on this issue of the speed of light. The phrase, he says, makes perfect sense to his Experimental Physics colleagues. But I shall demonstrate, here, that it is Pierre and his colleagues who have their wires crossed.' *[laughter]*

'I mean, Pierre, *[pointing at the statement on the screen]* how can that be? How can we even pretend that it's true? No-one has ever observed light travelling in a vacuum. This was well known to those physics teachers, the monks of the Middle ages. If you direct a beam of light through a hole in one side of a barrel so that it goes straight out through a hole in the other side,

then there's no way you can observe that light by looking down into the barrel. "The beam" as we call it, is completely invisible and you can tell that it is there only by putting something into its path, like smoke or grains of dust.

'And it is only by putting other such detectors between a light-emitter and a light-absorber that any modern physicist can say anything about the existence of light in a vacuum. And that's not all because, logically, wherever you put a detector ceases to be a vacuum. And if you want to prove that the light is there continually in that distance between A and B then you have to put your detectors everywhere across that distance; and then you have a continuous medium, not a vacuum. So not only is "light *in vacuo*" impossible to measure experimentally, it is also logically impossible to conceive!

'So [*pointing to the screen*], what the *hell* are we to make of that statement? Yet the whole of modern physics is based on that continuistic conception of light as being a something that *travels* entirely invisibly and inscrutably in a continuous nothing at a constant and universal rate *c*. You tell me what sense it can make!"

Prof. C.W. Kilmister : 'You say, "How can you observe it?" Okay, now suppose a physicist says to you, "I have a source of light here and a receiver there, and in between I have a long tube." He exhausts the air in the tube. Then he shines a light in one end of the tube, detects it at the other end and measures the distance and the time. Now if he wants to describe that as the light moving from A to B, he is not doing anything in a vacuum, is he. He's doing it outside!"

Pope: 'Yes, now that kind of thinking is fine for engineering-type purposes; bell-jars, vacuum-tubes ... and things like that. That's *one* kind of language-game.. But what I'm trying to say is this; when you're talking about *quantum* physics, about physics on that absolutely fundamental kind of level, as we are, here at ANPA, you have to divide-through by that "engineering" sort of language.'

Dr. P. J. Marcer: 'But surely, Viv, that is not the only game of fact! The point that Pierre has always been making is that in the game of experimental physics a description has no meaning until you can make a prediction and do some engineering-type experiment whose results correspond with the theory or the prediction. That's the way the world *is*, and if we don't like it that way, then that's fine. There are virtual realities and whatever, but in the world we live in, *that's* the reality that Pierre describes.'

Pope: 'Yes, Peter, but when engineers talk about, say, measuring phlogiston or ectoplasm, then I feel that as a philosopher I should step in. So the point I would make to Pierre is that every experimentalist makes *concealed assumptions*, even in what he may regard as the plainest and most factual possible observation. But may I just develop my argument first and then do the questions at the end.'

Prof. H.P. Noyes: 'I'll just put in a caveat. It is now possible to measure what is called the scattering of light by light, and therefore to treat light as something travelling in that sense. In the same sense that you scatter particles, you scatter light from itself. The existence of that calculation before the experiment that convinced Bridgman that light could be thought of as something travelling ... Bridgman was the person who originally criticised the idea of light as

something travelling. He made a big thing of it in the *Logic of Modern Physics*.¹ But after various calculations of the scattering of light by light he withdrew his objections – provided it can be done experimentally, and it *has* been done experimentally.²

Pope: 'Yes, I remember a time, Pierre, when you believed that what I was saying (about light) was acceptable. And something has since changed your view. I see now what that was. But what I am saying is that it's all a matter of the *interpretations* we give to physical events, to the results of experiments and so forth. These don't just fall out of the sky! They are ones that *we create*. And they are always *revisable*. We don't have to take the interpretations that were given us when we went to school, got our degrees or whatever and just say, "Well, that's it from now on; all we have to do is build on that." *All* these things are re-interpretable if the need arises.

'Besides, it would be a disaster for *your* theory, Pierre, if light *did* travel in space in the way you say. Let me explain why. You are mixing up *continuistic* ideas with *discreteness*. One of the things I find very strange is this. Take a detection-event – a "firing" in your terms. Now [pointing to the OHP] I have a piece of paper (transparency) here, which is very convenient. I can say to you "Take this as the universe ..." Now I'm caught straightaway! I draw a point on it and say "this is an emitter and this (another point) is an absorber." And you say, okay, now something has to happen between here and there – like in your "tube", Clive – otherwise how does the quantum leave here and appear there? So we come up with the concept of a "photon", something that "travels". A travelling particle, why not! But you are already caught, because it is very difficult, now, to drop that idea once you've got it up here, in your head!

'So, then you say, Gee! People like Aspect have shown that this and that (the points on the transparency) are connected together in a "superluminal" – that is, instantaneous – kind of way, so that if this is part of the Thomas Young experiment the photon "knows" immediately that it cannot go just now or that it cannot arrive there because it will be out-of-phase ... and so forth.

'So now that you've got this idea of the "photon" at the back of your mind, you are already committed to mysticism, because you now have to think of how that photon, as a travelling particle, can "get instantaneously" from here to there. Where it seems we get our wires crossed is where we say: "This (the transparency) is the space, and the problem is how, in this space, does the influence get from there to there". Hell, the *space itself*, if you are a discretist, has to be digitalised in the same way as those points.

'So you can't say "I'm a digitalist, discretist, combinatorial hierarchist" or anything like that and then say "Yes, well, light travels in a vacuum between those points and we prove this experimentally" because you *cannot* prove it experimentally. The space, the points, the vacuum, the whole shooting-match, has to be thought of in *information-theoretical* terms: discrete, stochastic, indeterminate, probabilistic ... *that's* the name of the game here at ANPA. Once you bring in determinacy, continuity, light travelling continuously in a continuous space, your discreteness is gone, your *information's* gone ... *everything's* gone.

'Now that's what made me cross at PIRT, listening to people talking about quantum physics and pointing to pieces of paper like that, saying "It's all happening *there, in the universe*". Something's terribly wrong with that! [pointing to 'speed of light' phrase on the OHP screen] It's

¹ P. Bridgman. *The Logic of Modern Physics*, 1927

² This compares with the refuted claim of Prof. Grosman's colleague, Prof. Abramson, to have actually photographed 'light in flight' (flying photons). [Copies of correspondence available – my ref. 3961-66].

no more than a *pretence* at knowledge. I might just as well have written, 'Why is a mouse when it spins?' There's no empirical, experimental or logical justification for it.

'Another catastrophe connected with that is this. Of course, if you are a physicist who is not bothered with philosophy, then this won't concern you. But if you're a *philosopher* you can't help seeing that if you're going to speak about the speed of light in space – if you're going to say that all causal influences are propagated *in vacuo* at the speed of light – then you are committed, whether you are aware of it or not, to a *localist* view of physics which makes it a complete mystery that things happen the way they do, in the way people like Aspect describe. Look, I'm walking about here. You know that as I'm doing so I'm *immediately* altering the balance of the solar system. I'm affecting everything around us, to some extent or another.³ But if that effect is confined to the finite speed of light, then when I stumble, like this, its effect would have to travel to the stars and back, so my momentum may make me fall not here, in this room, but somewhere else, maybe miles or millions of miles away, years or millions of years later if I were still around.⁴ Everything would be "out of sync." Take your holism, Alison (Watson). How would *that* work if you think in terms of the finite speed of light?

'So now you are caught – you see how the scenario goes! If you are aware of this problem you say "Yes. I see that. Hm! So there *must*, then, be some *superluminal* influence responsible for that holistic hanging-together of the points you've drawn on that paper." Boy, now you're in great trouble, because look at this. [rummages for a diagram from the PIRT talk] Here you can see (in Figure 1a) that there's *no* velocity limit. None whatsoever! You *make* the limit – by choosing the *wrong* clock. In both these diagrams the distance is the distance you

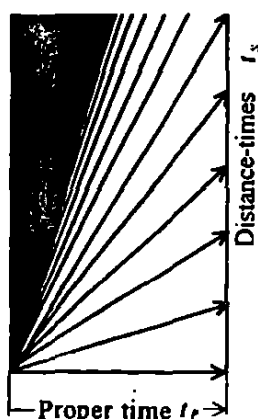


Figure. 1a

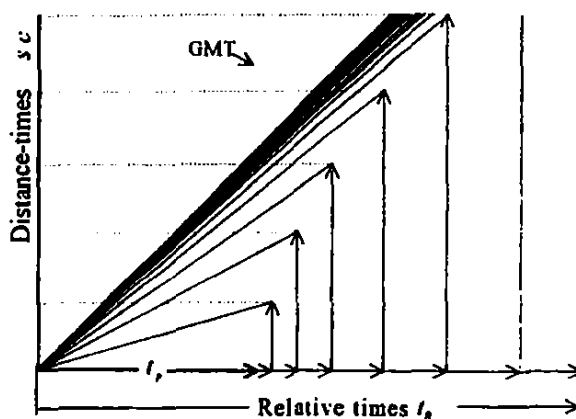


Figure. 1b

The comparative proper-time and relative-time aspects of motion. Note that in Figure. 1a the velocities increase without limit. In Figure. 1b they tend towards a finite limit where the ratio of units of distance-time to time is one – that is, $s/t_r = c$

informationally video-project⁵ as travelled by a body between two points A and B, and in this one (1a) you measure the time of that motion as you read it off the clock of the *body* that is travelling. And what do you get? You get the usual Newtonian picture of motion whose natural

³ That is, by the laws of conservation of energy, angular momentum and so on.

⁴ As Prof. Tom Phipps Jr. quotes Mach as saying: 'When the subway-train jerks it is the fixed stars that throw you down.' Reported in P. Graneau, 'The Riddle of Inertia', *Electronics World*, January 1990, p.62.

⁵ From observational patterns of what Manthey calls *co-occurring* quantum-events, which patterns, in the phenomenon of motion, change with observational time.

limit –or non-limit, rather – is infinity. In this case there can be *no problem at all* about instantaneous action-at-a-distance because, as you can see, there's no finite limit to physical interaction.

'But now you *make* it a problem because you unnecessarily – and with all respect to the great Einstein, he made the same terrible mistake here (may God help me for saying so) – you *unnecessarily* time the motion by the *other* clock, the clock of the observer. If you do that, then you get this other picture, here on the right (1b), which shows that same instantaneous speed as a *finite* limit.

'But it works! By that same *laboratory* clock and *laboratory* apparatus, the more energy you pump into a body to produce motion, the less and less the result manifests itself as motion and the more and more it manifests itself, therefore, as mass. Hey, relativistic mass! That's fine! One is not denying that these relativistic effects take place. What one is saying is that *nothing can go faster than light* because *light doesn't travel*. It's just a constant of scale in drawing the diagram. It's just like the ratio of 39.37 inches to the metre. You wouldn't be puzzled if you found that that constant is the same for everyone here, for all observers everywhere, no matter whether they were stationary or moving relatively to one another! But if you are going to call the constant *c* a *velocity*, then you make like Michelson and Morley. You start to wonder, Why the hell am I not travelling relatively to that constant? And that makes a "pig's ear" of the whole issue.

'Look, as I have demonstrated here (at ANPA), perhaps *ad nauseam* for some of you, this is all "relativity" is [draws following diagram, Figure 2]. As I say, this is all Relativity is! It's child's play! It was tried out on an average fourth-form and the teachers reported that everybody got it.⁶ This [indicating the vertical side of the triangle] is the observed distance a body moves in space. That (the base of the triangle) is the time you read off the body. And that (the hypotenuse) is the time-dilation. End of story! That's no more and no less than what relativity says. If you link time and space by the scale-constant *c* – thinking of it as no more than a conversion factor – then it follows that if you travel in space you travel in time. That diagram is perfectly simple. All you need in order to measure that time-dilation is a ruler and set-square. Otherwise, if you want to be mathematical about it, you can use the theorem of Pythagoras. Einstein's formula, the barbarously entitled 'Lorentz transformation', can then be deduced from the Pythagorean equation for the hypotenuse of that triangle in a few lines of simple algebra.⁷

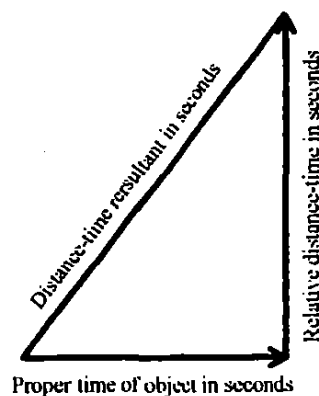


Figure. 2

'But doing it the *other*, the standard, way around has made a tremendous mess of this! You try to draw that diagram in *that* mode [replaces previous transparency and indicates Figure 1b) and, boy, you get some complicated and puzzling drawings! ... *Unnecessary!* So all I'm saying is that if you insist that light travels in space, that it *shines* in space, if you think like that

⁶ See *School Science Review*, June 1989 70 (235), p 86.

⁷ See *Alternatives*, (Proceedings of ANPA 15) pp.118 - 121. Also, Pope, N.V. & Osborne, A.D., 'A New Approach to Special Relativity,' *International Journal of Mathematical Education in Science & Technology*, 18, 2, March-April, 1987.

and talk like that, that between here and there (the points on the original 'bit of paper') you have, say, an "information-wave", then that's sheer nonsense. What the hell is an information wave when it's *between* there and there? That's a metaphysical line (*null geodesic*) that I've now drawn between those two points. How can *information*, as such, travel in a *vacuum*? A Schrodinger probability wave-function, then? But how the hell can a "probability-function" – or, indeed, a *wave of anything* – travel in a vacuum? What is it when it's on its way between the one place and the other, travelling at the "speed of light"? It's utter nonsense! There is no way, *no way at all*, in which you can make philosophical sense of language like that!

Dr. Bastin: 'What about an object which is travelling within a hundredth of the speed of light?'

Pope: 'That's okay, Ted, no problem there! If your object is travelling at, say, point nine-nine-nine-recurring of what we call the "speed of light" here [*indicates Figure 1b*], then it has a mass which increases consistently with that speed. But the *photon*! ... The photon has *mass*, for God's sake! It's got a frequency, and therefore an energy which, divided by *c*-squared is a mass. So if it's got a speed, then at that "speed of light" its mass should be infinite. Yet the photon, "travelling at the speed of light" has a mass in the order, for visible light, of about ten to the *minus* thirty-eight kilograms!

'And you see how people hedge, in saying that the photon's "stationary mass" is zero. They *have* to hedge, now, because, as my Grandmother used to tell me, "Oh what a tangled web we weave when first we practise to deceive". Well, it's *this* that makes me angry, this *pretence* at knowledge. We deceive ourselves! As George Berkeley said, "We kick up a dust and complain we cannot see."'

Marcser: 'You could change that for "Oh what a tangled web we weave when first we practise to perceive!" [*laughter*]

Pope: 'Well, ... Sure, Peter! But I don't want the point I'm making to be lost. You must understand that I'm using ignorance as a tool here, my tool as a philosopher. And I have to say that I cannot see *any sense at all* in the idea of the "speed of light". Nor do I see any *necessity* for it – I see things much, *much* more clearly without it. Without it, relativity, as I say, becomes literally child's play.'

Kilmister: 'I want to take up something that Ted said. I feel I don't really understand your answer to him. In your diagram (1b) you have a whole range of velocities which get nearer and nearer to *c*, and there's no problem with that. With those you can talk about travelling. And then, suddenly, you have a sort of discontinuity. As soon as the velocity is *actually c* then you mustn't talk about travelling. I mean, doesn't it worry you that there is this peculiar discontinuity in description?'

Pope: 'No, Clive, it doesn't. There is no discontinuity because you can never *actually* reach *c*.'

Bastin: 'Would it worry you if I said to you, suppose it's travelling ... [*question indistinct*]⁸ ... In some sense the expression "the speed of light" is simply ... [*indistinct*]...'

⁸ Dr. Bastin's position opposite the OHP shielded him from the microphone.

Pope: 'I do that because I have to genuflect to the old ideas in that sense, because ... Well, if I were to tidy up the language it would confuse the whole issue here, because it would be too simple. Let me put what you've just said in this way – I'll paraphrase what Clive has just said. [points to Figure 1a] "When you actually reach infinity, here, doesn't it worry you that it's okay for objects travelling right up to that asymptote of infinity but not at that asymptote itself?" No, obviously it doesn't worry me because you can *never* do that – travel *at* that asymptote. No physical object can. It's not a *speed*. It's a different thing. There is a *conceptual* discontinuity there although there is no physical discontinuity. You can forget about anything travelling *at* the speed of light, so if you say the photon travels at the speed of light, then that's no more than part of the general fiasco.'

Bastin: '... [bits of recording again missing] ... Now he (McGoveran) is altering the language. Now what he did ...' [recording lost].

Pope: 'Well, McGoveran and I may have to discuss that, Ted. Look, I'm not saying for one moment that I'm trying to upstage him and become famous for this. I just want to *know* what I'm being told.⁹ If someone like McGoveran tells me something I can understand, then ... okay! ... Mike, how are we doing for time?'

Manthey: 'You've used half an hour. I want to ask a question. It has always made sense to me that one can take this argument about the speed of light and say, actually, well, it has to do with creating conceptually consistent descriptions. You want to introduce this idea of a maximum velocity for the transfer of information in order that you do not introduce causal inconsistencies in any frame of reference. And then you get out of this whole business of things travelling in space ... Really, what you are doing is introducing a conceptual limitation which, in certain respects *looks* like the speed of something travelling through space, and in other respects *looks* like a conceptual requirement to maintain the consistency of separate events. I have no problem with that!'

Pope: 'Sure! The other day, my grandson asked me how does a radio work. I gave the usual "simple" explanation of a transmitter there and a receiver here ... and so on and so forth, in the way I was taught as a communications engineer. I mean, I learned all that stuff: Maxwell's left-hand rule, the lag and lead of a current, the bumpety-bump model of how dielectric displacement-currents are propagated *in vacuo*, *via media* – the whole damned thing! I earned my bread by it! So, yes, you can do that! But if you're in a society where everybody starts off counting horses by counting their legs and tails and dividing by five, then you can always get ways of adjusting that to deal with odd occurrences of horses whose tails have been docked, or who have legs missing or whatever. Those are "paradoxes" of the system. So you say, well, okay; and you generate new theories to take care of them. But at the end of the day, two thousand years of that would get you into the state we're in now!'

Manthey: 'Are you saying you have never heard this argument that the speed of light could be a conceptual device to preserve causal consistency?'

⁹ I had meant to add that 'The lives of philosophers are like those of spies. Their aim is to *know*, not to be known.' (anon.).

Pope : 'Yes, I've heard of it, Mike, but I don't see that it's *necessary*, you see! I would say, in this case, let's just count the horses. Never mind the legs, the tails, the this or that ...'

Dr. A. Deakin: 'Many people say they *do* count the horses. What you seem to be complaining about is, may I say, "horses for courses". You seem to be complaining that there are two different types of linguistic usages. One is older than the other, and you would say that these usages are inconsistent. But you have to remember that *all* our language-usages – and as a philosopher you should know this – are inconsistent. We simply recognise – or we should – when we're switching from one to another. So, for example, when a relativist talks about, say, the light travelling from here to there, the quantum mechanist will look at your photon-emitter and absorber and say, look, whatever happens here, all I know is that I had a counter near the emitter and a counter on the absorber and they both fired. But when the absorber persistently fires after the emitter, and that's the only thing I observe, I observe a lapse of time. There is no space, there is only time, there are only events. A relativist who's discussing particularly the higher part of the theory, doesn't need to use that kind of language. And if you insist on interpreting by using that kind of language, then *of course* it will make nonsense!'

Pope: 'Tony, I once heard a joke about what they were going to do in Ireland. They were going to change everybody to driving on the right. But they were going to let it happen *gradually*! [laughter] You see, Tony, that's maybe what we've done and that that's why it's all such a shambles! Perhaps it's why all our concepts are always clattering into one another. But I wonder if you understand my position. What I'm trying to say is this: you can talk about velocity, you can talk about space – this may answer Clive's point as well, and perhaps Ted's – you can talk about all those things, but you've got to remember that at the end of the day you are talking about *informational sequences of spaceless and timeless events*, and if you want this to remain a consistently *informational* exercise ...'

Deakin: 'Viv, you can't talk about sequences if they're not times.'

Pope: 'No, Tony, of course! Time and sequence are one and the same to me.¹⁰ I have no problem with this. Time *is* sequence. No sequence, no time. But you find people imagining that there is just one great time. However – and Pierre and I have discussed this – time has to be *purely statistical*, otherwise you lose your *informational* standpoint. Statistics, information, all these things go together. Lose the one and you lose the lot. The picture that Stephen Hawking presents – and you and I, Scott (Dr. Starson) were discussing this in the car – is a God's-eye-view of things, like the way I can take this bit of paper and draw all the various bits of "the universe" upon it. What Stephen Hawking doesn't realise – what cosmologists in general don't realise, and which I hope I am somehow getting through here, at ANPA – is that our conceptual bank-account, as it were, is that of *information-theorists, discretists*. Butchers, bakers, engineers, people who make tubes with standing-waves in them and so on, have their *own* conceptual bank-accounts. That is, they need to be free to speak in the way Tony wants them to. But my point is that *we* don't. We are only going to confuse ourselves if we mix up all those different

¹⁰ Time is also quantised. It goes only from one quantum-event to another, in discrete and irreducible quantum leaps.

bank-accounts. I go along with everything that Pierre goes for, for instance, insofar as I understand it. But I can't see how he can have his cake and eat it. He can't have fundamental discreteness, discontinuity, information, and all that, *and* still talk in the old continuistic way about the speed of light in space.'

Deakin: 'It's only a *convention*.'

Pope: 'Only a *convention*? But, Tony, if you go to court and the judge pronounces you guilty, you don't say "Well, that's only a convention." I can just see you, as they escort you down to the cells, murmuring, "It was only a convention, only a convention ..."'

Deakin: 'It's a convention which is *useful*.'

Pope: 'It (the courtroom "convention") is more than just useful, Tony, it's vital. Alison?' (Dr. Alison Watson)

Watson: 'Can I make the point that Tony is talking about, that ... ¹¹ we can only speak in terms of the classical concepts. There is a very peculiar trick going on, and that is that you can say "*A* fires and ... *B* fires ... But the point about that is that if you can't say anything about what happens between the firings, then you are in the very paradoxical situation of trying to explain the microworld in terms of the macroworld. So you are not explaining anything at all. All you can say is that this happens and that happens, but that is a (religious/invidious?) position to be in, otherwise you are not allowing yourself to speak about it.'

Pope: 'Yes, you see, Alison, that's why you have to take a holistic stance because what you are talking about there is the fallacy of reductionism. If you want to do what some people here would want to do, you will say, [*placing the transparency with just the two dots on it on the OHP*] "Take that quantum-event here and that quantum-event there" and then ask, "How does that isolated quantum-event get to know the other isolated quantum-event?" This is another fiasco because then you are into those strange and impossible realms we spoke about earlier. I take my starting-point in *observation* – and please don't confuse this with Positivism, because Positivism and Realism, so-called, are now, philosophically, dead ducks.¹² In observation I see things as a whole – not as 'the universe', of course, but as a *kind* of universe. And that's where we have to start from. I can't imagine how, in isolation, one cell in my body can know another. I have to take a holistic standpoint with regard to that. It's all part of the basic, given, observational-theoretical *Gestalt*.

'To explain this quickly isn't easy. Alison liked the way I explained it to her earlier, over coffee. She asked me how I would describe my philosophical position. When you have some very tightly structured view and you come to a meeting like this one, or at PIRT, if someone says, in the words of the poet, "The secret, quick about it, friend," it's like telling a shaggy-dog story by having to tell each little *part* of it to different audiences in different halls. And then they say, we don't get it! But how the hell *would* they get it when you have to tell it in that way?

¹¹ Recording indistinct.

¹² See *Alternatives*, (ANPA 15) 'Normal Realism, a Challenge to Physicists'. pp.111-115

So if anyone wants to know the whole philosophical position – the story as a whole – I'll sock it to them. Luckily, it's published and I can give you the references.¹³ Anyway, this "joke" thing helps to make my point about holism. You have to adopt a holistic or at least, a relationist starting position. I don't mean Holistic with a capital aitch, you understand, because those capital-aitch wholes (*sic*) I can never observe. So what I start with are those wholes I do actually observe, and that is what I mean by holism with a small aitch.'

Watson: 'If you *start* with a lot of already discrete and separated things, then you have the problem of how to connect them. If you start with a *whole*, then you have a totally different problem of how to connect them.'

Pope: 'Well, no. ... You see ... Take Planck's quantum h . Now you don't find that under a bush. You take ordinary magnitudes in the world around you – measures in metres, seconds, joules, kilograms, newtons ... or whatever ... and reduce them. You cut up a mass, let's say and then cut it down and down and down. Or you cut down a length, or a time, reduce it, reduce it, reduce it ... until you come to an empirical level where you can't reduce the time without increasing energy, or reduce the mass without increasing the time, or reduce this without increasing that ... and so on. At that basic level you squeeze nature i.. one dimension and it pops out in another. That dimensional see-saw occurs, of course, at the level of the action-quantum h .

Now the point I'm making is that you don't have to look for that ultimate limit of reduction anywhere other than in this room. It's a consequence of the way we arbitrarily measure things in the ordinary macroworld. So, alright, h is a "funny-factor" – 6.6266196 times ten to the minus thirty-four – what a hell of a number! But there's no *mystery* about it. It's what it is simply because we happen to have chosen, in the macrophysical world, the sorts of measures we have! If we'd chosen, say, squirgs instead of metres, then we would have a different constant. I see no problem with these things. You see, it stands to reason that you cannot reduce anything infinitely, because then you would end-up with a sum of infinitesimals, which is zero. So infinite reduction is impossible, which means that you are *bound* to come up against these constants sooner or later.'

Manthey: 'Viv, you now have another fifteen minutes. If you have any other ideas you want to present, then you should do it. If you want to answer the questions that's fine with me. I just want you to know you're running out of time.'

Pope: 'Okay, but let me make sure, first, that I've got the point across. Here is, then, the "shaggy dog" story, in one hall, in one minute. If we're into discreteness, as is our aim here at ANPA, then I suggest that all language which implies anything other than discreteness, like "field", "the continuous velocity of light in a continuous, self-extended vacuum", "ether" and words like that should be *systematically purged from our vocabulary* – and not retained for reasons of usefulness, Tony – because to get rid of them is absolutely vital for reasons of consistency ...'

¹³ Pope, N.V. & Osborne, A.D.: 'Instantaneous Relativistic Action-at-a-Distance', *Physics Essays*, 5, (3) 1992, pp 409-420; Pope, N.V., 'The New World Synthesis,' *Philosophia Mathematica*, II, v, 4 (1989) n.1, pp. 23-28; Pope, N.V., 'The Overdue Revolution,' *Mensa*, April, 1987, pp. 28-29.

Deakin: 'We use all language for usefulness. All you're grumbling about is that we have to use different languages for different contexts.'

Pope: 'Hm!'

Starson: 'I say to you that it is all discrete, tangible and comprehensible, and that inside of the vacuum you've got the background radiation of the Big Bang. That's energy, an unstructured energy. I classify three types of energy. The unstructured energy is the energy of temperature; the structured energy is the energy that is moving at the speed of light; and you've got bound energy, the energy that's bound by gravity waves which are travelling instantaneously through the fifth dimension, through this unstructured energy, linking everything together such that when you accelerate a particle towards the speed of light it doesn't reach infinity in the energy, it reaches another type of energy. It turns from bound energy into structured energy and it reaches the Planck mass in energy at one over the Planck time in frequency. And therefore it changes from one type of energy to another and travels along at the speed of light!'

Pope: 'Yes, as we discussed in the car on the way here. But, Scott, I don't *see* any of that! I'm a philosopher, so I'm ignorant, you understand. You point all that out to me, sure! But all I heard there was informational bits or bytes describing something which I cannot *observe*. Okay? And you may be right, you may be wrong. What concerns me is the *standpoint* you adopt. You have to start off in some kind of *epistemology*.

'How can I explain? (Let me remind you, first of all, that I'm not speaking as a Positivist.) When I analyse all the bits of information that I'm taking in I'm aware that I'm an electrochemical system, whose bits and bytes are somewhat huge. So I rely on the information I receive via *instruments* that are more sensitive, right down to the level of photons. And by that means, as I've said, I discover, in the way that Planck discovered, that you cannot reduce action down below a certain level because at that level they (action's dimensional components) start to see-saw, so that reducing one increases another. So I conclude that that is my ultimate relational or holistic element of information, the quantum of action. Whatever anyone or anything else then tells me *has to be based on that epistemological understanding*. I don't want to leap out of this (epistemological position) and say – as an engineer or cosmologist might – "Oh yes, I accept all that you, Scott, have just described."

'In this organisation (ANPA), therefore, I would be much happier to be a member *if it were consistent*; that is, if we were to eschew references such as yours, Scott, to the "Big Bang", to "light-velocity", "fields", "energy-waves" "gravity-waves" and all those other continuistic conceptions members talk about. These things simply scramble my mind, and my aim as a professional ignoramus, as I say, is to analyse that perplexity. I'm not in competition, here, with anyone to write papers on erudite physics or metaphysics of that speculative sort presented by members of this or any other society!'

'Is that quite clear, here? I simply cannot understand why we have to remain committed to the continuistic "speed of light" conception. It's not just a question of usefulness or pragmatism because if you're committed to talking about the "speed of light" you are also committed, as I say, syllogistically, to adopting a *localist* view. Then you are lumbered with things like the "EPR" or action-at-a-distance paradox, the paradoxical instantaneity of gravitation and inertia, and ...'

Deakin: 'Only if you are talking to a certain collection of people! I work for a radar company. We do immensely complex theoretical calculations with all sorts of factors and we use the classical language to describe it, knowing *perfectly well* that there are all sorts of problems with it. When we do these calculations we come up with a design which the customer says he wants. And, lo and behold, very often the radar performs to the specification we've calculated. Then we switch on and make sure the bits work. *That means* that in the conventions of our language – and I will give you an example where you would leap in on it – it is perfectly consistent with what we're doing, this theoretical business of thinking, writing symbols on paper and so on. And then you actually build the hardware and it actually does what you're thinking about up there (in the head) ...'

Pope: 'Look, Tony, I have to stop you there, because you're talking to the converted ...'

Deakin: But hang on a minute! You seem to be fussing about something that doesn't need fussing about. There is a wonderful thing that comes up when you're doing an electronic scan with radars, radars where you don't move the antennæ. You have many emitters and you make them work in sequence and in phase. And you *say* the beam moves about and we point it at certain places. Well it *does*, because the signals come back. But then you say the end of the beam's moving faster than the speed of light. What does that mean? Well, it *means* that your concept of using the speed of light in this context is nonsense. What you have to do is to *recognise* that it's nonsense. Then when someone says what really happens you have to completely change your language-game. And as a *philosopher* you should be happy with that!

Pope: 'Oh, well I *am* happy, Tony, and I told you so, right at the start. I'm perfectly happy with that! Next question.'

Dr. Bowden: 'Tony, perhaps you should be addressing that language all the time.' [*At this everyone starts talking at once.*]

Pope: 'Look, I think that what Keith says is right. But, perhaps, not "*all* the time", as you put it, Keith – not when you're speaking to your grandmother, for instance. But certainly I'm with you insofar as *when we are here* (at ANPA) *we should stick to this discretist language-game*. Otherwise, if you use the light-velocity language it creates nonsense in the context of what we are doing. I'm simply suggesting that we should *clean up our act*; that is, that we tidy up our language, making sure that it *makes sense*, that we're not mixing up continuistic concepts with discontinuistic concepts and just chucking them around *ad lib*, in the way that I saw at PIRT. There, people were talking right past one another while others were snoring in their seats.¹⁴ So what the hell they were there for I just cannot imagine!

Deakin: 'Perhaps they'd been to too many conferences!'

Pope: I'd like to know what you imagine I'm trying to do at this one, Tony!

¹⁴ Some exaggeration here. One or two new arrivals, as it turned out, were jetlagged.

Manthey: 'Any questions? Okay, let's take them in order. Mine's first. I want to go right back to the beginning of your talk, when you were responding to a question by Pierre, and you said "Pierre, you can't have a particle moving continuously through space, where the particle is a *quantisistic* concept and space is a *continuistic* concept. You have to be on the one side or the other. Everything's either continuous or discrete." Okay. I agree with that. And it strikes me that we have a place there where you can make a Zeno-type argument, that the photon would never get there unless you introduce a discontinuisation of the space. Therefore, when you talk of "one point to the other" there truly is nothing in between, because otherwise the whole thing turns into a Zeno paradox. So it strikes me that you could make a very clean argument along those lines – as you may say, in Danish, "You can't whistle with flour in your mouth." ' [laughter]

Pope: 'That *would* be difficult. Yes, that's what I'm saying, Mike. You either have the flour or the whistle!'

Noyes: 'I'd like to point out a way of thinking about the velocity of light which I think is useful. If you have an event happening here and an event happening there, then in order to talk about a *velocity* between those two events you have to have a clock here and a clock there and you have to know how those clocks are related to each other. Once you've ... related the clocks in the way Einstein/Bridgman tells you to do it, then you're going to get the formulas of relativity. And in that it is important to think about the *signal* going at the velocity of light, when you are using that rather than a material particle. But then you get a potential experiment that you can do, which is to determine whether or not you can transfer information at greater than the speed of light. You can perform such an experiment – and so far, nobody has succeeded, but that doesn't mean one could *not* succeed – in sending information at greater than the speed of light. If you can do that, if you can make what Redhead has called the "Bell telephone" [laughter], that is, if you can use the Aspect-experiment type of set-up to transfer information greater than the speed of light, then one could recognise by using that language that one had done so. There *are* experiments which, if that happened, would tell you that this concept of the speed of light not only is meaningful but demonstrated. As far as I'm concerned, then a *gedanken* experiment which you understand what the results would be is a perfectly useful concept which we should *not* rule out. Then we could make an empirical statement. No-one has done that. And it would be a very important consequence if someone could show the Aspect experiment could be used to convey *information* and not just correlation ... '

Pope: 'Can I just answer that, because we're running out of time. Experimental information that's not yet in can't be brought into the equation, can it? But I'm not talking about experiments. I'm talking about the *meaning* of the "speed of light". [Replaces Figure 1a on platten and points to it] These are all the velocities there are, let's say. Of course, I can't *depict* them all because all that would do is make a big blodge. But you see what I mean. We have *instantaneity*, here. Now let me show you another diagram. In the complicated, right-hand-side view (Figure 1b) we construct the motion of a body moving away and then returning to the same spot, like this: [Puts Figure 3 on platten, see below].

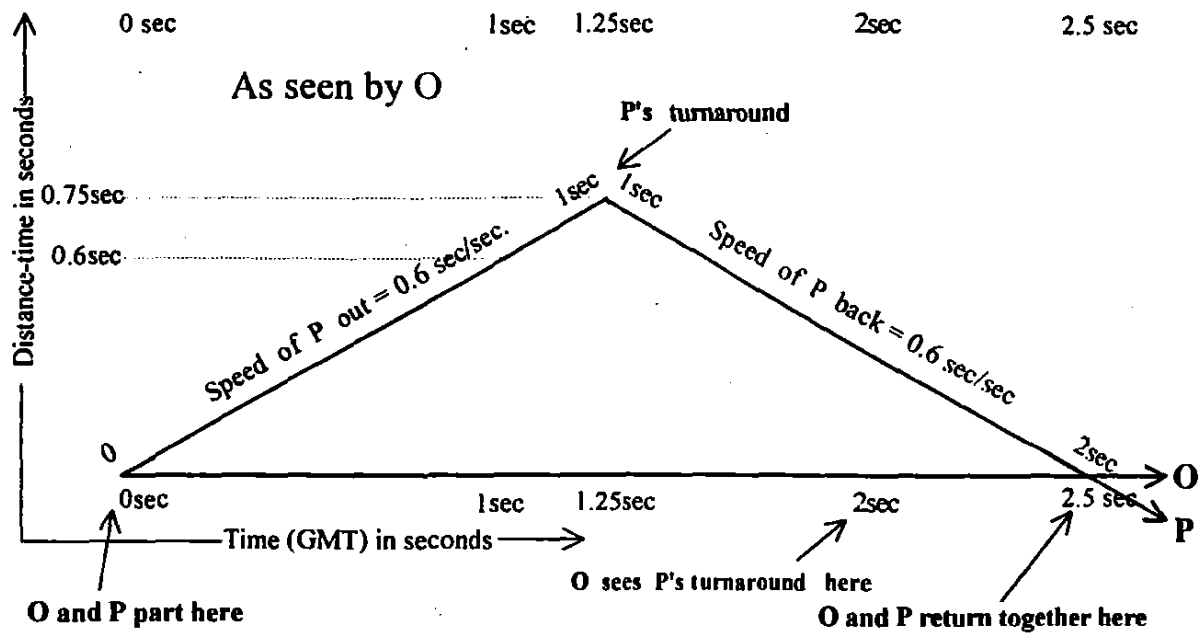


Figure 3. The dilation of P's proper time due to motion relative to system O

'So what you have to remember is that in relativity the *proper-times* registered by bodies are not everywhere the same. This means that when bodies go away from one another and come back to the same spot [*pointing to the intersection OP*] they measure different times. So how can you say, Pierre, *what time* it is at those points where you place your counters? I can look at the sun and say that the light and heat from that has taken *eight minutes* to get from there to here. But where did I see that light and heat set out? I can only justify that statement by *arbitrarily* setting the time at the sun eight minutes behind the time that I actually see it. That's *arbitrary*.

'So I can see a photon from, we'll say, the Andromeda nebula and say that it took about a hundred and fifty million years to get here. Or I can say, "That photon, in its own proper time, took no time at all." There's been no attrition and there are no other marks that the distance has left on it. It's as pristine as when it set out. (You see, Tony, how I'm forced to use the usual sort of double-talk here – "Set out"!) You don't *have* to think of the Andromeda nebula, in the contexts we are considering, as "out there" in the *primordial receptacle* that we imagine is space. You can much, much more consistently – certainly in this group – say "From the *Gestalt* of information that I have, which is holistic in the small-atch sense, in which the nebula is further than the bus I see across the road (that's an informational statement) in that *informational* space is an object which I call Andromeda and which I see *at the same time* as I see objects right alongside me ...

'Look, it's like on a television-set. The pixels out of which you project the faraway hills and those of the guy you project right in front of you are the same. This is an *information-projected* scenario. And that's okay! In this day and age we can surely accommodate ourselves to that way of thinking – and certainly so in ANPA! We can say that what was classically thought of as bits of matter all absolutely distributed in a self-sufficient void was really, all the time, an *informationally projected* scenario out of photonic pixels. And in the context of ANPA, *every single thing in that informational video-space is informationally projected in that same way*. Bodies travel in it – in the way you said, Ted – but *cinematographically*. Some go fast, some go

slow. No problem with that! The trouble comes when you start to wonder what speed the *pixels* travel at. They are your informational *givens*. And we are creating nonsense here at ANPA because we are projecting into those givens – into the very *data*, or informational '*stills*' if you like, into the very *photons* out of sequences of which we relativistically and communicationally spin the world – we are projecting into those *the same sort of distance and time that we see in the scenario*! A language which does that, surely, is wrong for *any* purposes. Think about it!

Manthey: 'That is exactly one hour, Viv. Thank you.'

Pope: 'Thank you all for your indulgence.' [*applause*]

The Onto-Epistemic Perspective of the World*

Rainer E. Zimmermann

Baumeisterstr. 4

D - 12159 Berlin

1. Introduction

The modern re-formulation of the task and scope of metaphysics and the recent undertaking of clarifying what philosophizing can actually mean today, point to a new positioning of physics (and science in general) with respect to philosophy: If, e.g., the twistor theory of Penrose is used to suitably approach a consistent description of the foundation of the universe's evolution, then the very notion of „substance“ in the sense of traditional philosophy gains a completely revised meaning which in turn points to a multitude of relevant implications for both the philosophizing itself and scientific research, at the same time. Asking for the foundation of the universe and its detailed evolution means here to ask for the conditions of the possibility for having a big bang scenario according to the standard model of cosmology in order to fully describe the initial emergence of the world and its further consequences.

Hence, the main problem is to actually describe the transition from the pre-worldly state (of substance) to worldly evolution as it is perceived by means of the research as it is undertaken in physics, that is: to describe the onset of substance's exteriorization into the worldly, or simply the onset of initial emergence itself. More than that: It is also necessary to conceptualize this transition in terms of a philosophy of nature which takes the aforementioned modern re-formulation of metaphysics explicitly into account. At the same time, a conceptualization of this type uncovers the strict onto-epistemic character of philosophizing, insofar it turns out to be based on a permanent cross-referencing between the two domains of interpretation which until recently have been

thought of as being completely disjoint. So the empirically obtained and mathematically interpreted results of physics have to be „cross-interpreted“ on a given background of basic expectations which from the outset are already conceptualized in a philosophical manner (though this fact may be latent and unclear).

On the other hand, this philosophical context (with the aspects of which the physical context appears to be „contaminated“ in a sense from the beginning on) has to be „cross-interpreted“ again with a view to scientific results achieved so far or results to be expected to be achieved in the future.

It is the purpose of this present paper to demonstrate the aspect of onto-epistemic cross-referencing by discussing some further implications of the twistor model introduced by Penrose. For more details on twistors I refer to my earlier papers given at ANPA 12 and ANPA 15 meetings.¹

2. Self-Organization and Chaos

With a view to the modern concept of self-organization as purported by the sciences at present, and to chaos theory, respectively, we can clarify according to the aforementioned, how self-organization comes into play, in first place, and what it actually is that is self-organizing. Note by the way, that it is not matter itself which can be taken as a suitable substance, because the concept of matter has been decisively re-formulated by Einstein referring to geometry proper (and geometry actually precedes matter in the run of evolution). On the other hand, space-time itself cannot be taken as a suitable substance either, because it is not possible so far to get rid of the „physical dualism“ as it is displayed by the strict separation between relativistic (macroscopic) physics and quantum (microscopic) physics, respectively. It is in fact only by a pre-geometric ansatz that this dualism can be made to vanish. And this is achieved e.g. by the twistor theory of Penrose. Hence, well in accordance with the classical idea, substance is something which is non-worldly by nature.²

The problem is now to illustrate in some more detail the actual onset of initial emergence, at the same time laying the grounds for all that what happens in the run of evo-

lution, once anything worldly has been created. In formal terms, this can be partially achieved for the „forward direction“: Basically, the evolution of the universe as being represented by means of an intrinsically dynamical geometry³, can be described by a dynamical system, which is in principle a (C^K) map $\varphi: R \times M \rightarrow M$ which in turn gives rise to a differential equation on M , of the form $dx/dt = f(x, \cdot)$, that is a vector field on M which can be thought of as being the tangent vector to a suitable curve $t \rightarrow \varphi_t(x)$. Generally, one will deal with explicit semi-group actions of Lie type (not full group actions, because thermodynamics prevents the onset of truly reversible processes). Spaces M will be in general smooth manifolds describing the process domains. Be M such a suitably chosen (manifold) space. Then a dynamical system on M is said to be chaotic, if (1) it has sensitive dependence on initial conditions, (2) it is topologically transitive, (3) its periodic points are dense in M .

Be in particular, W now the „set“ of variables describing the universe globally, and be I the „set“ of cosmic invariants, then an appropriate global, dynamical system can be given in the form $dW/dt = N(W, I)$ when for $N(\cdot)$ the above criteria are satisfied. This is the symbolic representation of the world as being chaotically constituted. For reasons of nomenclature we have chosen here N (for: negation operator - in a more strict and general sense than this expression is being used in logic sometimes, though its purely logic form is included). Note that in order to display the „composition properties“ of N more clearly, especially with a view to their importance for the criteria (1) - (3) above, it would be better to write the symbolic representation in the more adequate form $d^n/dt W = N^n(W, I)$, but in that case d^n/dt is not the same as the n -th derivative (which cannot be reasonably interpreted in one way or the other), but a „folding“ of subsequent actions of an intrinsic time operator (which will turn out as a measure for the number of formations of structure having taken place and increasing the world's complexity - similar to the time concept as introduced by Prigogine). We will come back to that. So, in principle, all of the further evolutionary stages of the worldly process can be visualized as a permanent differentiation and attaining of fine structures as derived from this original global system at the very beginning.⁴

Most of the aspects of self-organization and chaos can be illustrated in terms of what is called „quadratic family“ (of the type $F_\mu(x) = \mu x(1 - x)$) exhibiting a large number of

bifurcation characteristics usually associated with the onset of chaos and the stable organization in non-chaotic zones. (Note that the quadratic family has a repelling fixed point at 0 and a attracting fixed point at $\mu - 1/\mu$ provided $1 < \mu < 3$. For $\mu \geq 3$, two new fixed points emerge and bifurcation takes place (pointing to the phenomenon of period-doubling). It is also important to note that the shift map $\sigma: \Sigma_2 \rightarrow \Sigma_2 \Rightarrow \sigma(s_0 s_1 s_2 \dots) = (s_1 s_2 s_3 \dots)$, which is basically a continuous 2 - 1 map of Σ_2 , this being the sequence on the two symbols 0 and 1 (or the space consisting of infinite sequences of integers, elements being infinite strings of integers), is an exact model of F_μ when $\mu > 4$. In fact, Σ_2 can be made into a metric space.⁵

Note that in general, realistic processes turn out to be of mixed type rather than of integrable or completely chaotic (Anosov) type, which is more or less secured for Hamiltonian systems, but probable for others, too, this being an implicit result of the celebrated KAM theorem (which states that for sufficiently smooth Hamiltonians, sufficiently small perturbations of non-linear integrable systems preserve positive measure of regular motion).⁶

On the other hand, for the „backward direction“, the problem is somewhat more involved: The question is how a dynamical system can emerge at all. Insofar it is a map of the type $R \times M \rightarrow M$, this means to implicitly ask for the emergence of M . And this is a difficult problem to tackle, because there is hardly any indication as to the dynamical „enrichment“ of elementary structures in order to eventually attaining full smooth space-time structures. Note however that Penrose, in his early papers on twistors, points exactly into the direction of „condensing“ the underlying network in order to achieve macroscopic structures, at least in terms of principal directions in space time.⁷

Some work is being undertaken concerning this problem, e.g. by Eisenhardt and Kurth⁸, but there may be another way out of this in terms of recent „topos theory“: Originally, for Grothendieck, topology became the study of the cohomology of sheaves. And the sheaves sited on a given topology form a topos.⁹ So basically, a topos is the category of all the sheaves of sets on a site, and any functor on a site can be transformed into a sheaf (in turn serving as an example for a pair of adjoint functors). With the view to modal and intuitionistic as well as Boolean logic (for which there are

manifold implications) a topos can be visualized as being a universe of sets (that is a model of set theory, in fact). Still more interesting is the fact that geometric morphisms between topoi can be defined which exhibit the character of topoi as being generalized spaces. Insofar they should also have generalized points as their elements. The usual picture of topological spaces might not suffice for this. Hence, take a topological space X and a point x . Erect then at x a set A as a sheaf A_x on X concentrated around x . The resulting mapping from the category of sets into that of sheaves on X turns out then to be the direct image of a geometrical morphism, of the type $\mathbf{Sets} \rightarrow \mathbf{sh}(X)$. But an arbitrary topos, $\mathcal{E}$ say, may not have enough „points“ $\mathbf{Sets} \rightarrow \mathcal{E}$ in this sense. Hence, re-define the concept of space in terms of open sets rather than in terms of points. Objects so defined by a lattice of open sets are called *locales*. It is this concept of locales which appears to be promising with respect to the original problem, because twistors can be defined in fact, in terms of twistor functions (as being expressed by suitable nuclei of contour integrals in turn defining spinors): If X is an open set of Π , and $\mathbf{Sh}(X)$ is the sheaf of holomorphic functions of X , then elements of the first-order cohomology group $H^1(X, \Gamma)$, with $\Gamma(X): \mathbf{Sh}(X) \rightarrow \mathbf{Ab}$, are twistor functions $f(Z^\alpha)$ which are physically equivalent to particle fields of zero rest-mass.¹⁰ Hence, it is desirable to develop topoi analogies of twistor space here using the latter's background of cohomology groups. But this is still an unsolved problem.¹¹

In fact, some explicit scepticism appears to be in order here, some reasons for which I summarize shortly: First of all, the basic idea is quite straightforward, insofar it concerns the hypothetical transition from „poorer“ to „richer“ spaces (speaking in terms of structure). So the category of locales turns out to be simply the opposite of the category of frames, the latter being defined as a lattice given by the partially ordered set $O(S)$ of all open subsets $U \subseteq S$ of some topological space S (up to certain conditions). The morphism associated with the frame is that which preserves meets and joins. Hence, we do have a generalized structure here, being independent of the concepts of points. And the transition from this structure to „smoother“ (and insofar richer) spaces is secured, because the functor $(\text{locales}) \rightarrow (\text{spaces})$ is right adjoint to the functor $(\text{spaces}) \rightarrow (\text{locales})$.¹²

But the unsatisfying aspect is that the generalized structure discussed here is not so different from usual topological spaces as we know them, because it is mainly based on a concept of open sets which is in itself nothing much innovative or astonishing. What we would prefer to get instead (and what would be more in the sense of a desired reduction of structures as also mentioned by Eisenhardt and Kurth¹³) is a much simpler structure leaving the topological domain and going back to the algebraic domain, down even to groups, semi-groups and sets, the dynamic being produced then by sets of operators acting on base sets.

A similar unsatisfying aspect can be found when looking at other structures being defined in terms of categories and topoi: On the one hand, the calculation of cohomology groups, e.g., which reflects the geometry of a manifold can be reduced to the study of global differential equations on this manifold. But the dynamic of spaces is nevertheless based on metric and differential terms, although the underlying structure is of algebraic type. Note, e.g., that the starting point is a complex S^* in the sense of algebraic topology which can be expressed in terms of a sequence of linear spaces and mappings of the kind

$$S^0 \xrightarrow{L_0} S^1 \xrightarrow{L_1} \dots \xrightarrow{L_m} S^m$$

satisfying $L_j \circ L_{j-1} = 0$; $j = 1, \dots, n$. The cohomology groups of S^* are defined then to be the quotient spaces

$$H^q(S^*) := \ker L_q / \text{im } L_{q-1}, \quad q = 1, 2, \dots,$$

which are in principle vector spaces inheriting their structure from S^* directly. Hence, there is an important relationship between the connectivity properties of a space and cohomology groups, because the latter can be thought of as being sets of Abelian groups constructed from a manifold, the dimension of which being given by the respective Betti numbers (which in their turn are basically the ranks of those groups). For the simple and well-known case of de Rham cohomology we can clearly recognize this by noting that $H^r(M)$, the r th de Rham cohomology group of M is the quotient {closed r -forms/exact r -forms} with the topological invariant, e.g., $\dim H^1(\mathbb{R}^2 - \{0\}) = 1$, indicating that $\mathbb{R}^2 - \{0\}$ has one hole in its topological make-up. Again, though having combinatorial (and discrete) concepts of algebraic topology in mind, the

structures we actually deal with here are comparatively rich (and thus special), and not very poor (and thus general).

This is also true for the geometric morphisms we have mentioned above. Basically, a geometric morphism $f: \mathcal{F} \rightarrow \mathcal{E}$ between topoi is a pair of functors $f^*: \mathcal{E} \rightarrow \mathcal{F}$ and $f_*: \mathcal{F} \rightarrow \mathcal{E}$ such that f^* is (left) adjoint to f_* and (left) exact. Hence, a morphism $\varphi: G \rightarrow H$ of (Lie transformation) group (or semi-group?¹⁴) objects induces an essential geometric morphism between the categories of (right) G - and (right) H -objects in a topos $\mathcal{E}$.¹⁵ A point of the latter is thus such a morphism itself, on the type $p: (\text{Sets}) \rightarrow \mathcal{E}$ (in very much the same way as a point of the topos $\text{Sh}(X)$ is a geometric morphism $x: (\text{Sets}) = \text{Sh}(1) \rightarrow \text{Sh}(X)$). So when dealing with such morphisms at all and relating them to explicit (semi-) group actions or category actions¹⁶, a promising and elegant apparatus is won for treating problems of emergence (being thought of here in purely mathematical terms as problems of transitions between structures in a progressively uprising hierarchy of forms). But neither is it clear yet whether this apparatus is really applied to structures which can be used to consistently define some such hierarchy or whether seemingly „poorer“ structures are actually poorer than topological structures, - nor is it clear at all in how far the use of categories and topoi does imply anything about the intrinsic motions and/or dynamics of spaces.¹⁷ Instead, the available instruments provided by this new apparatus appear to be helpful for a re-formulation of the interrelationships between algebraic and topological structures and geometry proper, which is a useful result in its own right, but according to the program of emergence not quite that what is actually desired.

Note e.g. that a sheaf incorporates local geometric information, and the cohomology theory allows the codifying of the passage from local to global. It is defined in terms of topological spaces M and of presheaves of Abelian groups on M which are basically assignments $U \rightarrow S(U)$ of an open set U to an Abelian group $S(U)$ such that there are restriction homomorphisms plus conditions. Hence, a presheaf is a family of algebraic objects of the same type, parametrized by the open sets of M (in a similar way as the bundle $B \rightarrow M$ is a family of geometric objects of the same type, parametrized by the points of M). But we nevertheless deal with Abelian groups and homomorphisms,

which is a lot of structure. And again, the usual structure sheaves are typically smooth functions of vector fields, or holomorphic functions on real or complex manifolds. As well morphisms of sheaves are families of maps which in turn are algebraic homomorphisms of the underlying algebraic structures. Also, the category $\text{Sh}(X)$ of sheaves on a topological space X is a topos in the same sense as is the category $\text{Sh}(\mathcal{S}, J)$ of sheaves on a site. The topos itself however depends heavily on the existence of all finite limits and colimits: But their existence is the question in case of spontaneous emergence.

We can see this in the case of Grothendieck topologies: Such a topology on a category $\mathcal{S}$ is basically a function J which assigns to each object C of $\mathcal{S}$ a collection $J(C)$ of sieves on C (plus conditions). Given an object C of $\mathcal{S}$, a sieve on C is a set S of maps with range C such that for two of them, f and h say, $f \in S$ and $f \circ h$ imply $f \circ h \in S$. These maps - otherwise called arrows - are actually those paths which are allowed „to get through“ to C . But, in case of spontaneous emergence, is there any path that is allowed to get through? On the contrary, are not new paths actually beginning at the point (and instance) of emergence?

Hence, although the use of categories and topoi looks promising when talking of applications to the Penrose transform, this being an isomorphism between $H^1(U, \mathcal{O}(-2s-2))$, the first cohomology group consisting of a suitable subset of twistor space and the sheaf of holomorphic functions homogeneous of degree $-2s-2$, and the holomorphic massless fields of helicity s on U ¹⁸ so that holomorphic curves in twistor space become points of M and the metric of M can be derived from this setting a being an explicit correspondence between anti-self-dual Einstein (and vacuum) space-times and curved twistor space, the direct line of argument is still far from complete.

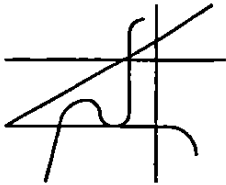
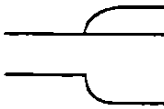
This can also be seen when looking at the non-standard model of Eisenhardt and Kurth.¹⁹ They introduce the topos AMOR of what they call antimorphic mappings which are mappings between a pre- and a post-state (of emergence) and which are not structure preserving. In particular, the objects of the topos are thought of as being generalized points of non-standard quality called monads including their complement (or: non-standard forms), and the antimorphisms are generally non-

homeomorphic mappings. So, in principle they should not conserve topological invariants between spaces.²⁰

Note first of all that antimorphisms can be categorized only, if the objects are sets or semi-groups, because they cannot be isomorphic, and thus there are no inverse elements. Of particular interest are the endomorphisms of the object set which is in fact a semi-group. Whether AMOR is actually a topos, is far from clear (at last it is not demonstrated yet). Some doubts are in order: For a category to become a topos it needs at least finite limits and colimits, exponentials and a subobject classifier. It is not easy to show that it is possible to construct a universal cone for AMOR necessary for its limits. In particular, for limits (and colimits) it is also necessary to have a diagonal functor which in turn has a right adjoint. Also, exponentiability depends on right adjoint functors. This seems difficult, because the notion of adjointness is mainly based on the existence of a natural bijection between morphisms. As in the case of AMOR the latter are actually antimorphisms, such an existence is unlikely (by definition). A similar argument as to the existence of a subobject classifier is still more involved (and also unclear). The remark given as to the possible application of a topos of Zariski type is probably no way out, too: because a Zariski topos $\mathfrak{Z}$ over the integers is a classifying topos for local rings which implies that there is an isomorphism between $\text{Hom}(\mathfrak{Z}, \mathfrak{E})$ and $\text{Loc}(\mathfrak{E})$, where $\mathfrak{E}$ is the underlying topos.²¹ Hence, the properties of $\mathfrak{Z}$ appear to be too „smooth“ either. And, by the way, rings are a still richer structure, again.

More promising is fact, appear older models of Thom trying to grasp the problem in linguistic terms. Thom stays with algebraic and topologic (as well as geometric) structures and defines, together with the property of structural stability, the logos of a form (or a system). By means of logoi for catastrophes he can relate this concept to singularities and interpret the catastrophes themselves as graphs of interaction between different logoi. Isology between logoi corresponds then to isomorphic relationships between catastrophes which unfold the respective singularities on a given substrate space. By means of linguistic correspondences, this can be generalized in order to embed the very process of interpretation into the form considered (a truly onto-epistemic concept which might be important for that what we discuss in the next section). Analogies then turn out to be incomplete isologies.²²

For the simple (and celebrated) example of a cusp catastrophe²³ we get the following diagram:

<u>organizing centre</u>	<u>universal unfolding</u>	<u>distinguished sections</u>
$V = x^4$	$V = x^4 + ux^2 + vx$	
<u>elementary graph of</u> <u>interaction</u>	<u>spatial</u> <u>interpretation (subst).</u> A fault (geology)	<u>temporal</u> <u>interpretation (verbs)</u> destructive/constructive to capture/to engender to break/to unite to change/to become to snap
		

3. The Dialectic of the Worldly

There is an intrinsic dialectic of the worldly here which is reflected on two different levels: On the one hand, it is necessary to note the individual conflict structures (the contradictions) of the respective dialectical mediations determining the quality of these levels. On the other, it is important to visualize them as being the concrete-real expression of a unified totality of that what exists. And the same is true for the mediation of these very levels between each other, too.

The first level in question is given here as that of the philosophical perspective proper, pointing to the contradiction between the basic ontological aspects of the worldly (as describing the reality of the worldly process and the speculation about its foundation as being derived from the empirically experiencing of this reality, at the same time)

and the epistemological grasping-seizing of them (bearing in mind that the epistemic process in this sense, as representing the unfolding of knowledge about this world and its foundation, is itself nothing but a specific mode of this ontologically founded being, in turn enhancing the speculative potential again, for those who actually do speculate: men) - (pointing to the contradiction between these two) which nevertheless, have to be understood in the sense of two (almost) disjoint components of representing the same underlying totality. Hence, the level described here is one of visualizing the world as if it were observed from some imaginary outside, abstracting in fact from a real observer who is an actual part of the worldly.

Consequently, the second level is given by the visualizing of the world in terms of an internal perspective, taking the worldly nature of observers explicitly into account. As for the observer it is his mode of existence to grasp-seize the world by epistemic means, it is thus conclusive to look for the pre-conditions of the structures immanent within the epistemic domain. One central aspect to be noted in this sense is the question of actually mediating the contradiction between formal (mathematical) and speculative (hermeneutical) languages. First of all, for the purpose of mediating, it is important to study the explicit differences between the two. This is roughly indicated in table 1. Note that these differences appear to be smaller than expected, the reason being that in fact, in both cases (formal as well as speculative) it is interpretation what is actually done, and the result is always a suitable model which is supposed to represent more or less accurately (and reasonably) a picture reflecting in one or the other appropriate way that what has been undertaken to be actually described and derived out of a given context (hence: to be explained).

Finally, it is also necessary to refer more consequently to the aforementioned background of unified totality which implies a wide range of results on the formal domain as to the explicit structuring of the hierarchically mediated unfolding of worldly evolution - which turns out to be an unfolding of forms, in first place. This is schematically illustrated in table 2. Here, the operator notation of dynamical systems is used in order to indicate a primary splitting of the original (global) system. Basically, this splitting is a breaking up of geometry itself into main regions of hierarchy which represent the subjects of various scientific fields of research due to their complexity at-

tained, the latter being expressed in terms of a characteristic complexity parameter k which in turn depends on the characteristic age of the dynamical systems within the respective region. This time scale (given by the parameter τ which is basically a measure for the number of formations of structure having taken place within systems of that region) is related to that introduced by Prigogine.²⁴

With the initial emergence of the worldly, an „epistemic symmetry-breaking“ takes place which differentiates between „local“ and „global“ aspects of a region, and between „microscopic“ and „macroscopic“ aspects, respectively. For the micro-aspects it is necessary to develop a specific formalism (available so far in physics only, partially also in chemistry and biology, but completely absent within the social domain) in order to treat them as properties of singularities which can be thought of as being the sources of fields of interaction the (non-linear) superposition of which generates the region's macro-aspects. However, the progressive unfolding of the original potential (of forms) is not a straightforward differentiation only, but it is also a supercombination of „mixed states“ in the sense of chaos theory. That is, a higher level of hierarchy is indeed a sublation of lower levels, in the sense that the latter are still present in it (they „enrich“ the level's complexity). The viceversa is not true, due to thermodynamical reasons. Hence, the functional expressions in table 2 are not pure, disjoint vector fields generating dynamical systems on their regional level, exclusively. They are coupled sublations in fact, that is to say, the generating expression is a composition as described earlier in terms of chaos theory. Hence, evolution can be represented by smooth vector fields on the respective levels of the hierarchy, but emergence is a discrete process composing vector fields and expressing by this the action of a discrete time operator.

Note that obviously, n is not equal to four in general, insofar we have chosen here merely a representation of the main regions which correspond to the main fields of research. Within the chosen regions there is an almost-infinite sub-splitting of the almost-global system governing them. The usual time parameter t displayed in table 2, as being commonly used co-ordinate time, shows up in fact as a suitable superposition of individual „ages“ τ . Hence t is itself a function of τ (and also of k therefore).

Table 1: Modes of Interpretation

formal	speculative
pre-geometry (twistor network) local = global microscopic = macroscopic abstract space concept	pre-worldly identity (substance) metaphorization (hermeneutical & poetical concept)
initial singularity	emergence
local $\neq$ global dynamic geometry as abstract expression of space-time-matter modelling as formally mapping of the empirical context uncovered formal conflict structure by the competing of determined and stochastic process regions superposition of long- and short- range interactions and mixture of states	worldly attributes as perceived expression of substance modelling as metaphorically mapping of the unfolding of the underlying worldly potential concrete conflict structure by the competing of tendency and latency „unclean“ sublation of compe- ting multi-spatial and multi- temporal structures

Table 2: Main Regions of the Hierarchies of Form

Extrapolated, local eigen- t (τ) time as approximated global time parameter		Complexity parameter value attained	k (τ)
real, structural age τ of the system			
micro- perspective (singularity theory)		macro- perspective (field theory)	
τ_3	social level	$W^4 = N^1(W^3) = N^4(W^0)$	k_3
τ_2	biological level	$W^3 = N^1(W^2) = N^3(W^0)$	k_2
τ_1	chemical level	$W^2 = N^1(W^1) = N^2(W^0)$	k_1
τ_0	physical level	$W^1 = N^1(W^0)$	k_0
local $\neq$ global			
pre-physical level (identity with a germ of difference)		$W^0 = N^0(W^0) = (W^0)$	
local = global microscopic = macroscopic			

All this has a number of important consequences of which I will mention here only one: namely the fact that the substratum underlying the processes given in one or the other region in the sense of table 2 is actually the same for all regions. For the practical research work undertaken this means that on the formal side physical structures and mathematical methods can be visualized which turn out to be universal in the sense that anything else (which is not treated explicitly in these scientific terms) is nothing but a sublation of it as described earlier. In fact, it is complexity which steers the actual quality of the processes taking place in one level of the hierarchy, or in one region of it. But the underlying material (space-time-matter) remains the same.

This latter result (which is nothing but a conclusion due to reasons of consistency) demonstrates clearly the double-quality of our statements about the world: Insofar they are of interpretative character, they are both formal and speculative. This can be illustrated when noting that in table 2 the unified totality underlying the worldly is represented in some abstract, formal manner. But the substantial conclusion about the substratum with which we deal all the time is drawn on a speculative background. Viceversa: The speculatively introduced transcendental nature of the worldly process leads to a formal conclusion about the existence of a Big Crunch (as we have seen earlier). Hence, the speculative assumption has been actually transformed into a physical argument within a mathematically founded context, the hypothesis of which can be empirically tested (in principle). Again: Even the analogous wording (in the case of „dual“) implies details for the mathematical treatment of a problem (in terms of properties of abstract spaces), and speculative conclusions about explicit expectations we might have when thinking of the detailed structure of worldly processes (their interaction being based on aspects of contradiction, competition, conflict and so forth) - as well as formal consequences again (when empirically uncovering conflict structures which can be modelled in terms of a specific class of differential equations as those given by Prigogine²⁵).

Hence, what we do realize is that we have already applied the results on the epistemic perspective explained earlier with regard to the different languages used. So, usually we have started in a traditionally speculative way, talking about substance. We have ended by choosing twistor space as an example for that what we could think of as be-

ing a suitable concept for a substance today. That is, we have ended with a formal argument. What we have done therefore is to formulate a speculative concept first and to formalize it then. Clearly, this sort of conceptualization „charges“ abstract formalizations with hermeneutical references of meaning.

In section 2 of this present paper, however, we have dealt with chaotic dynamical systems, in formal terms, exclusively, ending up with extending the formal domain towards the speculative region in looking for a suitable concept which can be used to found the emergence of a dynamical system, in first place.

Hence, what we have done is to alternate regressively-progressively between the formal and the speculative domain of interpretations for the concepts discussed. In fact, it is the actual discrepancy between and the excess of meanings which define the character of philosophical speculation (in contrast to, say, theoretical physics, proper). And it is this sort of speculation which can give a suitable framework for all that what philosophizing can mean today when facing the results of modern science.

4. Conclusion

It is self-evident that philosophy in the re-interpreted sense discussed in this present paper can only be able to deal with the required task and scope, if speculation is closely related to the results and insights achieved within the individual domain of the respective sciences. Neither is it possible to formally interpret phenomena of the social world, nor is it possible to deal with general relativity in poetical terms. But what is necessary to achieve is an appropriate inter-linkage of languages used for seemingly disjoint domains of the world in order to study the actual discrepancies resulting from the different qualities of their approaches and to draw conclusions from the various references of meaning so produced.

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- ¹ Cf. my: *Combinatorial Aspects of Emergence*, in: M. J. Manthey (ed.), *Alternatives in Physics and Biology*, ANPA 12, Cambridge, 1990, London, 1991, 236-258. - Also: *Twistors and Substance, On Some Metaphysical Aspects of Science*, ANPA 15.
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- ⁴ R. L. Devaney, *An Introduction to Chaotic Dynamical Systems*, Addison-Wesley, Redwood City etc., 1989.
- ⁵ Ref. 4, §§ 1.5 & 1.6.
- ⁶ I. C. Percival, *Chaos in hamiltonian systems*, in: M. V. Berry et al. (eds.), *Dynamical Chaos*, *Proc. Roy. Soc. London (Discussion Meeting)*, Princeton University Press, 1987, 131-143, here: 134 sq.
- ⁷ C.f. R. E. Zimmermann, *Initiale Emergenz und kosmische Evolution*, *System & Struktur* 1 (1), 1993, 39-55. And R. Penrose, *Angular Momentum: An Approach to Combinatorial Space-Time*, in: T. Bastin (ed.), *Quantum Theory and Beyond*, Cambridge University Press, 1971, 151-180.
- ⁸ P. L. Eisenhardt and D. Kurth, *Emergenz und Dynamik*, Junghans, Cuxhaven, 1993.
- ⁹ S. MacLane and I. Moerdijk, *Sheaves in Geometry and Logic*, Springer, New York etc., 1992, 2sq. - Note that Eisenhardt and Kurth refer to *topoi*, too (Ref. 33, 79-89). Although the tendency of their argument is similar to that in this present text, it is not yet quite clear whether the basic line of development is really the same. Refer to Ref. 36 below for this open question.
- ¹⁰ C.f. R. Penrose, *A Brief Outline on Twistor Theory*, in: P. G. Bergmann and V. DeSabbata (eds.), *Cosmology and Gravitation*, Plenum, New York, London, 1980, 287-316.
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- ¹³ *Emergenz und Dynamik. Naturphilosophische Grundlagen einer Nichtstandard Topologie*, Junghans, Cuxhaven, 1993, 33 et passim.
- ¹⁴ This is far from being trivial. Refer to the two first contributions of K. H. Hofmann (*Lie groups and semigroups*) and J. Hilgert (*Applications of Lie semigroups in analysis*) to K. H. Hofmann, J. D. Lawson, J. S. Pym (eds.), *The Analytical and Topological Theory of Semigroups*, de Gruyter, Berlin, New York, 1990, 3-26 and 27-50, respectively.
- ¹⁵ MacLane, Moerdijk, op. cit. (note 12), 361.
- ¹⁶ Ibid. V 6, 7.
- ¹⁷ Hence, the remark in Eisenhardt, D. Kurth, op. cit. (note 13), 5 (Anm. 4), 79 is unclear.
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- ¹⁹ Eisenhardt, Kurth, op.cit. (note 13), 78, 83 (Anm. 12).

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THE ULTIMATE HYPOTHESIS

Peter Marcer
Aikido Enterprises
53 Old Vicarage Green
Keynsham, Avon
BS18 2DH, UK

ABSTRACT

A mathematically specified, physically realisable and experimentally validatable model of Evolution as a process of phase conjugate adaptive resonance. A model of Genesis from the Creation to Consciousness to the edge of time, and which portends new paradigms for chemistry, information processing and thought.

The holomovement as proposed by Bohm¹ may be specified mathematically through an emitter/absorber model of quantum mechanics such that the product of each emission or process of holographic decoding is a frame of a 3+1 dimensional space-time movie where there is adaptive change from frame to frame as the consequence of the absorption or process of holographic encoding of the frame into a stationary quantum interference pattern and its subsequent re-emission². It is a model of holography or production of holographic object images³ which applies to any kind of wave as the consequence of interference with a suitable reference wave. It includes the quintessentially quantum phenomenon of self-interference or presence of a reference wave in the wave process of generating wavelets from the mother wavelet or Huygens' principle. Such object images may therefore be acoustic, chemical, even seismic etc. as well as electromagnetic and it may be postulated gravitational, i.e. the gravitational object images concern the inertial properties of objects in motion as the result of adaptive change from frame to frame in the same way say that acoustic object images determine the acoustic properties of objects. Thus the postulated movie is indeed as we perceive and cognize reality to be, an assembly of three dimensional objects images in motion with inertial, acoustic, chemical etc. properties, as a primary consequence of adaptive change and where the present concerns those emissions and absorptions currently in progress. The physical condition whereby the precise perception of reality coincides with reality itself such that object images of whatever kind coincide with the objects themselves is called phase conjugation^{4,5}. This condition is also the model says, the prerequisite for the adaptive resonance taking place³. It is model therefore which defines an experimentally validatable process of evolution by phase conjugate adaptive resonance with reference to an historical record of a now fixed past of emissions and absorptions, and where to observers like ourselves who are actors in the movie, i.e. intelligent object participators in the evolution

without complete knowledge of the complete historical record up to the present, the future course of emissions/absorptions remains therefore largely unpredictable.

The adaptive change from frame to frame corresponds, the model says, to a shift register operation², or a heat engine model of reversible computation at the binary level^{6,7}, operating in a Carnot cycle as classically the Second Law of Thermodynamics requires. That is, mathematically this historical record constitutes the unique birthordering (or birthorder preserving automorphism) of the self referential system being generated as described above^{8,9}. It provides a clear explanation in the fundamentally time reversible regime of quantum mechanics for the Second Law and the arrow of time that is observed.

The basis for such an historical record, the Berry or geometric phase^{10,11} of a quantum system has already been experimentally validated, so as to show that the Berry phase contains all the information about the system - where it has been, how long it has been away, and what other quantum states the system has passed through in the course of the emissions/absorptions taking place. But in holography a system's phase holding all the necessary information for the encoding/decoding process, i.e. essentially the only real quantity of physical significance is in this model, the Berry phase. It is an historical record therefore where the different alternatives that exist in quantum linear superposition determine the modes of quantum coherence across the system and provide the basis against which further adaptive resonance takes place. And thus in the case of an initial empty historical record this model is a model of something for nothing, which takes place from the dynamic quantum vacuum described by such emitter/absorption models in terms of creation and annihilation operators and Feynman diagrams representing possible histories of emissions and absorptions¹². This model of holography by quantum mechanical means is however unique in that it not only describes the spontaneous emergence and absorption of particles etc. from this vacuum or quantum sea, but space and time as fundamental attributes of the emission and absorption process, i.e. the particles' etc. geometric decoding (and encoding respectively) determine their position in space-time relative to one another. And the very first record in this adaptive process, it may therefore be postulated corresponds to the first act of resonance, i.e. the Creation or Big Bang.

It is a fundamental physical model of image and signal processing¹³ which therefore it may be inferred from the above description applies to the Universe as all that exists as a quantum system where the model of evolution becomes a model of Genesis, or Everything from nothing, i.e. the Ultimate Free Lunch. A quantum model of self-organization from the dynamic quantum vacuum by means of an emitter/absorber model of holography applying to any kind of wave and which therefore includes the chemical self organization of chemical systems evolving by adaptive resonance, defining an experimentally validatable model of Life, where a chemical historical record of a particular species would be its DNA. Such chemical self-organization implies the optimum control of uncertain quantum systems¹⁴. This has recently been experimentally validated in the laboratory^{15,16} for chemical systems by irradiating a chemical soup using lasers under computer control of a genetic algorithm so as to adaptively produce a particular chemical output in an optimum way. It is a process corresponding to the exact solution of the relevant Schrodinger equation for the chemistry in real time by adaptive filtering or selection of the correct laser spectrum to produce the desired chemical output; a process where the adaptive filtering taking place is specified in terms of the same quantum mechanical Hilbert-Schmidt operators¹⁴ employed in the quantum holographic model to describe the interferometry taking place^{17,18}.

It infers as already implied that the perception and cognition taking place in brain/minds as chemical information processing systems employ the same processes of phase conjugate adaptive resonance to carry out the image and signal processing required. In this process of adaption or learning, the brain/mind functions as a square law detector so the closest pattern to the one newly input is incrementally amplified while the remaining stored patterns of the learned historical record are simultaneously attenuated so as to produce the stream of conscious cognition. Consciousness is therefore in this model, this amplified or principal mode of adaptive resonance of the brain/mind system where the different alternatives in quantum linear superposition appropriate to its Berry phase or mental states have the potentiality through adaptive resonance to determine the neural events taking place in the active segments of the brain. A potentiality of mind to control the brain which must be learned so as to produce the stream of conscious perception and cognition necessary to facilitate survival in a reality which as already described is the result of other more general modes of adaptive resonance or evolution. That is, mind is the Berry phase of the brain/mind system where learned subsequences of the historical record are 'programs' able to initiate behaviour via the mechanism of neural activity, i.e. those to play tennis for example and where the brain/mind system of the model employs the self same processes of holographic image and signal processing implemented chemically so that awareness corresponds to the 3+1 dimensional space-time movie of the postulated Evolution, but subject to the limitations of its sensory apparatus or senses, and the location or local frame of reference of the brain/mind. Thus the motion of this local reference frame corresponding to the brain/mind's historical record of experiential knowledge and its reference wave system necessary to the holographic encoding/decoding in progress specify what can in this model be called the Self. Simple perceptual experiments verify the phase-conjugation or coincidence in space-time of the object images which the brain and its sensory apparatus construct with the objects themselves, as a commonsense requirement or paramount condition for the brain/mind body's survival. Snap your fingers and ask where the brain constructs the acoustic object image of the snap. Your senses immediately tell you, that it is outside the head coincident, i.e. phase conjugate with where the snap occurred in space-time. To confirm this, look at an object nearby and reach out and touch it. The visual object image the brain/eye system creates is coincident in every geometric respect with the tactile object image the brain/touch system creates, and with the object itself in space-time outside the body. Thus although there is a subjective cognizance of object images or objects according to the subject's historical record of experience, there is in this form of image and signal processing a universality of perception of a space-time world with objects. That is, a bat will see the same reality acoustically that we perceive visually, but will attach quite different meanings to the objects 'seen'. This universality of perception of object images in space-time coincident with the objects themselves thus provides an iconic labelling for the image and signal processing in progress, facilitating communication between entities perceiving and cognizing in this way by quantum holography. Such a form of image and signal processing where there is such a canonical iconic labelling constitutes computation in the formal sense, and it can be postulated will provide a basis for language in terms of shared explicit but arbitrary canonical labellings of the objects. It is however an analogue model of computation grounded in quantum theory, and based on adaption or learning rather than instruction or algorithms. Further as has been shown, such learning may begin from a state of no experiential knowledge, i.e. an empty historical record, quite contrary to the state of complete knowledge it is thought digital information processors would require if they were to exhibit intelligent behaviour. Indeed in brain/minds where through adaptive resonance or consciousness the mind can control the brain so that mental events cause neural events rather than vice versa, such mental events are represented by the creation and annihilation operations of the emitter/absorber model and so

may constitute truly creative acts of thought giving rise to ideas or constructs, i.e. artifacts which never before existed within the Universe. Such creative thought or mental events which then become neural events by adaptive resonance are in fact part of the Universal Evolution and so brain/minds engaged in such creative acts are an actual agency of the Evolution itself. Equally mental processes will allow such brain/minds to override or inhibit Evolution on a local basis, i.e. in a region of space for a limited period of time, that is to exercise so called free will.

The mathematics of the model^{2,3,18} says that exponentially complex time behaviours arriving say as sensory information, may be not only encoded (and simultaneously decoded) through the mechanism of a reference wave, but transmitted as a real signal on a carrier wave. Thus this form of image and signal processing overcomes the combinatorial explosion of real world complexity that is the obstacle to efficient computation and information transmission in other processing models. Similarly the model permits representations of reality or assemblies of objects in motion in space-time to be encoded holographically by physical means using transducers without the need to resort to a mathematical or computation specification^{19,20} and subsequent encoding by program or algorithm. These involve direct or indirect human intervention in the case of digital information processing where such specifications and programs are frequently difficult to make error free or are often not feasible. It is a practical form of image and signal processing which for example describes that taking place in synthetic aperture radars and magnetic resonance and SQUID tomography, substantiating both de Broglie and Bohm's concept that the probability fields of quantum mechanics and the quantum potential respectively function as a guiding field or radar governing the dynamics of elementary particles.

Such a model of the evolution of the Universe, i.e. self-organization in a self-referential quantum system by means of holography, need not require the continuous creation of energy but simply the reconfiguration of energy and matter in space-time by means of increasingly complicated topological transformations that are a central feature of the adaptive resonance of this emitter/absorber model^{3,13,18}. Conservation of energy could be adhered to simply by matching the positive energy in the form of matter and radiation at any point of the evolution, with negative energy that general relativity infers could come from the curvature of space-time. Indeed the condition of self-organization of an uncertain quantum system or optimum control is a semi-classical condition that could resolve the apparently irreconcilable dichotomy between quantum theory and general relativity. It requires for example that the Evolution must correspond to a Hamiltonian and such a Hamiltonian defining the energy of the Evolution can indeed be postulated from the fact that the holographic encoding and decoding process of the emitter/absorber model proposed corresponds to an embedding of the complex plane C co-ordinates $z = x + iy$ into the group of topological transformations G of the model specified by the Heisenberg group²¹. This is in excellent accord with Berry's Hypothesis²² concerning the Berry phase that in this model specifies the Evolution, that it concerns the Hamiltonian of an unknown dynamical system without time reversal symmetry of which the phase space trajectories are chaotic and the eigenvalues of which are the imaginary parts E_m $m = 1, 2 \dots$ of the zeros of the Riemann Zeta function

$$\zeta(z) = \sum_n \frac{1}{n^z}$$

where n is taken here to be the number of emissions/absorptions. This well-known function by the Riemann hypothesis has its zeros on the line $1/2$ so that $\zeta(1/2 + iE_m) = 0$ and can be interpreted as defining every fermionic state of the evolution which, by the Pauli

exclusion principle, would therefore correspond to the canonical labelling of the information processing taking place, called earlier the iconic labelling or specification of the phase conjugation conditions for object images to coincide with the objects themselves. And thus the unknown dynamical system of Berry's postulate is, it can be intuited that of the Evolutionary model proposed, where the eigenvalues of the unknown Hamiltonian without time reversal symmetry specify the actual acts of creation of objects. It is a model where all the phenomena taking place, i.e. the creation of objects, their motion and eventually their annihilation are the consequence of the quantum coherences of the evolution of the model. And since these in brain/minds correspond to mental events, it is appropriate to designate the field of quantum coherence as the Psi field, and to say that the Psi field determines emergence in the evolutionary model proposed, and in particular the emergence of consciousness in brain/minds and to reflect that such consciousness will be responsible for all acts of creative and destructive thought, both facilitating and temporarily inhibiting the evolution in progress.

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APPENDIX

Working Paper for Main Paper

SELF-ORGANISATION/GENESIS - THE SOLUTION!? Short Title

SELF-ORGANISATION BY MEANS OF QUANTUM HOLOGRAPHIC ADAPTIVE RESONANCE Long Title

The Heisenberg group G , Lie algebra g and nilmanifold describe the quantum holographic processes to be considered. This description includes the classic beam splitter quantum (self) interference experiments by, for example, Mach-Zehner interferometry. It is a methodology applicable to all waves, i.e. electron waves, ion waves, x rays, acoustic waves etc. as well as optical waves - provided the wavelets are coherent enough to form the required stationary quantum inference patterns in the hologram plane, where wavelet mixing takes place.

When holography is performed by the excitation of stationary waves inside a wave propagating medium with reflecting boundaries, phase conjugation occurs spontaneously and both virtual and real images of the stationary quantum interference patterns formed between two waves with one acting as the reference wave, are elicited by wave diffraction. Such images are of geometric time varying behaviours which are spatio-temporal geodesics. For example in a cavity such adaptive resonance allows it to function as a square law detector, so that the closest stored patterns elicited in mode competition with it are simultaneously attenuated. The cavity thus functions as a parallel computer with a definite metric for pattern discrimination, where the nature of the information processed is not bits but holographic encodings. The mathematics of the Heisenberg group says exponentially complex time behaviours can not only be encoded as such patterns and decoded, but also transmitted as real signals, so overcoming the combinatorial explosion of real world complexity which is the obstacle to efficient computation and information transmission in other processing models.

Furthermore the newly input pattern, a time varying piece of information will itself become stored without limit to the number of patterns or encodings holographically superimposed. Such superimpositions therefore constitute an historical record or memory corresponding to the Berry phase in a quantum system against which further self organization by adaptive resonance takes place. The historical record of the system as a whole therefore constitutes a unique self-reference frame for this further self-organization. It provides a model of evolution and for learning by adaptive resonance which is spontaneous or automatic, initiated from an empty self-reference frame or historical record/memory, i.e. a mathematically specified and physically realisable model of genesis or something for nothing. Such genesis or evolution, which can be interpreted as taking place from the dynamic quantum vacuum, can be expected to be hierarchical since from the self-similarity properties of holography as found for example in holograms, the features of the evolution/learning on a lower/one level of scale, will be replicated by equivalent features on a higher/another level as further adaptive resonance proceeds.

It is proposed to investigate the nature of the neuron and the brain, i.e. of intelligence defined as the genesis/perception of order/concepts or artefacts that never previously existed/perceived, and the nature of the cosmogenesis by means of this model of adaptive resonance. Such a cosmogenesis would constitute a free lunch or everything from nothing as a fully mathematically specified and physically realisable model of the holomovement

advocated by Bohm, where the information metric for the adaptive resonance can be postulated to be entropy as proposed by Zurek and the self-adjoint Hamiltonian operator for the cosmic adaptive resonance is that advanced by Berry for the dynamical system without time reversal symmetry of which the phase space trajectories are chaotic. This Hamiltonian has eigenvalues which are the imaginary parts $E_m, m = 1, 2, \dots$ of the non-trivial zeros of the Riemann Zeta function $\zeta(z)$ and is appropriate to the fractal self-similarity properties that quantum holography would require.

If the above postulates can be validated, as my preliminary research in the form of published papers indicates strongly will be the case, then a strong possibility exists of a grand scientific unification spanning number theory through computation and chaos theory to quantum physics and cosmology, extending eventually to the neurosciences. In the final case, the preliminary work on the model of the neuron working by quantum holography, presented in preliminary form at the recent University of Liege COMETT symposium on the design of new intelligent machines, is indicative of a highly biologically neuromorphic model. This for example requires the synaptic button to be a resonant cavity predicting the existence of the presynaptic vesicular grid of hexagonal hololattices as found in mammals. It is the principal part of the synaptic mechanism for the provision of a standardized metric for synaptic gain, that an assembly of such neurons would require if they are to function as a neural net or brain, and it is truly remarkable that the model should predict the hexagonal structure found, as well as the probabilistic release of a single synaptic vesicle from the grid so as to provide the synaptic gain across the synaptic cleft - a mechanism in biological systems which is truly amazing in itself.

Such an assembly of neurons working as a neural net or brain is appropriate to a model of the mind/brain system which can be interpreted as Cartesian. In this interpretation the brain behaves classically, the mind quantum mechanically and consciousness concerns the dynamics of the quantum vacuum. That is, such a brain is a prepared classical wavefield apparatus capable of making quantum mechanical measurements in the sense of an experimental apparatus in high energy particle physics. Thus the Heisenberg nilpotent group, Lie algebra, and nilmanifold describing the image and signal processing properties of quantum holography can be considered as the basis for a mathematical description of the Psi field, the field of quantum coherence which concerns consciousness, intelligence and creativity. And when consciousness concerns an act of creativity or the elicitation of entirely new knowledge from the quantum vacuum where such knowledge will usually be appropriate to the universe of discourse under investigation, and the elicitation is by adaptive resonance exemplified by the well known Eureka phenomenon, then by implication the mind/brain system is an agency for the on-going cosmogenesis.

TO SUMMARIZE

The cosmogenesis of everything from nothing is a self-organized creation where a visible, i.e. electromagnetic universe governed by general relativity is elicited spontaneously by means of adaptive resonance quantum mechanically in accordance with the standard model! This is totally analogously to the illumination of brain activity - an image of the adaptive resonance of consciousness - as can be seen by means of magnetic imaging tomography using quantum holography; except that in contrast to magnetic imaging tomography where a single image slice is displayed, both universe and brain exhibit quantum parallelism displaying all their image slices simultaneously. These 'slices' are the galaxies, and the currently active brain segments respectively.

THE ENCHANTED LOOM

Peter Marcer
Aikido Enterprises
53 Old Vicarage Green
Keynsham, Avon
BS18 2DH, UK

How the patterns of the Cosmos, Life and Thought are woven into the cloth of the Universe from the three fundamental strands of time as explained by the emitter/absorber model of quantum holography defined through the Heisenberg nilpotent Lie Group, algebra and nilmanifold. Within the specification of the Heisenberg group the three strands of time are determined by

the synchronization parameter x or time from path difference,
the synchronization parameter y or time from relative phase,
the synchronization parameter z or time from frequency.

These synchronization parameters x, y, z common to all observable phenomena specify the means by which the essentially guided or optimally controlled self-organization of the Quantum Universe takes place through phase conjugate adaptive resonance as evolution or learning as processes of self-correction. Such self-organization and optimal control extend quite naturally to the chemistry of life - see the proposal for an experiment to validate its origins in Appendix - and to the morphology and dynamics of brains specifying learning and the processes of thought and consciousness.

INTRODUCTION

Quantum holography^{1,2,3} may be defined mathematically through the emitter/absorber model of quantum mechanics (see below) by means of the representations of the Heisenberg nilpotent Lie group G , algebra $\mathfrak{g}$ and nilmanifold. The real three dimensional Heisenberg Lie group of unipotent matrices

$$\begin{pmatrix} 1 & x & z \\ 0 & 1 & y \\ 0 & 0 & 1 \end{pmatrix} : = (x, y, z) \quad x, y, z \in \mathbb{R}$$

describes the generation of wavelets from the mother wavelet for the case of phase coherence. The real synchronization parameters are appropriate to macroscopic quantum field theory. They include as G orbits the case of affine wavelets (generated from the mother wavelet) described through the affine $(at + b)$ solvable Lie group of real matrices

$$\begin{pmatrix} a & b \\ 0 & 1 \end{pmatrix} \quad a > 0, b \in \mathbb{R}$$

with average width parameter a and synchronization parameter b .

That is, in the context of Jessel's formulation of Huygens' Principle defining the action of the generation of wavelets from the mother wavelet and quantum mechanics, the Lie group G represents the non-commutative group of symmetries to analyze and synthesize in terms of the unitary dual of G , the convolution structure of the wavelets under Fourier transform action F .

Now consider the holographic reciprocity principle of degenerate coherent four wavelet mixing

$$\begin{aligned} \iint_{\mathbb{R} \oplus \mathbb{R}} H_i(\psi, \varphi; x, y) \exp(-2\pi i y t) \bar{\psi}(t-x) dx dy &= \bar{\varphi}(t) \\ \mathbb{R} \oplus \mathbb{R} & \qquad t \in \mathbb{R} \\ \iint_{\mathbb{R} \oplus \mathbb{R}} H_i(\psi, \varphi; -y, x) \exp(-2\pi i y t) F\bar{\psi}(t-x) dx dy &= F\bar{\varphi}(t) \end{aligned}$$

This shows that the Fourier action of spatial encoding in the hologram plane $\mathbb{R} \oplus \mathbb{R}$ results in no information loss. To see this note that the principle gives a stationary quantum interference pattern by means of error correction/correlation terms appropriate to the path difference x and phase difference y of the two wavelet mixing

$$\psi(t') dt' \otimes \varphi(t) dt \rightarrow H_i(\psi, \varphi; x, y)$$

where H , the holographic transform is the probability of detecting a photon within a unit area attached to the point (x,y) of $R \otimes R$. Thus there is full recovery of the holographic object image on the reciprocal process of decoding when quantum mechanically the collapse of the wave function occurs. This is because these terms make the original non object bearing reference and object bearing beams indistinguishable in the hologram plane where these beams correspond to $\psi(t)$ and $\phi(t)$ respectively or vice versa.

Thus the holographic reciprocity principle provides a quantum mechanical confirmation that Jessel's formulation of Huygens' Principle for the generation of wavelets from the mother wavelet:-

"that the perturbation of the field A that passes through the surface S containing a wave source S_α is identical to the perturbation that is obtained by removing the source and substituting it by an appropriate system of secondary sources S'_α distributed on the surface S "

expresses the principle of conservation of information as it applies to all physical systems.

To determine the unitary dual of G which encodes the structural and signal geometric properties, notice that the connected affine group of the real line R admits the left and right Haar measures

$$\frac{da \otimes db}{a^2} \quad \text{and} \quad \frac{da \otimes db}{a} \quad \text{respectively}$$

and that the affine Lie group has only two non-trivial, non-interactive coadjoint orbits O_1 which are represented by the complementary open half-planes. Correspondingly the Heisenberg group G with one dimensional centre C_0 of unipotent matrices

$$\begin{pmatrix} 1 & 0 & z \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} : = (0,0,z)$$

such that for any given centre frequency $v \neq 0$, has centre character

$$X_v : C_0 \ni (0,0,z) \rightarrow \exp(2\pi i v z)$$

which determines up to a unitary isomorphism a unique infinite-dimensional irreducible unitary linear representation of the Schrodinger type U_v of G in the standard Hilbert space $H = L^2(R)$. This is unimodular and has Lebesgue measure $dx \otimes dy \otimes dz$ defining both its left and right Haar measures.

In fact the Heisenberg group admits infinitely many non trivial, non-interactive, coadjoint orbits O_v ($v \neq 0$). These are transversal to the longitudinal centre line C_0 and planar, uniquely determined by the centre character X_v so that $O_v \rightarrow X_v$. The representations U_v of G are such

that

$$\overline{U}_v(x,y,z) = U_v((x,y,z)^{-1}) \text{ for all } (x,y,z)$$

i.e. $\overline{U}_v$ is the feedback or back-projection representation of G associated with U_v . Thus the centre characters X_v are these representations modulo C_0 i.e.

$$U_v/C_0 = X_v \text{ and } \overline{U}_v/C_0 = X_v$$

Thus G will implement in an appropriate gauge, the symmetries of sesquilinear or phase conjugate resonance based self-organization at the quantum level appropriate to any geometric scale both micro and macroscopic.

And so as originally found by Weyl if $\{P,Q,Z\}$ are a canonical basis for $\mathfrak{g}$ the Lie algebra of G , then

$$[P,Q] = PQ - QP = Z \quad ; [P,Z] = 0 \quad ; [Q,Z] = 0 \text{ for all } P,Q$$

so that these quantum mechanical commutators are the structure relations of $\mathfrak{g}$. Introduction of the usual complex mode co-ordinates

$$R = 1/2(P + iQ) \text{ and } R' = 1/2(P - iQ)$$

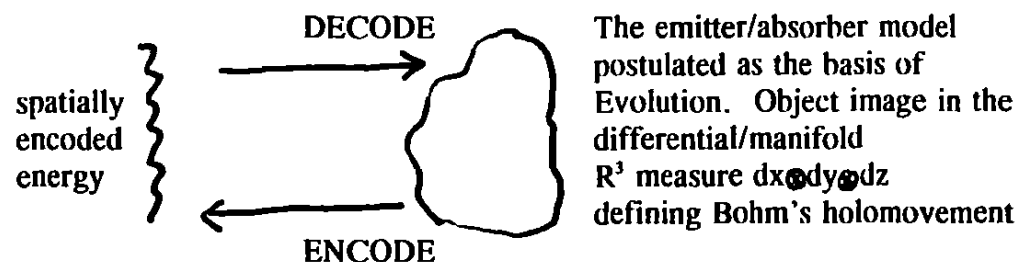
permits the different alternatives at the photon level that can co-exist in quantum complex linear superposition to be expressed in terms of the annihilation and creation operators of the emitter/absorber model

$$a = U_1(R) \quad ; \quad a' = U_1(R')$$

through the linear Schrodinger representations U_1 of G where in terms of the number states $|n_k\rangle$ which are quantum states with n_k quanta occupying the mode k , these number states are the eigenstates of the number operator

$$N_k = aa' \quad \text{and} \quad [a,a'] = \hbar$$

is the bosonic commutation relation, i.e. diagrammatically:-



The natural Lie diffeomorphism of the emitter/absorber model (or differentiable mapping with a differentiable inverse) is such that

$$\begin{aligned} \exp: g &\rightarrow G \quad \text{and} \\ \log: G &\rightarrow g \end{aligned}$$

Thus this form of geometric encoding/decoding allows the treatment of exponential complexity in an optimum way and similarly for data transmission of real signals modelled by the group G 's one dimensional centre C_G since

$$\begin{aligned} \exp: c &\rightarrow C_G \quad \text{and} \\ \log: C_G &\rightarrow c \end{aligned}$$

where c is the centre of g . This implies the possibility of essentially unlimited data compression and memory because at the most primitive level the transmission of information and its storage are one and the same.

It is also worthy of note that as an emitter/absorber model of quantum mechanics specified as a Lie transformational system in terms fundamental topological mappings, i.e. the diffeomorphisms above which as a model of image and signal processing describe the nature of the error correction/correlation terms appropriate to the evolution as an adaptive process, that such diffeomorphisms eliminate the need for the renormalization procedures currently necessary in more standard quantum mechanical theories and models.

It is therefore useful to contrast this form of image and signal processing with that of orthodox digital computation where the computation of an output corresponds to a many to one transformation or substantial information loss and corresponding thermal dissipation of energy. This in the case of exponential complexity may inevitably make such a digital computation thermodynamically impractical. In the case of quantum holography by means of a resonant cavity, however, the thermodynamic loss in the cavity due to the attenuation of all but the closest stored representation to the one newly input, is matched by a gain equal to the loss or amplification of this closest representation. This implies that the thermal dissipation will be minimized and that the transformation of a motherwavelet to a generation of wavelets models the read in, while the inverse transformation or selection of wavelets to combine to form a motherwavelet models the read out. It suggests as would be expected in a quantum mechanical model that entropy⁴ no longer plays simply the role corresponding to increasing disorder, but acts as an information metric as was proposed and proved to be the case by Zurek^{5,6}. Such a metric is appropriate to algorithmic information rather than classical information theory and shows that the quantum mechanical computation taking place holographically as described above will indeed be able to transcend Godel's theorem and the halting problem of classical computation.

OTHER NOTABLE FEATURES OF THE MODEL

This model explains why

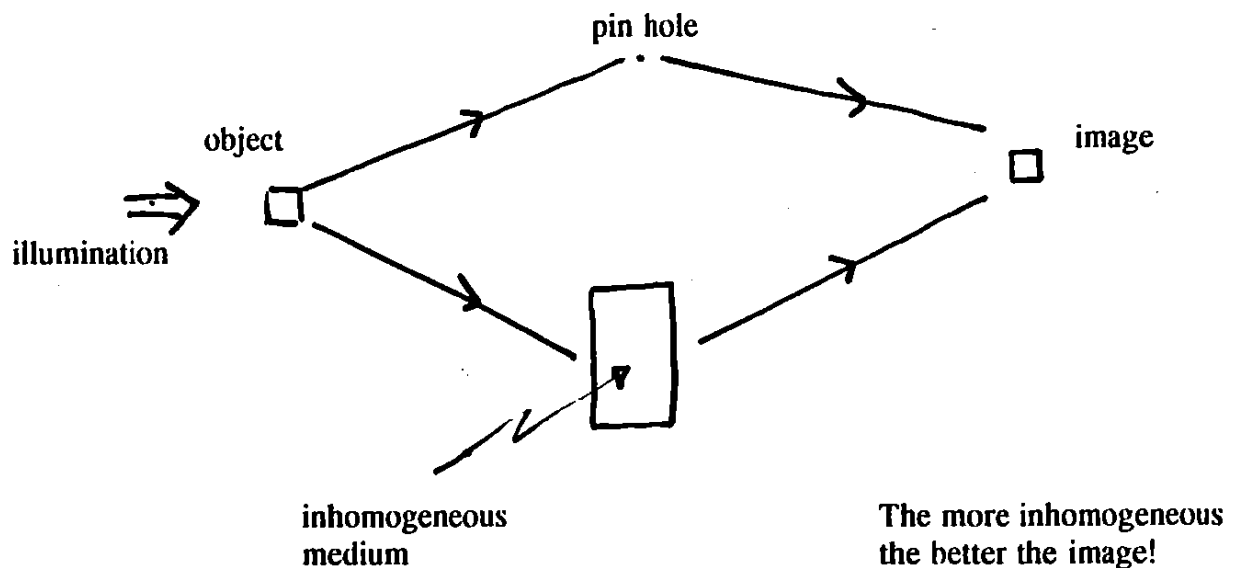
- a) the observable universe is spatially three dimensional, i.e. as a consequence of the three synchronization parameters,
- b) how the dichotomy between general relativity and quantum mechanics might be resolved, i.e. because the spatially encoded energy of the quantum holographic process is a stationary quantum interference pattern or spatio-temporal geodesic, i.e. the action of time on the basis of the emitter/absorber model can be interpreted as solely due to the superposition of spatio-temporally coherent retarded signal wavelets and advance response wavelets. Thus $H_+(\psi, \varphi; \dots)$ and $\bar{H}_+(\psi, \varphi; \dots)$ which are spatially local and temporally global can be considered as the wavelet transform of the retarded signal $\psi L^2(R, dt)$ with respect to the advanced reference response wavelet $\bar{\varphi} L^2(R, dt)$ and vice versa so that the time averaging performed by integration along the whole real line R by superposition of the net wavelets which is expressed in the modular scalar product $\langle | \rangle$ of the complex Hilbert space $L^2(R, dt)$ and the doubling of the variables effectively freezes the time t of the advanced signal wavelet packets and the retarded response wavelet packets into the spatial synchronization variables (x, y) of the symplectic hologram plane $(R \oplus R, \Omega_v = v \cdot dx \wedge dy)$ where $v \neq 0$ is the frequency. Thus the spatial encoding of the relative phase y avoids the loss of phase information under wave packet reduction and the knowledge of the co-ordinates (x, y) with respect to the symplectic frame allows the identification of the split photon channels in accordance with the non-local quantum property of individual optical photons passing by different pathways, since $H_+(\psi, \varphi; x, y)$ is the probability of detecting a photon of energy $h\nu$ within a unit area attached to (x, y) in $R \oplus R$ the hologram plane. This conservation of information on wave packet reduction is a truly remarkable feature of quantum holography.
- c) the Cosmos consists only of matter and not anti matter since in the emitter/absorber model there is essentially a dynamic equilibrium between matter and spatially encoded energy.

The Heisenberg group G induces a shift register action on the Heisenberg nilmanifold, this being the principal action by means of which the self organized phase conjugate adaption takes place, i.e. according to the Schur Lemma

$$\iint_{R \oplus R} H_+(\psi', \varphi'; x, y) \bar{H}_+(\psi, \varphi; x, y) dx dy = \langle \psi' \otimes \varphi' | \psi \otimes \varphi \rangle$$

The model describes superresolution² where the introduction of noise only serves to sharpen images.

Superresolution imaging may be required (conceptual optical system).



Superresolution or one way phase conjugation concerns only partially coherent "illumination" or wavelet mixing. There are two types of coherence, i.e. temporal (longitudinal or axial) which is the requirement that wavelets all travel at the same time or at the same frequency and spatial (transversal or lateral) which is the requirement that all the wavelets move together in phase as if they started from the same point in space. Both together are unnecessary for holography and hence one may simply use a coherent non object bearing beam for data capture on a partially coherent object bearing beam. Thus in a holophonic model of the ear, it would be expected as is the case, that the ear itself will give out a coherent acoustic signal⁷ so that it can capture by using the process of acoustic superresolution all the acoustic invariants or sounds as distinct from noise. In this process, the sounds captured are then quite naturally segmented according to their frequency properties, and at a more sophisticated level according to their geometric shapes and locations as happens with bats.

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APPENDIX

A Proposal for Experiments to Validate the Origin of Life

Date - 5.5.94

Introduction

The recent conference "Towards a Scientific Basis for Consciousness" at Tucson was significant in the way from many different papers there emerged a coherent scientific hypothesis of the conditions essential in living systems for the production of consciousness.

These conditions and other recently proven properties of quantum coherence as applied to chemical systems constitute a similar hypothesis about how on Earth life could spontaneously self organize, that may be tested through a modification of the original experiments of S.L. Miller as described in the inset, by applying these new conditions in place of those used by Miller and subsequent experimenters.

The essential feature of the validation that distinguishes it from the conduct of Miller's original experiment, and why the model proposed can be postulated to concern the origin of Life.

The essential feature of quantum coherence or holography that must be used in the proposed revised Miller experiment is to exert an optimal control of the uncertain quantum system the revised Miller experiment constitutes: see Science vol. 258, 16 October, 1992, "New Ideas for Guiding the Evolution of a Quantum System" p412-413, S.A. Rice. It is to irradiate the atomic and molecular constituents of life inside the apparatus coherently so as to give the desired reactions. The accent is on coherently and what in current laboratory practice is described as "teaching lasers to control molecules" Physical Review Letters, 68, 10, 9 March 1992, 1500-1503, R.S. Judson, and H. Rabitz. This suggests a process guided by human design or conscious intent, but in fact such an optimum control can I would claim be produced spontaneously as the result of quantum mechanical phase conjugate adaptive resonance as described through the harmonic analysis on the Heisenberg group, Lie algebra and nilmanifold, see Walter Schempp "Harmonic Analysis on the Heisenberg Nilpotent Lie group with applications to Signal theory", Pitman Research Notes in Mathematics vol 147, John Wiley, New York 1986. The hypothesis implies such a control be exerted in the solvent or medium in which the molecular reactions are to take place. The harmonic analysis describes through the Heisenberg nilpotent group, all the processes of constructive and destructive quantum interferometry i.e. quantum coherence, defining the fine structure not apparent from the perspective of the Heisenberg Uncertainty Principle, although from this analysis the Principle is itself deducible. The fact that the converse is not true, has concealed properties of the standard theory since 1928 when Hermann Weyl uncovered the Heisenberg group and its relationship with Heisenbergs quantum commutators. Independently R. Nobili, Physical Review A, 35, 4, February 15, 1987, 1901-1922 "Ionic Waves in Animal Tissue"

THE SEARCH FOR LIFE'S ORIGINS

In 1952-3 Stanley Miller and Harold Urey pioneered a type of experiment that seemed to give strong support to the idea that life could have originated gradually from non-living chemical substances. The theory behind these experiments was based on what the conditions were supposed to be like on the newly formed Earth about 4.5 billion years ago. The atmosphere consisted of a mixture of gases that would be poisonous to most modern life-forms, being made up chiefly of methane, ammonia, carbon monoxide and dioxide, and nitrogen. Oceans covered most of the planet's surface and were whipped up by volcanic activity and huge electric storms.

Miller's apparatus was designed to recreate these primordial conditions in a laboratory, to find what chemical changes might have taken place on Earth. In early experiments he passed 60,000 volt electric sparks through the mixture of gases, often continuing this for many days.



A classic experiment
Stanley Miller is seen here with the apparatus that was held to solve the mystery of life's origins.

The results of the experiments were surprising and, at the time, were hailed almost as the answer to the question of life's origins. Miller found a host of organic or life-associated molecules in the resulting "soup", among which were two basic types of biochemical building blocks,

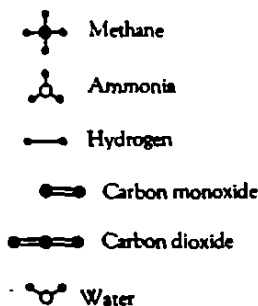
amino acids—the constituents of proteins, and nitrogenous bases—the constituents of DNA.

The experiments have continued and many hundreds of organic molecules have now been synthesized. In the early Earth's oceans these molecules would have accumulated, there being no living organisms to "eat" them, and according to the ideas of the time no oxygen to break them down. One researcher has estimated that the primordial soup would have been brimming with large molecules—in terms of organic material about one third as concentrated as chicken broth.

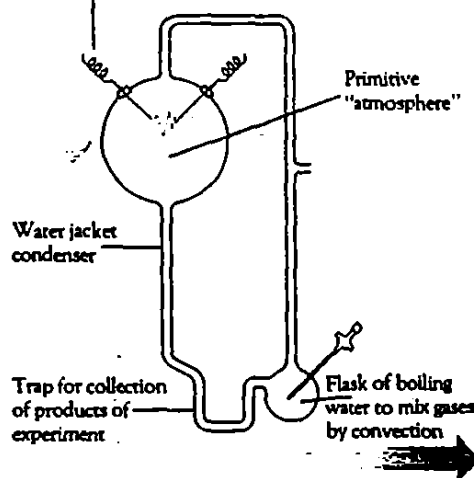
So far so good. However, the next step—the coming together of subunits into larger organized molecules with the capacity to reproduce themselves—has not occurred in the laboratory flask. There is evidence that some molecules can multiply on their own in a test tube, but this is only if they are correctly assembled in the first place, and are "helped" by an enzyme to speed things along. As for the

The real test of the revised Miller experiment will be the coming together of subunits into larger molecules with a capacity to reproduce themselves under the conditions of the experiment

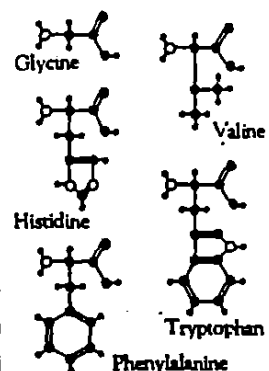
Recipe for the early atmosphere
The experiment used gases that were almost certainly common over 4 billion years ago. Oxygen was supposed not yet to be present, while gases poisonous to modern life-forms were abundant.



Tungsten electrode producing 60,000 V spark



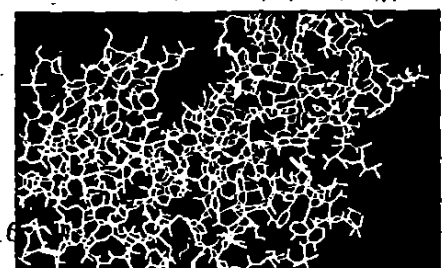
Chemicals in the soup
Below are just some of the amino acids that were discovered at the end of the experiments. Many of the building blocks needed for giant molecules, and hence life, were produced.



appearance of complex biochemicals in the primordial soup, there is an enormous gap in the evidence, one that seems unlikely ever to be bridged.

Life's chemical complexity.
The computer-generated structure of a simulated alternative: Probable structure of ANPA16 shows how great a difference

there is between the products of Miller's experiments and many of the molecules found in living cells. Hundreds of amino acids are joined together in a specific sequence to form the molecule.



states that "when holography (describable through the harmonic analysis) is performed by excitation of stationary modes inside a wave-propagating medium with reflecting boundaries...phase conjugation occurs spontaneously and both virtual and real images of recorded information are elicited by wave diffraction." This was supported by the independently researched model of quantum coherence presented at Tucson by Mari Jibu, Kunio Yasue and Scott Hagen which postulated temporarily stable molecular structure at the macroscopic level and emphasized the role in conscious and living systems of microtubules and coherent water. The essential role of quantum coherence was also hypothesized by a number of other speakers notably Roger Penrose, Danah Zohar, Enzo Insinna, Fred Wolf and Ian Marshall, and the enormous informational power of molecular reactions taking place as in living systems by lock and key pattern recognition was discussed by Michael Conrad and Steen Rasmussen. All are indicative of the fact that such optimum controls as hypothesized above are taking place in living systems.

Possible examples are the structures of microtubules and coherent water which make up a significant proportion of the human body, and glial tissue in brains as postulated by Noboli as the basis for brain holography by means of ionic Schrodinger waves. The glial cells are much more numerous than are the neurons. The microtubule can be described through the model of the Heisenberg group where it would be an instantiation of the group's one dimensional centre C_0 appropriate for the transmission of holographic encodings as real signals. And this was indeed the purpose postulated at the conference by both Stuart Hameroff, and Jack Tuszynski. It perfectly matches the function of the axon in the model of the neuron working by quantum holography - W. Schempp and P. Marcer paper recently submitted for publication - where such an axon is a cylindrical lens for the transmission of such real signals on a carrier wave and where the neurophysiology indicates that the microtubular organization is responsible for such transmissions.

Coherent water was described by John Watterson. It corresponds to a state of water at a particular phase transition point. A similar transition point was identified by Tuszynski as essential to the functioning and self organization of the microtubule. And coherent water is similarly describable through the representation of the Heisenberg Group

$$\begin{pmatrix} 1 & x & z \\ 0 & 1 & y \\ 0 & 0 & 1 \end{pmatrix} : = (x,y,z) \quad x,y,z \in \mathbb{Z}$$

as appropriate to the medium within which molecular informational encoding and decoding take place by for example molecular lock and key reactions. That is at the phase transition point the water has 3 dimensional cellular structure - described by Watterson, where each cell remarkably is sized to house all the living proteins in their most coiled form. The harmonic analysis says therefore that both the microtubules and the coherent water can be expected to be self-organizational by means of phase conjugate adaptive resonance producing an optimal control if appropriately irradiated or supplied with energy.

The Proposal

This is to repeat the Miller experiment with such irradiation employing phase conjugation so as to produce coherent water in the lower flask, see diagram, and possibly also phase conjugate irradiation of the primeval atmosphere of the upper flask containing the basic elements of life as used by Miller. Irradiation might also be tried using a computer employing a genetic algorithm as in the paper by Judson and Rabitz above, so as to see what complex molecules are elicited.

The expectation is that the basic elements of life ought to show a considerably more rapid self-assembly of the amino acid groups or other complex molecules than previously found by Miller and that the basic processes of DNA and RNA should come into action demonstrating the basis for the origins of life proposed here, i.e. phase conjugate adaptive resonance. The maintenance of these specific conditions continuously, which at the beginning of actual life on Earth could be expected to occur only on a very occasional basis would correspond to a very considerable acceleration of life's formation in the experiment.

Further protein-like substances are already known to be produced in the existing Miller experiment, and which when dissolved in hot water and allowed to cool, condense out as myriads of tiny spherical globules. The walls of these globules have many of the properties of cell membranes and can be therefore expected to behave as cavities where self-organized phase conjugate resonance will induce further stages in the chemical self-organization proposed, and where in particular the water enclosed will take increasingly its coherent form.

It is worthy of note that in deep space where atoms and molecules are extremely sparse and therefore might be expected to have little chance of chemical reactivity, that thanks to quantum mechanical properties contrary to expectation the chemistry is very rich and a variety of organic and other molecules such as for example Buckmasterfullerene have been found by spectroscopic analysis. Deep space too therefore could represent a source of the basis chemicals necessary to life, but where once again quantum coherence is the key to their formation!

Theoretical and experimental support for the model proposed, has already been provided by the paper by B.E.P. Clement, P.V. Coveney and P.J. Marcer Surreal numbers and optimal encodings for universal computation as a physical process: an interpretation of the genetic code, which predicts the relationship between Hamiltonian paths, models of computation based on Huygens Principle, and DNA, published in the CCAI Journal 10, 1/2, 149-163, 1993. This has recently been substantiated by the work of L.A. Adleman, Science 255, 11 Nov., 1021-1023, 1994, Molecular Computations of Solutions to Combinatorial Problems, where the actual solution to an Hamiltonian path problem is carried out by chemical procedures using DNA.

Is The Coulomb Law Inevitable?

A.M. Deakin- 75, Clatterford Rd, Newport, Isle of Wight PO30 1NZ, UK

ABSTRACT

The argument here presented suggests that the Coulomb force is not an independent element of either the Schrodinger or the Dirac models of the hydrogen atom. Rather the Coulomb force derives from the other elements of the respective models. The Schrodinger model permits an inverse cube force, in addition to the Coulomb force, which can be made, roughly, to reproduce the Sommerfeld / Dirac fine structure in the spectrum. Questions are raised about a possible connection between the inverse cube term and Feynman's derivation of Maxwell's (Lorentz invariant) equations from non-relativistic QM.

1. PRELIMINARIES

The simplest models of the hydrogen atom assume that the force between the proton and the electron is equal to the square of the electronic charge (expressed in suitable units) divided by the square of the separating distance; this is the Coulomb law. In both the Schrodinger and Dirac models the force is expressed in terms of an additive scalar potential. Thus in the Schrodinger model, for example, the Hamiltonian operator is taken to be [1], Art. 10

$$(1) \quad H \equiv -(\hbar^2/\mu)\Delta + V$$

where

$\hbar$ is (Plank's constant)/(2π)

μ is the mass of the electron

Δ is the differential operator ∇^2

V is the potential usually expressed as

$$(2) \quad V \equiv -e^2/r$$

where e is the electronic charge and r is the radius (between proton and electron). The eigen equation for the Hamiltonian is then [1], Art. 13

$$(3) \quad H\psi = E\psi$$

where

ψ is the eigenfunction corresponding to an eigenvalue (energy level) E . To obtain the eigenfunctions and eigenvalues the DE (3) must be solved subject to certain boundary conditions on ψ .

In both the Schrodinger and the Dirac models this calculation proceeds in four steps:

- Derive eigen equations for the z component and magnitude of the angular momentum
- Compute the eigenvalues of these angular momenta
- Derive, in consequence, the eigen equation(s) for the energy- the so called *radial equation(s)*
- Calculate the energy levels

To perform the first three of these steps we do not require detailed knowledge of the potential function V ; it is sufficient to assume, merely, that V depends only on r .

It is important to realise that we may add an arbitrary constant to V without affecting the observational consequences. This action increases each eigenvalue E by the constant (see (3)); but the observable spectrum results from *differences* in the eigenvalues and is, therefore, not altered.

2. THE SCHRODINGER MODEL

2.1 The Radial Equation

The radial equation obtainable from Schrodinger's simplest model (1) and (3) is [1], Art. 18

$$(4) \quad -h^2(R'' + 2R'/r)/(2\mu) + [h^2 l(l+1)/(2\mu r^2) + V - E]R = 0; \quad l=0, 1, 2, \dots$$

where R , the radial factor of ψ , is a function only of the coordinate r ; (the symbol ' denotes differentiation with respect to r). The equation is to be solved so that R is *bounded, single valued* and subject to the conditions

$$(5) \quad rR \text{ bounded at } r=0 \text{ and at } r=\infty$$

Thus we may safely assume that

$$(6) \quad R = r^\rho (c_0 + c_1 r + c_2 r^2 + \dots); \text{ Frobenius form}$$

where ρ and $c_0, c_1, c_2, \dots$ are constants.

2.2 Pretend that We do not Know V

If we transpose the radial equation and substitute the Frobenius form then we get

$$(7) \quad 2\mu(V-E)/h^2 = R''/R + 2R'/(rR) + A/r^2 \\ = \alpha/r^2 + \beta/r + U(r); \quad U(r) \text{ is a series in positive powers of } r$$

where

$$(8) \quad \alpha \equiv \rho(\rho+1) + A; \quad \beta \equiv c_1(2(\rho+1) - A)/c_0; \quad A \equiv -l(l+1)$$

2.3 The Force

It follows from (7) that the force is

$$(9) \quad F \equiv -V' = \delta/r^3 + \gamma/r^2 + W(r); \quad W(r) \text{ is a series in positive powers of } r$$

where

$$(10) \quad \delta \equiv \hbar^2 \alpha / \mu; \quad \gamma \equiv \hbar^2 \beta / (2\mu); \quad V(r) \equiv -\hbar^2 U'(r) / (2\mu)$$

The expression (9) states the most general form consistent with the radial equation (4).

2.4 The Near Field

Sufficiently close to the origin (the proton) the singular terms in (9) dominate. Either

$$(11) \quad F \approx \delta / r^3 \text{ for } \alpha \neq 0 \text{ and } r \rightarrow 0$$

or

$$(12) \quad F \approx \gamma / r^2 \text{ for } \alpha = 0 \text{ and } r \rightarrow 0; \text{ requires } \rho = 1$$

giving the choice of either an *inverse cube* law or an *inverse square* law for the force.

The *pure* inverse cube law is unsatisfactory: in the *classical model* it gives unstable orbits (at any radius) that either branch to infinity or spiral in or out [2], Art. 12.71; in the *QN model* there are no acceptable eigenfunctions R .

2.5 The Far Field

Although we can reject the inverse cube law in favour of the inverse square law for the *near field* it appears that, for the *far field*, we must accept the most general law (9). Notice, however, that the singular term in (9)

$$(13) \quad F = \delta / r^3 + \gamma / r^2 \Rightarrow V = \frac{1}{2} \delta / r^2 + \gamma / r + \text{a constant}$$

has properties that differ fundamentally from those of the regular term $V(r)$. For consider, in the *semi-classical* case, an

electron elastically scattered by the proton. Given the law (13) the electron can never pass through the proton; but, given the law

$$(14) \quad F=V(r)$$

it can evidently do so.

It seems reasonable, therefore, to suppose that a particle is a singularity of the force; at least this seems to be the attitude taken by experimental physicists when they observe the scattering of one particle by another. Accepting this hypothesis the most general law, for the force field of the proton in the Schrodinger model, is (13) while (14) represents the field due to a (spherically symmetric) distribution of remote matter. From now on we neglect the remote matter term.

2.6 The Inverse Cube Term

It can be shown that the law (13), containing an inverse cube term as well as the inverse square term, gives a stable orbit (precessing ellipse) in the classical model [2], Art. 12.741. This law also gives acceptable eigenfunctions in the QM model [1], Example III, 15. So why is the inverse cube term present? It turns out that if we set

$$(15) \quad \delta = -e^4/(\mu c^2); \quad c \text{ is the speed of light in vacuo}$$

then the eigenvalues E approximate (to within an additive constant) those given by the Sommerfeld-Dirac formula. The fine structure (associated with the angular momentum quantum number) approximates only poorly when the quantum numbers are small; but the approximation improves as the quantum numbers increase. So it appears that the inverse cube term can account, roughly, for relativistic features of the spectrum. By including this term we make the Schrodinger model more accurate.

2.7 The Approximate Correspondence

This approximate correspondence (in energy levels) can be established as follows. The energy levels which result, in the Schrodinger model, from the law (13) can be expressed as

$$(16) \quad E_n = -\frac{1}{2}\mu(\gamma/h)^2 (N+\epsilon)^{-2}; \quad N=1,2,\dots$$

where [11, Example III, 15]

$$(17) \quad \epsilon \equiv \frac{1}{2}[(2l+1)^2 + \omega]^{-1/2}; \quad \omega \equiv 4\mu\delta/h^2; \quad l=0,1,2,\dots$$

By contrast the Sommerfeld-Dirac formula for the energy levels is [3], Art. 72

$$(18) \quad E_d = \mu c^2 [1 + \lambda/s^2]^{-1/2}$$

where

$$(19) \quad \lambda \equiv e^4/(hc)^2 \approx 5.325 \times 10^{-5}$$

and

$$(20) \quad s \equiv M + (j^2 - \lambda)^{1/2}; \quad M=0,1,2,\dots; \quad j=\pm 1, \pm 2, \dots$$

We can exploit the fact that

$$(21) \quad 1 \gg \lambda; \text{ see (19)}$$

and further (to be justified below) that

$$(22) \quad 1 \gg \omega \Leftrightarrow 1 \gg \epsilon; \text{ see (17)}$$

to make approximations.

Choose

$$(23) \quad \gamma = -e^2; \quad \delta = 0 \Leftrightarrow \epsilon = 0; \text{ see (13), (16) and (17)}$$

and we get

$$(24) \quad E_{\pm} = E_0 \pm \frac{1}{2} \mu e^4 / (hN)^2; \text{ see (16), (17) and (23)}$$

which expresses the energy levels obtained from the usual Schrodinger model. Choose

$$(25) \quad N \equiv N + |j|; \text{ see (16) and (20)}$$

and, to the first order in λ ,

$$(26) \quad E_{\pm} \approx \mu c^2 (1 - \frac{1}{2} \lambda / s^2); \quad s \approx N - \frac{1}{2} \lambda / |j|; \text{ see (16), (18), (20), (21)}$$

so that

$$(27) \quad E_{\pm} \approx \mu c^2 (1 - \frac{1}{2} \lambda / N^2) = \mu c^2 + E_0; \text{ see (19) and (24)}$$

Having established the correspondence when $\delta=0$, to the first order in λ , we now improve the approximation by suitable choice of $\delta \neq 0$. We find that

$$(28) \quad \epsilon \approx \omega (1 + \frac{1}{2})^{-1/8}; \quad E_{\pm} \approx E_0 (1 - 2\epsilon / N); \text{ see (16), (17) and (22)}$$

and, to the second order in λ ,

$$(29) \quad E_{\pm} \approx \mu c^2 + E_0 [1 + \lambda (1/|j| - 3/(4N)) / N]; \text{ see (18) and (20)}$$

The formulae (28) and (29) approximate in the sense that

$$(30) \quad E_{\pm} \approx \mu c^2 + E_0; \text{ see (27)}$$

only if

$$(31) \quad \delta = -\lambda h^2 (1 + \frac{1}{2}) [1/|j| - 3/(4N)] / \mu; \text{ see (17), (19), (28), (29)}$$

which requires δ to be a function of the quantum numbers. However, when

$$(32) \quad M \gg |j| \equiv l+1 \gg 1; \text{ see (17) and (25)}$$

δ is given by (15) and is independent of the quantum numbers. The formula (15) implies (22); see (17), (19) and (21). QED.

3. THE DIRAC MODEL

3.1 The Radial Equations

There are two radial equations obtainable from Dirac's simplest relativistic model [3], Art. 72

$$(33) \quad (a_1 + V)\psi_1 = \psi'_2 + (j+1)\psi_2/r; \quad (a_2 - V)\psi_2 = \psi'_1 - (j-1)\psi_1/r; \text{ see (20)}$$

where V is subject to the scaling

$$(34) \quad V \rightarrow V/(hc)$$

and

$$(35) \quad a_1 \equiv (\mu c - E/c)/h; \quad a_2 \equiv (\mu c + E/c)/h$$

$\psi_1(r)$ and $\psi_2(r)$ are the components of a 2×1 state vector. Each component is subject to the same restrictions as $R(r)$ and can, therefore, be represented by a Frobenius form. As a result we have

$$(36) \quad \psi'_1/\psi_1 = \chi_1/r + X_1(r); \quad \psi'_2/\psi_2 = \chi_2/r + X_2(r)$$

where χ_1 and χ_2 are constants and X_1 and X_2 are series in positive powers of r .

3.2 The Near Field

Multiply the equations (33) and divide through by $\psi_1 \psi_2$ to get

$$(37) \quad (a_1 + V)(a_2 - V) = \beta_1/r + \beta_2/r^2 + P(r); \text{ see (36)}$$

where β_1 and β_2 are constants and P is a series in positive powers of r . Divide the equations (33) to get

$$(38) \quad [(a_1 + V)/(a_2 - V)] (\psi_1/\psi_2)^2 = [(\chi_2 + j + 1)/r + X_2] / [(\chi_1 - j + 1)/r + X_1]$$

We deduce, from (37), that, as $r \rightarrow 0$, $V \rightarrow \infty$; this is with the proviso that one or both of the constants β_1 and β_2 are not zero. It then follows from (38) that as $r \rightarrow 0$

$$(39) \quad -(\psi_1/\psi_2)^2 \approx (\chi_2 + j + 1)/(\chi_1 - j + 1); \quad r \rightarrow 0$$

showing that ψ_1/ψ_2 becomes constant. Therefore, from the first of the original equations (33),

$$(40) \quad V\beta_1/\beta_2 \approx \beta'_2/\beta_2 + (j+1)/r \approx (\chi_2 + j + 1)/r; \quad r \rightarrow 0; \text{ see (36)}$$

we deduce that V varies as $1/r$ and that

$$(41) \quad F \approx \gamma/r^2; \quad r \rightarrow 0; \quad \gamma \text{ is constant}$$

3.3 The Far Field

Because, the only singularity in the potential V is of order one, the most general form for the force is

$$(42) \quad F = \gamma/r^2 + G(r)$$

where G is a series in positive powers of r . If, as in the Schrodinger case, we adopt the hypothesis that the particle is the singularity in the force then the field of the proton is

(43) $F = \gamma/r^2$

Notice that if both the constants ϕ_1 and ϕ_2 are zero (contrary to the assumption made in Section 3.2) then there is *no singularity* and hence, according to hypothesis, *no central particle*.

4. COMMENTARY

4.1 The Mathematical Question

The Hamiltonian operator of a free particle does not have acceptable eigenfunctions in either the Schrodinger or the Dirac models. The mathematical question addressed here is: *what function of the radius, when added to the free particle Hamiltonian, yields an operator with acceptable eigenfunctions?* We have possibly loosened the specification by requiring only that an 'acceptable eigenfunction' must be representable in Frobenius form.

4.2 What Has Been Shown

We have shown that the force must be, in general, the sum of a singular function and a regular function. In the Dirac model the singularity has one term of order two; hence the force near the proton varies as the inverse square of the radius. In the Schrodinger model the singularity has, in general, two terms of second and third orders respectively; the second order term (inverse square) *must* always be present. We can reject the third order term (inverse cube) *by fiat*; but there is no obvious reason why we should.

The regular terms, in both models, we assume to be the result of the (potential) presence of remote matter; the singular terms we assume to be generated solely by the central particle. This interpretation amounts to an extra hypothesis based on the notion that the singularity of the force *is* the particle.

By considering the singularity to be the only field present we can analyse the effect of the third order force term in the Schrodinger model. It turns out that, by appropriate choice of the coefficient of the third order term, we can cause the

energy levels roughly to approximate those given by the Sommerfeld-Dirac formula. Thus, by exploiting the third order term instead of rejecting it, we make the model more accurate.

4.3 The Strength of The Inverse Cube Term

The Bohr radius (smallest orbital radius in the Bohr model of the hydrogen atom) is

$$(44) \quad r_0 = h^2 / (\mu e^2) = 5.292 \times 10^{-11} \text{ ms}$$

At this radius the ratio of the inverse cube term to the inverse square term is

$$(45) \quad \delta / (\gamma r_0) = \lambda = 5.325 \times 10^{-5}; \text{ see (13), (15), (19) and (23)}$$

which shows that the inverse cube term can be regarded as a perturbation. It is interesting to note that the two force terms are equal at the range

$$(46) \quad \delta / \gamma = e^2 / (\mu c^2) = 2.818 \times 10^{-15} \text{ ms}$$

the so called *classical radius* of the electron.

4.4 Fields, Feynman, Dyson and Tanimura

In 1948 Feynman showed Dyson a 'proof of the Maxwell Equations' based solely on the rules of non-relativistic QM and Newton's laws. The proof (I paraphrase Dyson [4]) began with assumptions invariant under Galilean transformations and ended with equations invariant under Lorentz transformations. Feynman did not publish but, after Feynman's death, Dyson reconstructed the proof [4]; and, later, Tanimura extended the method to establish Einstein's gravitational geodesic equations [5].

The inverse cube term (see (13)) is a natural product of the Schrodinger model. This model makes *no reference* to relativity. The fact, that the coefficient of the inverse cube term can be chosen (see (15)) so that the spectrum obtained

from the Schrodinger model roughly approximates the Sommerfeld spectrum, may be fortuitous; the inverse cube term may have nothing to do with either relativity or electromagnetism. Yet when we *import* SR along with QM, as in the Dirac model, the inverse cube term is notable by its absence (see (43)). This suggests that, in the Schrodinger model, the inverse cube term may, in some way, be connected with the content of Feynman's proof.

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CHAOS, EMERGENCE AND COMPLEXITY: ON THE ONSET OF VARIETY

P.L.Eisenhardt

Institut für Geschichte der Naturwissenschaften, Johann Wolfgang Goethe Universität,

Robert Mayer Straße 1, Postfach 111932, D-60054 Frankfurt am Main

ABSTRACT

A theory of emergence will be outlined based on a version of non-standard topology having monads (infinitesimal quantities) as fundamental entities not reducible to point sets. Emergence is defined as a specific mapping of the monadic space into itself in a way that connectedness of that space is "fractal". In standard topology this mapping were a non-homeomorphism.

The limits of the concept of selforganization will be shown after the concepts of "chaos", "selforganization", "complexity", and "emergence" are compared to one another; these limits consist in the assumptions of homogeneity of the subsystems and of a low degree of order not transmitting itself from one scenario to another of a higher degree of order (chain of evolution).

1. INTRODUCTION

In the following I will sketch a theory of emergence. I cannot but outline some essential points because time is limited and in the long run we all are dead. I am still working on

the theory with my colleague D.Kurth; some more elaborated versions are available in German [1], but we are still working on the mathematical details.

This theory will be an object-theory not a metatheory in the framework of philosophy of science the latter being the main focus of the discussion at the moment [2].

There are several object-theories of emergence but I have no place to discuss them. The most detailed one is the theory of G.J.Chaitin (for a summary cf. [3], for further information on object-theories cf. [4] and [5]). Furthermore it is possible to interpret H.Haken's Synergetics as a theory of emergence as done in [6] and indirectly taken over by Haken [7].

2. WHAT DOES "THEORY OF EMERGENCE" MEAN?

What is emergence? To answer this question you get embarrassed instantly - there is no repartee. The reply depends on the status which "emergence" gets according to criteria of philosophy of science. In rough outlines you can reconstruct four types of theories of emergence:

- a. no-theory of emergence,
- b. metatheory of emergence,
- c. object-theory of emergence,
- d. philosophy of emergence.

I hurry to explain.

To a.: Scientists often use the word "emergence", but they have no idea. Theoreticians of chaos and scholars searching for and after complexity describe the coming up of new qualities or properties of artificial or natural systems from an old pre-state or ground-state [8], [9], [10]. May be the systems became unstable, may be they bifurcate or get more complex - all these transitions represent the emergence of new system-properties and result therefore in a final or intermediate state either having properties which are radically new (no one could have predicted them at all), or possessing properties that

could be classified at the beginning (you know classes of end-states which are possible in principle but you do not know which one comes).

However, the description remains within the framework of the theories of chaos, complexity or selforganization, e.g., and also within the limits of these theories. No independent theory of emergence is propounded.

But without such a theory one cannot understand the "deep structure" of the transformation from an old to a new state of a system in general. (A short explication of the relation of a theory of emergence to other relevant theories will be given in section 3.)

To b.: Here we are at the highest level because it is a matter of the meta-level of philosophy of science. The concepts "reduction", "supervenience", "physicalism", "level", etc. are explicated and their logical and semantical relations are constructed. Essentially it concerns applied logic - in a sense it is formal ontology, too.

In general one describes the relations between different levels of systems reconstructed in a formal language - these levels refer usually to levels of nature. The problem consists in advancing the exact relationships between the base and the supervenient properties (the latter have to be divided in relational and non-relational ones).

So the supervenient properties could be non-reducible and dependent on the base properties. "Dependence" means generally "what is alike in all base respects does not differ in some 'higher' (supervenient) respects", ontologically the concept represents the fact that supervenient properties cannot exist without base properties but not the other way round.

Furthermore the question has to be resolved to what extent "emergence" and "supervenience" differ in meaning. One could suggest that "supervenience" means "level-transcending emergence": mind is 'nt body, but steam is water [11], [12].

To c.: At the metalevel one explicates things, at the objectlevel you pull a job. Here you have to do it, namely to set up a mathematical theory of emergence that refers to universal structures of every emergent or searches for invariants of every emergent transformation or mapping.

The subject of c is the subject of this article.

To d.: This point deals with the emergentists, for example C.Lloyd Morgan and Samuel Alexander. Here we have a metaphysics of emergence like Whiteheads cosmology: the ontological structure of the universe consists of particular emergent levels getting more complex - properties of higher levels are unpredictable from knowledge of the deeper levels.

3. CHAOS, SELFORGANIZATION, COMPLEXITY, AND EMERGENCE

In this section I want to consider some intertheoretical relations of the theories of chaos, complexity, selforganization and emergence, but I do it at the object-level to prepare you for the subsequent explanations. I do think that my explications at this point are necessary for drafting a theory of emergence. One has to distinguish the four theories mentioned above to demarcate their universe of discourse.

The fundamental concept we take as startingpoint is "symmetry". Using this concept we arrive at the concept of "order" which is commensurable and central regarding the theories in question. "Symmetry" means "invariance relating to rotations, reflections, and translations"; for example the restriction of rotations (symmetry of rotation) increases asymmetry (compare squares to circles).

"Order" is defined as "state of asymmetry", that is increase of asymmetry means increase of the degree of order (compare cells to crystals of sodium chloride) - conservation of order represents the stability of a system.

That's our tool-box, let's go to work.

" **Deterministic chaos** " means according to these definitions : "**bifurcation of order**". The states of the system are deterministic, but in the subsequent course these states separate, split, diverge, and run in all directions, and so the relevant information concerning the initial state of order gets lost regarding to a calculation, that means regarding to an epistemic state not to the ontic state.

Generally chaotic systems possess fractal geometric attractors (these are to some extent final states with geometric structures that have dimensions you cannot attribute to whole numbers). So we have no choice but to attach the following: fractal geometry consists of metrical order structures with fractal dimensions (Hausdorff dimension) being in general self-similar and self-referential. Your attention is drawn to the fact that metrical structures are presupposed in fractal geometry: fractal order is order with distance.

The next concept is **"selforganization"** - one can explicate it as **"origin of order"** in an internal way so that the particular degree of order is not stamped externally (initial and boundary conditions emboss order too, yet this order is not particular regarding the system in question), but is generated internally. Notwithstanding a specific degree of order is always necessary for a selforganizing system (think of external conditions), and so the slogan "order out of chaos" means naturally "order of degree $n+k$ out of order of degree n " (k is a non negative number).

Here we have a chain of different order-states of systems which is called "scenario". Selforganizing systems are always systems constrained by scenarios which mark out the area of selforganization. A typical scenario may be "stochastic chaos, specific order of degree n , specific order of degree $n+1$, deterministic chaos" - in synergetics the paradigm consists in the laser, which has the following scenario: no laser action, laser action, laser pulses, laser turbulence. (It is possible to relate to every link of this chain a topological description of stability theory (so called "bifurcation hierarchy") like: stable focus, limit cycle, torus, chaos (fractal attractor).)

Every link of these scenario is getting more complex in the relation to the preceding ones - we have a hierarchy of degrees of order. Moreover every level (or link) discloses new qualities not revealed at the other levels.

"Complexity" is a general property of selforganizing or dynamical systems that describes the different levels of the particular internal degrees of order: it is the **measure of the degree of order**. In a way this measure depends on the point of view of an observer and his formal tools, but it should be ontically anchored as far as possible. Complexity should reveal the structural shaping of a system and the number of the

possible connexions, interactions, and "knottings" of fundamental entities of the system described. The identification of these entities is relative to the representation space the former ones are described in.

But what about "emergence"? What is emergence according the considerations above?

"Emergence" is the fundamental concept of a general theory which **explains** the way of the **transition to different degrees of order** in a hierarchy of complexity; it is the theory of the deep structure of complex dynamical systems and it looks for universal properties of these transitions.

To do that one has to choose an appropriate mathematical representation; I prefer a particular topological framework. In the following I will give an outline of some basic entities and relations.

4. LOCAL AND GLOBAL EMERGENCE

"Emergence" at the object level has two different meanings: local emergence refers to the deep structure of the transition from a pre-state to a state showing new qualities searching for universal properties of this transition. Here we have only one step of emergence, the local transmission of action from one degree of order to the next one.

Global emergence means the structure of a whole evolutionary chain, generally a coupling of scenarios transcending always the local degrees of order. Here we have a hereditary transmission of order so that one link produces the boundary and initial conditions of the next one.

R.E.Zimmermann refers to global emergence when he says very precisely: "The main point is that it does not suffice to deal with the different scenarios being determined by certain given structures at a given time, and then to consider the possible transition between such scenarios...Emergence transcends therefore self-organization in so far , as it deals not only with the spontaneous creation of structure, but also with the creation of the boundary conditions generating the underlying dynamical systems in first place."

This evolutionary chain can be mathematically structured as follows: "Technically, this means that systems of (non-linear coupled) differential equations the solutions of which are functions, have to be replaced by 'super-systems' of differential equations the solutions of which are again systems of differential equations including their boundary conditions. Such a concept can be used to discuss emergence rather than mere self-organization. Obviously, the global process of emergence is the evolution of the universe as a whole." [13]

In the following I want to deal with the mathematical structure of local emergence at a conceptual level. Section 7 touches on the problem again from another perspective.

5. TOPOLOGY CHANGE AND EMERGENCE

Every transition can be reduced mathematically to an iteration of mappings that implies the conservation of structures - these mappings or transformations are called "morphisms" (this is the subject of category theory). But emergent transitions are not structure- conserving, because essential structures of a system change radically when an emergent event takes place. So I want to take a crucial step forward. The idea consists in preferring an inherent mathematical description for the emergent transition not an external one. That is a very subtle problem, because the relation of mathematical structures to dynamical entities and events is unsolved, especially it is not evident whether one must represent mathematically objects and their relations to a certain degree directly.

For example, it is **not** necessary to state non-linear dynamics in non-linear spaces (what ever that may be). Most mathematics is concerned with morphisms of structures in a static way (may be with the exeption of topos theory); dynamics, processes and transitions (which are essentially in time) are handled either as a combination or iteration of morphisms to approximate the real process; or one can show that some

conditions are not met by cutting up a positive reference to the universe of discourse. So one often gets an external quasi-platonistic framework for phenomena in flux.

I do think that a particular representation of topology change gives an **inherent** description of emergence. This change of topology means to look at a type of mapping which is not structure-conserving, it shall be called "**antimorphism**". In topology this type of mapping appears when you observe a non-homeomorphism. That is a non-bi-unique mapping being also non-continuous regarding the converse mapping. The antimorphism does not conserve essentially topological invariants, for example the topological genus.

To give a very simple example of an antimorphism: the mapping of a sphere (genus 0) into a torus (genus 1). (These figures are thought of as hollow surfaces.) But let us have a closer look at another example called "mathematical phase transition". [14]

Such a catastrophic phase transition appears going over a path out of the interior of the Mandelbrot set M to the boundary which is surrounded by particular Julia sets J ; at this point there is a dramatic change because the structure of connectedness of the topological manifold is altering, namely from a (globally) connected structure to a totally disconnected structure. (The altering of the sphere to the torus mentioned above is from "simply connected structure" to "triple connected structure".)

This is meant as follows: The Mandelbrot set M cannot be separated so that there remain two non-empty, open subsets - the Julia set aforementioned is equivalent to Cantor's discontinuum C . This refers to the fact that the subsets of C which are maximally connected consist of a single point - the dimension of C can be different from the dimension of J .

One question is unsolved: One does not know whether the Mandelbrot set is **locally** connected, that is to say whether the intersection of the neighborhood V of every point of a subset of M (that subset is the intersection of any open set U and M) and M is connected (V is a subset of U). In locally connected manifolds therefore any

neighborhoods have to be connected. The other way round it is valid that locally disconnected sets are "stronger" connected than totally disconnected ones.

We have a hierarchy as follows: a. globally connected manifold, b. locally (dis)connected manifold, and c. totally disconnected manifold.

I do think that connectedness is essential for the topological representation of emergence.

To summarize the issue in one sentence: There is a critical point of the path out of the Mandelbrot set; at this point occurs a critical instability and the type of order in the sense of "connectedness" changes abruptly, furthermore changes the Hausdorff dimension of the manifold in question, namely from about 2 to a number between 1 and 2.

This critical point has to be characterized more precisely to come to more universal conclusions. Before doing this let us make the idea of an antimorphism clearer.

In a way this emergent mapping is a bordism [15], because you may have three manifolds M of dimension $n-1$ one related to two (a boundary of a circle in relation to two other ones) as boundaries of another manifold W of dimension n (a surface that looks like a trouser the boundaries of the circles being the waistband and the ends of the legs; mathematically $\partial W = M_1 + M_2$ - the latter ones are closed manifolds and W is compact and with boundary - the ends of the trouser legs are considered as one manifold).

Now imagine the waistband shifting in the direction of the legs. There will be a bifurcation point where one manifold divides up into two ones (namely at the crotch). That is the point of emergence changing for example the genus of the manifolds so that you have a non-homeomorphic mapping.

We want to look at the bifurcation point and want to know what is going on here in detail.

For this purpose we have to generalize the representation space.

6. FRACTAL TOPOLOGY

A theory of emergence should reveal the universal structure of all transitions from a pre-state to a state after this pre-state showing new qualities. The relation of these two states we conceptualized as antimorphism. But there is a prerequisite regarding the topological space, namely the metric structure of that space. We will now abandon the latter to analyze the mathematical phase transition a little bit more far-reaching. Dropping the metric means losing the Hausdorff dimension, only the concept of neighborhood defined as point set is left. And what about connectedness? That is the main point. For reasons of generality I do not want to presuppose a very enriched structure so that only a small amount of topological invariance will remain. But I will not jump ahead.

We need a topological space that is appropriate to represent emergence inherently, and that is in my opinion a space appropriate to represent connectedness naturally and fundamentally. I want to suggest to you to consider a particular space of non-standard topology [16] which is more discrete than the continuous space of the normal point set topology. This proposed non-standard space is no point set, but consists of non-metric quantities infinitely small, the so called "monads". These monads are in our version of the theory the fundamental entities of the non-standard topological space not reducible to other entities like points as it is accepted in usual non-standard topology.

All figures of this space are composed of these monads, the former being non-metric too. In this version the mathematical phase transition representing the emergent transition consists in particular relations of monadic configurations. Many self-similar figures like Cantor's discontinuum (very important) or Antoine's chain can be formed. The fundamental figures of our non-standard topology are essentially totally disconnected, that is their maximally connected subsets consist of a single monad, and not a point or a monad reducible to points.

So the antimorphism as the general structure of the mathematical phase transition can be considered very naturally a **fractal connectedness** of the non-standard topological figures in question, because the fractality is an inherent property of the figures and their

relations respectively; moreover one can reduce continuous and semi-continuous figures to monads (as non-metric discontinua).

In a sense these considerations try to generalize fractal geometry as the mathematical structure of phase transitions qua emergent events. The more general theory is called "fractal topology"; in this theory **not dimension** is fractal but **connectedness** in the sense of the relation of the figures and the disconnected figures themselves.

In order to prove whether a domain is (simply) connected you have to draw tight a Jordan curve continuously up to a point. But in our model there are no points so that you have no simple structure of connectedness.

It will cost a lot of effort to generalize more precisely - may be one has to use dimension theory in the sense of algebraic topology (hint of R.E.Zimmermann)-but be careful because of dimension - , so I will finish my sketch as follows:

At that point most of the topological invariants get lost, but (dis)connectedness as an ersatz-invariant remains. All figures are embedded naturally in a non-standard space mentioned above which characterized in detail forms a kind of complement to the figures so that the monads and the complementary monads are the fundamental entities forming continua and quasi-continua. In this version of non-standard topology there is no usual concept of neighborhood presupposing **homogeneity** of the particular point set of standard topology, whereas the theory here introduced is based on the fundamental **heterogeneity** of the universe of discourse which is set-theoretically comparable to Ch.S.Peirce conception of ineunts and exeunts, where a set is defined by members belonging to the set (ineunts) and the members which are **not** elements of the set in question (exeunts): "1st, the characters of the collection may consist in the possession of certain characters by certain relatively primitive individuals, termed its *ineunts* or *members* (*Elemente*). 2nd, the characters of the collection may consist in the possession of certain characters by other of the individuals of the same category as its ineunts, these being termed its *exeunts*." [17] (Peirce drew a sharp distinction between ineunts and exeunts to avoid the paradox of the set of all sets.)

Because of this heterogeneity and the missing metric the figures of our non-standard topology will be very entwined, winding, shredded, and highly asymmetrical like an extremely mixing flow in phase space. For example, there is a fractal topological representation of a kind of Cantor's discontinuum by performing a particular infinitesimal partition of a set homeomorphic to an onedimensional figure not closed. You get a set of totally disconnected monads and the complementary monads being the "embedding space".

Further details and generalization will come from algebraic topology, for example, one has to consider abelian group structure of the bordism-classes of n -dimensional manifolds compared to the classes of all possible monadic mappings. Here you have to take account of the fact that **dimension** as a topological invariant is dropped out.

We have achieved a more universal representation of the problem of emergence. The paradigm consists in the antimorphic mapping (to be iterated) of a quasi-continuum into another one - the mathematical phase transition being an event in the non-standard topological space meaning "representation space" is represented as a non-standard topological discontinuum in the sense of a non metric set of monads and complementary monads totally disconnected.

We look "into" the critical point (through the magnifying glass of our ansatz) and say that the fractal connectedness characterized in this way is a universal property of any emergent event.

7. SELFORGANIZATION, COMPLEXITY, VARIABILITY

In this section the problem of selforganization in relation to global emergence plays a role, moreover the limits of idealization of the theory of selforganization (as origin of order) will be considered; complexity as the measure of order does not go far enough for specific complex systems of higher order, which are "self-mover" with a real interior.

There are some central questions of biology dealing with very complex systems: a. How can the stability of the organism be explained in spite of the dynamical flow of the molecules?; b. What is the precise relation of genotype to phenotype? c. What about the sequence of organisms in the evolutionary chain?

Is the explanatory power of the theory of selforganization, for example synergetics, strong enough to answer this questions? Or is there too much idealization involved (?): "A motionless elephant would have angular momentum zero, but then it would be spherically symmetric." (Heisenberg)

The central concept here is "coherence", that generally means "order" - especially you have coherent light waves, these are waves with always the same time dependence of the amplitude except phase shifting. In a way synergetics is an extended stability theory of coupled nonlinear oscillations (for details cf.[18]), its paradigm consists in the laser where you can find after the critical threshold a coherent wave internally produced. Haken specifies as follows: "The energy which flows into the (laser)system has to be unstructured possessing no specific quality - there are no phase relations impressing the system a specific degree of order. So the energy flow is incoherent." [19]

What is going on? The energy flow will be coupled, therefore the degrees of freedom will be reduced. This coupling is analogous to a cardan shift or something similar, and it is the same thing with chemical reactions. To describe selforganization mathematically you reduce complexity in such a way that you have to reduce the dimensions of the state space. You get the instable modes and know the many stable modes in that way - sometimes one degree of freedom characterizes the system.

The stable modes will be slaved by the order parameter that characterizes the state of the system. This concept was introduced by L.D.Landau who wrote: "We can introduce a quantity 'degree of order', which would characterize the deviation of the crystal from its ordered state; it is equal to 1 in the completely ordered crystal, decreases as a function of the deviation from the ordered state, and becomes zero in the disordered crystal". [20] (Order is symmetry, cf. section 3.) In synergetics it is not possible to get norm 1, so the

degree of order depends on the number and the way of cooperation of order parameters. That degree is limited by specific scenarios.

In my opinion there remain several open questions:

1. What about the coupling of energy flow? I do think that a mechanism of energy coupling is always presupposed in synergetics. A desideratum consists in a description of the solidification (in complex systems) which is necessary for energy coupling (for example, in organisms: bones and blood-vessels).
2. Is it possible to couple scenarios to describe a chain of building blocks of self organization? In other words: does not synergetics refer only to local emergence? Can this theory describe a whole evolutionary chain? Structurally this leads to a mathematical description of the hereditary transmission of order as in v.Neumann's theory of self reproducing automata.
3. Is not the limitation "homogeneity of the subsystems" of a selforganizing complex system too strong? What degree of heterogeneity is necessary ? Most complex systems have heterogenous subsystems and you have to deal with them.
4. The "upper" limit of selforganization (in synergetics) is chaos. What has to be done to overcome this boundary, because in chaos there is a lot of order-production?

In a word: We need a theory of selforganization including organized, complicated, and structured systems as an answer to these four central questions (at the moment synergetics is developed further including the concept of information and of information-processing systems).

The theory of complexity has its limits too, because the measure of complexity depends on the way of describing the system in question, so that you get different degrees of complexity according to different theories. No detailed discussion is needed because I can refer to articles of Th.Dorfmueller and D.Kurth; just this short remark as a result may be not out of place: emergence is always emergence of complexity (D.Kurth) and shows the universal property of fractal connectedness - furthermore complexity of a system is characterized by the number of "self-penetrations" of the figures. This seems to be more "ontic" than the complexity-measures of the other theories (for a short

overview cf.[21] and [22]; the new theory is carried out in [23], he gives an overview too).

Highly complex systems with a hereditary transmission of order, coupling of scenarios, coupling mechanisms of energy flow, solidification and heterogeneity of subsystems cannot be adequately described by the existing theories of selforganization - these systems have a very high degree of coherence and variability (W.Gutmann's theory may be more appropriate but unfortunately it is at best a special case of a not yet existing universal theory). At the end these systems have to be characterized positively - what is the kernel of the discussion above?

A variable system produces some of its essential boundary conditions and is in this way a "self-mover". Systems of this type form a real interior that relates to the exterior (environment), but this relation does not mean "interaction" in the first place but "standing for": the interior refers to the exterior - to be precise, these systems put the interior as the exterior. This is the threshold that separates complexity from variability; I call it the "thesis of minimal representation". (Cf. for the difference of nature and representation [24] and [25]; on the threshold between information and meaning cf.[26])

Generally interaction is precise and in a way one-to-one, it is a natural event that does not **stand for** anything, for example Dretske writes: "The width of growth rings in trees growing in semi-arid regions is a sensitive rain gauge, an accurate indication of the amount of rain fall in the year corresponding to the ring. This does not mean, however, that these rings **represent** the amount of rainfall in each year. For that to be the case, it would be necessary that it be the function of these rings, by their width, to indicate the amount of rain in the year corresponding to each ring."

In this sense indication is a mere interaction not a representation of anything. Increasing complexity requires variability from a certain degree of order. Here the system needs an interior space of possibilities to survive that exceeds the possibilities of interaction: the system can be **mistaken**. The function of this interior consists in an abstract extension of the system's environment, so that its possibilities of interaction are increased. There

may be a natural limit for the interaction in the sense of "energy balance and consumption". The interior space is not very expensive and enlarges nevertheless the possibilities of the system. But there exists a price: reference is always indeterminate not precise or one-to-one. This indeterminacy of the interior space is the reason of the enlargement of possibilities because it relates the interior to the exterior as many-to-one. The indeterminacy is the necessary condition for variability.

So these variable systems control their environment much better than other complex systems - they move relatively independent of the environment moving "out of the interior". So they control the environment looking at an interior "screen" and produce their boundary conditions in that way, for example by foresight and preventive action they first bet that their interior is the exterior, and so on. A complex system is always right, but does not make much progress, a variable system is mostly mistaken, but leads the way.

8. SUMMARY

Some types of theories of emergence and some theories of nonlinear dynamics have been compared from the point of view of the fundamental concept of order. Local emergence as the deep structure of an evolutionary step has been distinguished from global emergence as a whole chain of such steps. Emergent transitions were represented as mathematical phase transitions qua topology change - here the concept of "connectedness" was fundamental. It was stated that the appropriate representation space of emergent transitions is some sort of "fractal topology" considered in the framework of a particular version of non-standard topology. The conclusion was drawn that in a way "fractal connectedness" is a universal property of emergent transitions. Limits of selforganization (and complexity) were shown consisting in strong idealization and homogenisation (and observer-dependence) of systems - these

restrictions can be inappropriate. The concept of "variability" has been introduced: variable systems produce in a sense their own boundary conditions.

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ALGEBRAIC STRUCTURE IN GENERAL RELATIVITY

C W Kilmister

Red Tiles Cottage
High Street
Barcombe
Lewes
BN8 5DH, U K

I am going to pose some mysteries about the relation between differential and algebraic properties which arise from the Clifford algebras you have become used to from contributions of Mike Manthey and others. To fix notation, I define C_4 (the Clifford algebra on 4 generators) by means of the four generators E_a ($a = 1, 2, 3, 4$) with a multiplication rule:

$$E_a E_b + E_b E_a = 2 \eta_{ab}$$

so that, in particular, E_1^2, E_2^2, E_3^2 are all -1 and E_4^2 is 1 . Evidently the algebra is of dimension 16 and if one defines $E_5 = E_1 E_2 E_3 E_4$, so that $E_5^2 = -1$, all the basis elements for the algebra are:

$$1, E_5, E_a, E_{a5}, E_{ab}.$$

(Here the shorthand notation $E_a E_5 = E_{a5}$ and $E_a E_b = E_{ab}$ ($a \neq b$) is used.)

There is a well-known interpretation in 4-space in which a vector C^a is read as an algebraic element $C^a E_a$ and so on. The proper Lorentz group is expressed as

$$C^{a'} E_{a'} = q C^a E_a q^{-1}$$

where the rotations are given by $q = \cos \theta + E_{23} \sin \theta$ etc and the boosts by $q = \cosh u + E_{14} \sinh u$ etc. Under improper transformations, E_5 becomes $-E_5$ so that the general element of the algebra splits up into five pure parts, which are respectively scalar, pseudoscalar, vector, pseudovector and bivector.

Now to general relativity. I am concerned only to do algebra, so I choose geodesic coordinates at one point. But how do I introduce tensors of rank two or four into the algebraic picture? The usual answer is in terms of direct products; for g^{ab} , for example, one considers $g^{ab} E_a \otimes E_b$, where $\otimes$ is the direct product. I propose a different path, that of LINEAR FUNCTIONS on the algebra. It is a theorem (to be found, for instance in my Ph.D. thesis

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of 1950) that a general linear function can be written in the form

$$F(q) = \sum_n A_n q B_n, \quad (n = 1, 2, \dots, 256)$$

and obviously this splits up into the 25 pure functions

$$F(q) = \phi q + T^{ab} E_a q E_b + \frac{1}{2} C^{abc} E_{ab} q E_c + \dots$$

and we can look at these separately. For any such pure function, I want to ask the question: does it entangle q ? By this I mean, do the pure parts of q get mapped into the same pure parts or are they mixed together (entangled)? To take a very simple example, let T^{ab} be any tensor of rank 2. The function $T(q) = T^{ab} E_a q E_b$ is to be calculated. To do this we need to be able to calculate

$$\begin{aligned} E_a E_b &= \eta_{ab} + E_{ab}, \\ E_a E_b E_c &= \eta_{ab} E_c + E_{ab} E_c \\ &= \eta_{ab} E_c + \eta_{bc} E_a - \eta_{ac} E_b + \epsilon_{abcf} E^f \end{aligned}$$

and so on. Then we can easily see that, if we write

$$q = \phi + \psi E_5 + C^a E_a + D^a E_{a5} + \frac{1}{2} F^{ab} E_{ab},$$

$$\begin{aligned} \text{then } T(q) &= (T\phi + T^{ab} F_{ab}) + E_5 (T\psi - T^{ab} \tilde{F}_{ab}) \\ &\quad + E_a (2T^{ab} C_b - TC^a + 2\tilde{T}^{ba} D_b) + E_{a5} (2\tilde{T}^{ba} C_b + 2T^{ab} D_b - TD^a) \\ &\quad + \frac{1}{2} E_{ab} (2T^{ab} \phi + 2\tilde{T}^{ab} \psi + T^{eb} F_e^a - T^{ea} F_e^b + T^{ea} \tilde{F}_e^b - T^{eb} \tilde{F}_e^a). \end{aligned}$$

Here T^{ab} , T^{ab} are the symmetric and skew parts of T^{ab} , and the tilda denotes the dual of a bivector, $\tilde{F}_{ab} = \frac{1}{2} \epsilon_{abcd} F^{cd}$. Evidently, if and only if $T^{ab} = 0$, parts are separated in the sense that $T(\phi)$ is scalar, $T(\psi E_5)$ is pseudoscalar $T(C^a E_a)$ is vector, $T(D^a E_{a5})$ is pseudovector and $T(\frac{1}{2} F^{ab} E_{ab})$ is bivector. Thus, in this simple example, T does not entangle if and only if it is symmetric.

Now let me remind you about general relativity. The theory is in terms of a tensor of rank 4, R^a_{bcd} , which determines the curvature of the affine connexion. For a general affinity (which is more general than the usual state of affairs in general relativity) R^a_{bcd} is skew in c, d and so has $4 \times 4 \times 6 = 96$ components. If the affinity is symmetric (as it is in general relativity) a further condition arises:

$$R^a_{(bcd)} = R^a_{bcd} + R^a_{cdb} + R^a_{dbc} = 0.$$

This set of 16 equations reduces the 96 degrees of freedom to 80.

But in general relativity the affinity is derived from a metric and then the further conditions

$$R_{abcd} = -R_{bacd}, \quad R_{abcd} = R_{cdab}$$

reduce the degrees of freedom from 80 to 20. Now the important feature of this - the details above do not matter, is that these equations are the result of DIFFERENTIAL operations. The fact that R_{abcd} is skew in c, d for instance, is because it is a generalised curl of a three-index symbol and the other equations arise in the same sort of way as a result of one set of symbols being derived from another by differentiation. I want to show here that the same sets of equations arise ALGEBRAICALLY.

I begin by cheating a little bit. Since I want to use the linear functions I talked about earlier, I consider the pure function:

$$R(q) = \frac{1}{4} R^{abcd} E_{ab} q E_{cd}.$$

Thus I had better assume that R^{abcd} is skew in both ab and cd (and so has 36 degrees of freedom) or else some of it will get lost in the algebraic form. Next I ask for the conditions that R should not entangle and there are 5 cases, corresponding to the pure parts of q. I will not bore you with the rather heavy calculations; the results are that cases 1 and 2 give

$$R^{ab} = R^{ba} \quad \& \quad *R = 0$$

where R^{ad} is the contracted form $R^{ab d}$, $*R$ is the left dual defined by

$$*R_{ab}^{cd} = \frac{1}{2} \epsilon_{abcd} R^{pqcd}, \quad *R = *R_{ab}^{ba}.$$

Then cases 3 and 4 give

$$R_{br}^{*} = *R_{br} \quad (\text{contracted in the same way})$$

while case 5 gives

$$*R_{ab} = *R_{ba}.$$

A first surprise is that these conditions for non-entanglement are exactly equivalent to the equations

$$R_{abcd} = R_{cdab}, \quad R_{a(bcd)} = 0,$$

so we have exactly the conditions for R_{abcd} to be the curvature tensor in general relativity. But all these conditions, which are usually thought of as differential identities, have arisen from the one algebraic requirement

of non-entanglement.

Let me make two further remarks for the cognoscenti: a good deal has been written lately about the Lanczos tensor L^a_{bc} from which the Weyl tensor can be derived by differentiation. The conditions for the Lanczos tensor to be non-entangling turn out to be a little more subtle, and I do not fully understand what is going on, but they certainly include the various identities and gauge conditions that Lanczos found or imposed on L . Secondly, you may be thinking that the Bianchi identities

$$R^a_{b(cd;e)} = 0$$

ought to be lurking somewhere. They do not seem to be linked with non-entanglement. It is true that if you define a differentiation operator

$$D = \delta^a_1(\dots)E_a$$

then

$$DR(q) = \frac{1}{4}\delta^e R^{abcd}E_{ab}{}^q E_{cd}E_e = 0$$

gives both the Bianchi identities and a set of field equations:

$$R^a_{bcd;a} = 0.$$

These field equations are weaker than Einstein's but consistent with them because they can be reduced to

$$R_{ab;c} - R_{ac;b} = 0$$

This shows the strength of the algebraic methods but possibly only as a technique whereas the entanglement notion points to something deeper.

A Classical Alternative to Special Relativity

SUMMARY

*The present paper is dedicated to the honour of Ths. E. Phipps.
It is argued that Special Relativity (SR) should be rejected in favour
of a Classical Alternative (AR) based on the invariance of proper time τ ;
this involves a modification of Einstein's second postulate which allows the
one-way velocities of photons to vary, their average velocity being invariant.
AR & SR agree that the Doppler Shift (DS) is symmetric by inertial motion.
Due to the symmetry of DS identical atomic clocks display the same rate;
this permits us to integrate DS into symmetric signal-functions (SF).
SF-symmetry is the condition of absolute time and simultaneity.*

From the *Relativity Postulate*, taken as a principle stating the equivalence of observers in inertial motion (cf. Poincaré), we infer that no inertial observer can be ascribed a privileged status. The coordinates (t, x) & (t', x') of each pair, O & O' , of inertial observers should therefore be treated symmetrically: $t \leftrightarrow t'$ & $x \leftrightarrow x'$. Thus $x' \equiv \phi(x, t, v)$, v being the velocity of O' relative to O , implies $x \equiv \phi(x', t', v')$, v' being the velocity of O relative to O' . However, when we now further add the *Invariance Postulate* for light-velocity in the form $\pm 1 = t^2 - x^2 = t'^2 - x'^2$ ($c \equiv 1$), the standard Lorentz Transformations (LT) are unavoidable due to the extended symmetry $t \leftrightarrow x$ & $t' \leftrightarrow x'$ which implies $t' \equiv \phi(t, x, v)$ as well as $t \equiv \phi(t', x', v')$. Hence, if we want to vindicate the Galileo Transformations (GT), we shall have to modify at least one of the postulates of SR. However, if we do not wish to weaken the *Relativity Postulate*, our only possibility is to modify the *Invariance Postulate*.

§1. THE DESCRIPTION OF INERTIAL MOTION

I shall now venture to derive a completely new version of the GT *ab ovo*. By 'the velocity of light' I understand the quotient between an element of distance, as measured by an observed photon, and the corresponding element of proper time. The average two-way velocity of light is put to $c \equiv 1$ by all equivalent observers. Let a set of observers $O, O', O'', \dots$ follow the inertial collinear motion of an object Ω . Proper time being invariant, the transformations of coordinates must be Galilean. Hence we begin by postulating the *Invariance of Proper Time* to relative motion:

$$\boxed{d\tau^2 = dt^2 - dx^2 = d\tau'^2 = dt'^2 - dx'^2}$$

If this holds, we are ensured a perfect agreement with relativistic electrodynamics. But what is the necessity of integrating it into: $\tau^2 = t^2 - x^2 = t'^2 - x'^2$? None at all! That choice - if we make it - is dictated by our own convention and not by nature. The standard frame-coordinates t' & x' ($t = ', '' \dots$) of an observer are given in terms of proper time τ where τ'_1 & τ'_2 are the instants of emission & reception of a reflected photon and $\bar{c}'_{\rightarrow}$ & $\bar{c}'_{\leftarrow}$ are the average velocities to and fro, resp., of the photon [1]:

$$\begin{aligned} \tau_g &\equiv \tau + x/\bar{c}_\leftarrow \equiv t + x & \tau'_g &\equiv \tau' + x'/\bar{c}'_\leftarrow \equiv t' + x' \\ \tau_l &\equiv \tau - x/\bar{c}_\rightarrow \equiv t - x & \tau'_l &\equiv \tau' - x'/\bar{c}'_\rightarrow \equiv t' - x' \\ \{1/\bar{c}_\leftarrow + 1/\bar{c}_\rightarrow\}/2 &= 1 = \{1/\bar{c}'_\leftarrow + 1/\bar{c}'_\rightarrow\}/2 \end{aligned}$$

However, there is no reason for ascribing a fundamental significance to frame time! It is simply an unfounded prejudice that frame time is the proper one to apply to events occurring at a distance, whereas proper time cannot be applied at a distance due to lack of an operational definition: we shall prove the opposite to be the case! Let us dissolve our *Invariance Postulate* in the following conventional components:

$$\begin{aligned} \bar{e}^\alpha d\tau_g &\equiv \bar{e}^\alpha (dt + dx) \equiv \bar{e}^{\alpha'} d\tau'_g \equiv \bar{e}^{\alpha'} (dt' + dx') \\ e^\alpha d\tau_l &\equiv e^\alpha (dt - dx) \equiv e^{\alpha'} d\tau'_l \equiv e^{\alpha'} (dt' - dx') \\ dt' + dx' &= e^{-\omega} (dt + dx) \cdot \omega \equiv \alpha - \alpha' \cdot dt' - dx' = e^\omega (dt - dx) \end{aligned}$$

Already now the standard *LT* are unavoidable in the well-known differential form:

$$\boxed{dt' = dt \cosh \omega - dx \sinh \omega} \cdot \boxed{dx' = dx \cosh \omega - dt \sinh \omega}$$

A little imagination suffices to suggest how these equations can be integrated in a way obliterating $\tau^2 = t^2 - x^2 = t'^2 - x'^2$, but preserving $d\tau^2 = dt^2 - dx^2 = dt'^2 - dx'^2$. In fact, there are two important ways in which the integration can be performed, both of them conforming to the classical rule of synchronization $\tau = 0 \Leftrightarrow \chi = x = x'$. In both cases $(\tau, 0)$ are the proper coordinates of the common object Ω situated at the invariant distance χ at the instant $\tau = 0$ when all observers $O, O', O'', \dots$ coincide:

$$\begin{aligned} \tau &= t \cosh \alpha - (x - \chi) \sinh \alpha = t' \cosh \alpha - (x' - \chi) \sinh \alpha = \dots \\ 0 &= (x - \chi) \cosh \alpha - t \sinh \alpha = (x' - \chi) \cosh \alpha - t' \sinh \alpha = \dots \\ \boxed{t' = t \cosh \omega - (x - \chi) \sinh \omega} &\cdot \boxed{x' = (x - \chi) \cosh \omega + \chi - t \sinh \omega} \\ \tau &= \sqrt{t^2 - (x - \chi)^2} = \sqrt{t'^2 - (x' - \chi)^2} \end{aligned}$$

Whereas the first way of integration confers a privileged status to the object frame the second way, constituting the core of our new theory, is a bit more complicated:

$$\begin{aligned} \tau &= (t - \tau_o) \cosh \alpha + \tau_o - x \sinh \alpha = (t' - \tau'_o) \cosh \alpha' + \tau'_o - x' \sinh \alpha' \\ 0 &= x \cosh \alpha - (t - \tau_o) \sinh \alpha = x' \cosh \alpha' - (t' - \tau'_o) \sinh \alpha' \\ \boxed{t' = t \cosh \omega - x \sinh \omega + \text{constant}_1} &\cdot \boxed{x' = x \cosh \omega - t \sinh \omega + \text{constant}_2} \\ \tau &= \sqrt{(t - \tau_o)^2 - x^2} + \tau_o = \sqrt{(t' - \tau'_o)^2 - x'^2} + \tau'_o \end{aligned}$$

These equations are to be preferred because they conform to a perfect symmetry of signal-functions that bestows operational sense to the invariance of proper time τ . The trouble with the standard integral Lorentz transformations is that they are manifestly incompatible with Galileo invariance, except in a special case, and that they give priority to frame time, thereby seducing us into a neglect of proper time. If all constants are put to zero, $t' = t \cosh \omega - x \sinh \omega$ & $x' = x \cosh \omega - t \sinh \omega$ yield:

$$\tau^2 = \tau_g \tau_l = t^2 - x^2 = t'^2 - x'^2 = \tau'_g \tau'_l = \tau'^2$$

So even standard *SR* is compatible with proper time invariance, cf. Törnebohm [2]; but the problem with this τ -coordinate is: $dr/dt = \text{inertial} \Leftrightarrow dr/d\tau = \text{non-inertial}$.

What is nasty with *SR* is that it mixes up two types of synchronization: while the first yields a *frame-external synchronization* of equivalent *master-clocks*, the second yields a *frame-internal synchronization* of non-equivalent *slave-clocks*:

TYPE 1 SYNC. - GEOMETRIC MEAN: $\tau = \sqrt{\tau_3 \tau_1} = \sqrt{\tau'_3 \tau'_1} = \tau'$
valid for two privileged master-clocks governed by the invariance of proper time
(this is the synchronization of Milne & Whitrow, Bondi, and Törnebohm)

TYPE 2 SYNC. - ARITHMETIC MEAN: $t = \frac{1}{2}(\tau_3 + \tau_1) \neq t' = \frac{1}{2}(\tau'_3 + \tau'_1)$
valid for two comoving clusters of slave-clocks displaying divergent frame times
(this is the standard-synchronization of Einstein and all his followers)

Small wonder then that *SR*, by confounding these two types of synchronization, to some takes the appearance of eliminating absolute simultaneity and universal time. But the relativization of frame time does *not* imply a relativization of proper time. In order to prove this we shall introduce a *TYPE 3* synchronization that reduces to *TYPES 2 & 1* above in special cases, yielding the arithmetic mean for objects at rest and the geometric mean for moving objects coinciding with the observer at $\tau = 0$. As the only clock-readings we need to consider are those of our two master-clocks it seems irrelevant to postulate the existence of comoving clouds of slave-clocks, and for the sake of clarity we shall provisionally ignore the readings of such clocks.

We now proceed with a presentation of preliminaries to our new theory.

First we define the frame velocities of *P* with respect to *O* & *O'* as *v* & *v'* where:

$$v \equiv dx/dt \equiv \tanh \alpha \quad . \quad v' \equiv dx'/dt' \equiv \tanh \alpha'$$

Next we define the proper velocities of *P* with respect to *O* & *O'* as *V* & *V'* where:

$$V \equiv dx/d\tau \equiv \sinh \alpha \quad . \quad V' \equiv dx'/d\tau' \equiv \sinh \alpha'$$

We further define the frame and proper velocities between *O* & *O'* as *w* & *W* where:

$$w \equiv \tanh \omega \quad . \quad U \equiv V - V' \neq W \equiv \sinh \omega$$

As a consequence of these definitions we derive the velocity transformations below:

$$v' = (v-w)/(1-vw) \quad . \quad w = (v-v')/(1-vv') \\ U = \sinh \alpha - \sinh(\alpha - \omega) = 2 \sinh \frac{\omega}{2} \cosh(\alpha - \frac{\omega}{2}) \xrightarrow{\alpha \rightarrow 0} W$$

The relationship obtaining between *dt* & *dt'* is identical to that derived from *SR*; this suffices to explain the (misleadingly) so-called relativistic 'clock-retardation':

$$d\tau = dt/\cosh \alpha = dt'/\cosh \alpha' \quad . \Leftrightarrow \quad d\tau = dt\sqrt{(1-v^2)} = dt'\sqrt{(1-v'^2)} \\ dt' = dt\sqrt{(1-v^2)}/\sqrt{(1-v'^2)} = dt(1-wv)/\sqrt{(1-w^2)} = (dt-wdx)/\sqrt{(1-w^2)}$$

We now synchronize the master-clocks of *O* & *O'* according to $\tau = \tau' = 0 \Leftrightarrow x = x'$ which is the classical synchronization procedure appropriate to *GT*, but not to *LT*. Having thus defined a common time-zero by the coincidence of our master-clocks, our postulate of clock-rate invariance then suffices to establish the identity $\tau \equiv \tau'$. Now let *P* coincide with *O* at *O*-time $\tau = \tau_o$, and with *O'* at *O'*-time $\tau' = \tau'_o$; hence:

$$x = v \int_{\tau_o}^t dt = v \int_{\tau_o}^{\tau} d\tau \quad . \Leftrightarrow \quad x' = v' \int_{\tau'_o}^{t'} dt' = v' \int_{\tau'_o}^{\tau'} d\tau' \\ x = \{t - \tau_o\} v = \{\tau - \tau_o\} V \quad . \quad x' = \{t' - \tau'_o\} v' = \{\tau' - \tau'_o\} V'$$

All consequences of our new theory are derivable from these double expressions. When our two basic double relations are rewritten in hyperbolic terms, they yield:

$$\begin{aligned}
 x &= (t - \tau_0) \tanh \alpha = (\tau - \tau_0) \sinh \alpha \\
 t &= \tau + x \tanh(\alpha/2) = (\tau - \tau_0) \cosh \alpha + \tau_0 \\
 \tau_3 &\equiv t + x = e^\alpha (\tau - \tau_0) + \tau_0 \quad . \quad \tau_1 \equiv t - x = e^{-\alpha} (\tau - \tau_0) + \tau_0 \\
 \tau - \tau_0 &= e^{-\alpha} (\tau_3 - \tau_0) = e^\alpha (\tau_1 - \tau_0) = \sqrt{[(\tau_3 - \tau_0)(\tau_1 - \tau_0)]} = \sqrt{[(t - \tau_0)^2 - x^2]} \\
 x' &= (t' - \tau'_0) \tanh \alpha' = (\tau - \tau'_0) \sinh \alpha' \\
 t' &= \tau + x' \tanh(\alpha'/2) = (\tau - \tau'_0) \cosh \alpha' + \tau'_0 \\
 \tau'_3 &\equiv t' + x' = e^{\alpha'} (\tau - \tau'_0) + \tau'_0 \quad . \quad \tau'_1 \equiv t' - x' = e^{-\alpha'} (\tau - \tau'_0) + \tau'_0 \\
 \tau - \tau'_0 &= e^{-\alpha'} (\tau'_3 - \tau'_0) = e^{\alpha'} (\tau'_1 - \tau'_0) = \sqrt{[(\tau'_3 - \tau'_0)(\tau'_1 - \tau'_0)]} = \sqrt{[(t' - \tau'_0)^2 - x'^2]}
 \end{aligned}$$

In order to derive GT, we finally use the classical rule of synchronization:

$$\begin{aligned}
 \tau = \tau' = 0 &\Rightarrow x = x' \Rightarrow -V\tau_0 = -V'\tau'_0 \equiv \chi \\
 \chi &= x - V\tau = x' - V'\tau \Rightarrow x' = x - (V - V')\tau
 \end{aligned}$$

$$\boxed{\tau = \tau' \quad x' = x - U\tau \quad U \equiv V - V' \frac{\alpha \rightarrow 0}{\alpha \rightarrow \omega} W}$$

$$\begin{aligned}
 V &\equiv \sinh \alpha \quad . \quad V' \equiv \sinh \alpha' \quad . \quad W \equiv \sinh \omega \quad . \quad U \equiv \sinh \alpha - \sinh(\alpha - \omega) \\
 e^\alpha &= d\tau_3/d\tau \equiv \sigma \quad . \quad e^{\alpha'} = d\tau'_3/d\tau' \equiv \sigma' \quad . \quad e^\omega = d\tau_3/d\tau'_3 \equiv \sigma''
 \end{aligned}$$

Our new Galileo equations are translatable back into modified Lorentz equations:

$$\begin{aligned}
 \chi &= -\tau_0 \sinh \alpha = x - \tau \sinh \alpha \equiv x \cosh \alpha - t \sinh \alpha \Rightarrow \\
 \tau &= t - x \tanh(\alpha/2) = t \cosh \alpha - x \sinh \alpha + C \quad C \equiv \chi \tanh(\alpha/2) \\
 \chi &= -\tau'_0 \sinh \alpha' = x' - \tau \sinh \alpha' \equiv x' \cosh \alpha' - t' \sinh \alpha' \Rightarrow \\
 \tau &= t' - x' \tanh(\alpha'/2) = t' \cosh \alpha' - x' \sinh \alpha' + C' \quad C' \equiv \chi \tanh(\alpha'/2) \\
 \tau + \chi &= e^\alpha (t + x) + C = e^{\alpha'} (t' + x') + C' \Rightarrow t' + x' = e^\omega (t + x) + e^{\alpha - \omega} (C - C') \\
 \tau - \chi &= e^\alpha (t - x) + C = e^{\alpha'} (t' - x') + C' \Rightarrow t' - x' = e^\omega (t - x) + e^{\omega - \alpha} (C - C')
 \end{aligned}$$

By addition and subtraction of the last two right hand equations we easily obtain:

$$\begin{aligned}
 t' &= t \cosh \omega - x \sinh \omega + K \cosh(\alpha - \omega) \quad . \quad x' = x \cosh \omega - t \sinh \omega + K \sinh(\alpha - \omega) \\
 K &= C - C' = \chi \left\{ \tanh \frac{\alpha}{2} - \tanh \frac{\alpha - \omega}{2} \right\} = \{x - \tau \sinh \alpha\} \sinh \frac{\omega}{2} / \cosh \frac{\alpha}{2} \cosh \frac{\alpha - \omega}{2}
 \end{aligned}$$

Having found the constants of integration, we equate our two expressions for x' :

$$\begin{aligned}
 x' &= x - \tau \{ \sinh \alpha - \sinh(\alpha - \omega) \} = x \cosh \omega - t \sinh \omega + K \sinh(\alpha - \omega) \\
 \tau \left(\frac{\sinh \alpha - \sinh(\alpha - \omega)}{\sinh \omega} - \frac{\sinh \alpha \sinh(\omega/2) \sinh(\alpha - \omega)}{\cosh(\alpha/2) \cosh(\alpha/2 - \omega/2) \sinh \omega} \right) &= \\
 &= t - x \left\{ \tanh(\omega/2) + \frac{\sinh(\omega/2) \sinh(\alpha - \omega)}{\cosh(\alpha/2) \cosh(\alpha/2 - \omega/2) \sinh \omega} \right\}
 \end{aligned}$$

A prolix calculation verifies that this is reducible to our coordinate, $\tau = t - x \tanh \frac{\alpha}{2}$. We have thus tested the formal consistency of our new synchronization procedure.

TYPE3 SYNC. - SYSTEMATIC MEAN:

$$\begin{aligned}
 \tau &= t - x \tanh \frac{\alpha}{2} = \sqrt{[(\tau_3 - \tau_0)(\tau_1 - \tau_0)]} + \tau_0 \\
 \tau &|_{\tau \rightarrow -\infty} \frac{1}{2}(\tau_3 + \tau_1) \quad . \quad \tau|_{\tau \rightarrow 0} \sqrt{(\tau_3 \tau_1)}
 \end{aligned}$$

If we rewrite our coordinate by means of variable one-way light velocities, we find:

$$\boxed{\tau = t^t + x^t \{1 - 1/\tilde{c}_{\leftarrow}^t\} = t^t - x^t \{1 - 1/\tilde{c}_{\rightarrow}^t\}}$$

$$\underline{1/\tilde{c}_{\leftarrow}^t = 1 + \tanh(\alpha^t/2) \quad . \quad 1/\tilde{c}_{\rightarrow}^t = 1 - \tanh(\alpha^t/2)}$$

$$1/c \equiv \{1/\tilde{c}_{\leftarrow}^t + 1/\tilde{c}_{\rightarrow}^t\}/2 = 1$$

This shows that the velocity of light, though variable, remains a limiting velocity. A photon aiming at a receding object will always catch up with it, sooner or later.

Up till now the whole difference to SR can be said to depend on convention. We can introduce τ without leaving the experimental basis of the standard theory, as the use of a different rule of synchronization has no consequence to experiment. But with AR, our alternative relativity, an observer is free to identify proper time, as calculated by means of direct signals reflected by the object, with frame time as calculated by means of indirect signals reflected by a series of coinciding fix-points. This distinction between direct and indirect signals is the core of our new theory, and experimental evidence of the difference will support AR as against SR.

§2. THE GENERALIZATION OF SF TO 3-SPACE

The concept of a signal-function (SF) is borrowed from E.A. Milne [3]. Assuming $v_x \equiv dx/d\tau \equiv \sinh \ln \sigma_x$ to be constant in the direction of x we define:

$$(\theta + \phi)/2 \equiv (\tau - \tau_0) \sqrt{(1 + v_x^2)} + \tau_0 \quad . \quad (\theta - \phi)/2 \equiv \sqrt{(\tau - \tau_0)^2 v_x^2 + y_0^2 + z_0^2}$$

These definitions immediately allow us to derive SF for inertial motion in 3-space:

$$\underline{\theta(\tau) = \{(\tau - \tau_0) \sqrt{(1 + v_x^2)} + \tau_0\} + \sqrt{(\tau - \tau_0)^2 v_x^2 + y_0^2 + z_0^2} \equiv t(\tau) + r(\tau)}$$

$$\underline{\phi(\tau) = \{(\tau - \tau_0) \sqrt{(1 + v_x^2)} + \tau_0\} - \sqrt{(\tau - \tau_0)^2 v_x^2 + y_0^2 + z_0^2} \equiv t(\tau) - r(\tau)}$$

Using $\phi \equiv \theta^{-1}$ to recover $\theta(\tau)$, we readily prove $\theta(\tau)$ to be symmetric in 3-space:

$$\tau - \theta(\tau) \Rightarrow \tau = \{(\theta - \tau_0) \sqrt{(1 + v_x^2)} + \tau_0\} - \sqrt{(\theta - \tau_0)^2 v_x^2 + y_0^2 + z_0^2}$$

$$(\theta - \tau_0)^2 v_x^2 + y_0^2 + z_0^2 = (\theta - \tau_0)^2 (1 + v_x^2) + (\tau - \tau_0)^2 - 2(\theta - \tau_0)(\tau - \tau_0) \sqrt{(1 + v_x^2)}$$

$$(\theta - \tau_0)^2 - 2(\theta - \tau_0)(\tau - \tau_0) \sqrt{(1 + v_x^2)} + (\tau - \tau_0)^2 - y_0^2 - z_0^2 = 0$$

The solution of this second-order equation in $\theta - \tau_0$ is easily seen to replicate $\theta(\tau)$. For $v_x \equiv v_x/\sqrt{(1 - v_x^2)}$ our DS, $\sigma_r \equiv d\theta_r/d\tau$, is identical to the standard DS of SR. It is important to notice that $\sigma_r = d\theta_r/d\tau$ is DS as measured in direction r/r pointing from observer to source, whereas $\sigma_x = d\theta_x/d\tau$ is DS as measured by a co-observer remaining stationary relative to the first one at distance $a_0 \equiv \sqrt{(y_0^2 + z_0^2)}$ and coinciding with the source, which moves at velocity $v_x = \text{const.}$, at instant τ_0 . With $\cos \eta \equiv x/r \equiv r \cdot \hat{r}/r\hat{r}$ and $\hat{r} \equiv v_x$ we can rewrite θ_r, ϕ_r in terms of $r, \hat{r}$:

$$\underline{\theta_r(\tau) = \tau + r \{1 + \cos \eta [\sqrt{(1 + \hat{r}^2)} - 1]/\hat{r}\} \equiv \tau + r/\tilde{c}_{\leftarrow}}$$

$$\underline{\phi_r(\tau) = \tau - r \{1 - \cos \eta [\sqrt{(1 + \hat{r}^2)} - 1]/\hat{r}\} \equiv \tau - r/\tilde{c}_{\rightarrow}}$$

Our principle of proper time invariance is now easily generalized to 3-space:

$$\begin{aligned} t &= (\tau - \tau_0) \cosh \ln \sigma_r + \tau_0 \quad .\Downarrow. \quad r = (\tau - \tau_0) \sinh \ln \sigma_r \\ dt &= d\tau \cosh \ln \sigma_r + d\ln \sigma_r (\tau - \tau_0) \sinh \ln \sigma_r \\ dr &= d\tau \sinh \ln \sigma_r + d\ln \sigma_r (\tau - \tau_0) \cosh \ln \sigma_r \end{aligned}$$

$$dT^2 \equiv dt^2 - dr^2 = d\tau^2 - (\tau - \tau_0)^2 d\ln \sigma_r^2 = \text{invariant}$$

This shows firstly, that $dT = d\tau$ in case of inertial motion, and secondly, that if we choose to map r in Euclidean space, we have to map $\ln \sigma_r$ in Lobachevskian space:

$$\text{Euclidean } (dt, dr) \text{ metric} \Leftrightarrow \text{Lobachevskian } (d\tau, d\ln \sigma) \text{ metric}$$

Although the quadratic represents a special case, our result has general validity. According to that, the triangle-inequality $\sigma_{13} \leq \sigma_{12} \sigma_{23}$ refers to hyperbolic space; correspondingly, we define collinear motion by transitivity of DS : $\sigma_{13} = \sigma_{12} \sigma_{23}$. We then make some definitions which we assume valid for hyperbolic vector space:

$$\begin{aligned} j &\equiv PQ/PQ \quad . \quad j' \equiv P'Q/P'Q \quad . \quad j^* \equiv PP'/PP' \\ V &\equiv V_{pq} \equiv j \sinh \ln \sigma \quad . \quad V' \equiv V_{p'q} \equiv j' \sinh \ln \sigma' \\ U &\equiv U_{pp'} \equiv V - V' \neq W \equiv W_{pp'} \equiv j^* \sinh \ln \sigma^* \end{aligned}$$

In accordance with our present choice of definitions and metric we further obtain:

$$\begin{aligned} \sinh \ln \sigma / \sinh \ln \sigma' &= \sinh \ln \sigma^* / \sinh \ln \sigma' = \sinh \ln \sigma^* / \sinh \ln \sigma \\ \cosh \ln \sigma' &= \cosh \ln \sigma \cosh \ln \sigma^* - \sinh \ln \sigma \sinh \ln \sigma^* \cdot i \cdot i \\ \sinh \ln \sigma' &= \sqrt{(\cosh \ln \sigma \cosh \ln \sigma^* - \sinh \ln \sigma \sinh \ln \sigma^* \cdot j \cdot j^*)^2 - 1} \\ \sigma = \sigma' \sigma^* &\Rightarrow V_x = \sinh \ln(\sigma' \sigma^*) \quad . \quad V'_x = \sinh \ln(\sigma / \sigma^*) \quad . \quad W_x = \sinh \ln(\sigma / \sigma') \end{aligned}$$

The classical synchronization procedure for moving master-clocks implies:

$$\begin{aligned} r(\tau) &\equiv \int_{\tau_0}^{\tau} V d\tau \quad .\Downarrow. \quad r'(\tau) \equiv \int_{\tau'_0}^{\tau} V' d\tau \\ r(0) &= r'(0) \Leftrightarrow \int_{\tau_0}^0 V d\tau = \int_{\tau'_0}^0 V' d\tau \Leftrightarrow \tau = \tau' = 0 \end{aligned}$$

It is now easy to state the form of GT which characterizes AR , our new theory:

$$r' = \tau \quad . \quad r'(\tau) = r(\tau) - \int_0^{\tau} U d\tau \quad . \quad U = V - V' \neq W$$

The most peculiar consequence of our modified GT is the surprising result $U \neq W$. So we cannot insert W , the relative velocity between P & P' , we have to insert U ; but U is the difference between V and V' , and V' can be calculated by means of:

$$\begin{aligned} V' &= j' \sqrt{(\sqrt{(1+V^2)} \sqrt{(1+W^2)} - VW)^2 - 1} \\ j \cdot j' &= \cos \vartheta^* = \sqrt{1 + (\sinh \ln \sigma / \sinh \ln \sigma')^2} \end{aligned}$$

The possibility of $V \equiv \sinh \ln \sigma > 1$ is sufficient to explain the 'meson time delay'. The retardation of cesium clocks put into round-the-world circulation is irrelevant: AR - like SR - makes no pretension of dealing with gravitational phenomena.

§3. THE DESCRIPTION OF ACCELERATED MOTION

AR is readily generalized to cover accelerated motion; according to standard wave theory - writing ν for frequency, λ for wave-length, and σ for DS - we have:

$$c \equiv \lambda \nu \equiv \lambda_0 \nu_0 \equiv 1 \quad . \quad c' \equiv \lambda' \nu' \equiv \lambda'_0 \nu'_0 \equiv 1$$

$$\sigma \equiv \lambda \nu_0 / c \quad . \quad \sigma^{-1} \equiv \lambda_0 \nu / c \quad . \quad \sigma' \equiv \lambda' \nu'_0 / c' \quad . \quad \sigma'^{-1} \equiv \lambda'_0 \nu' / c'$$

Just as no theory of relativity can renounce at the reciprocity of uniform relative velocity, so neither can a theory of relativity dispense with the symmetry of *DS*. However, this does not preclude an asymmetry of *DS* due to the influence of fields, but in that case we are entitled to speak of clocks deviating from absolute time: identical atomic clocks exposed to different influences can not be synchronized. Let us now assume that the one-way velocities of photons depend somehow on *DS*. It will then be convenient to apply the concept of *Signal-Functions (SF)*, cf. *Milne*. Let functions θ & ϕ relate the *advanced epoch* $\theta(\tau) \equiv \tau_2$ and the *retarded epoch* $\phi(\tau) \equiv \tau_1$ of a reflected signal - i.e. a *radar-signal* - to the instant of reflection τ . First define the derivatives of *SF*, with respect to invariant proper time τ , as *DS*:

$$\sigma \equiv d\theta/d\tau \equiv d\tau/d\phi \quad . \quad \sigma' \equiv d\theta'/d\tau' \equiv d\tau'/d\phi'$$

Then assume the one-way velocities $c_{\rightarrow}$ & $c_{\leftarrow}$ of photons to vary in general with σ :

$$c_{\rightarrow}(\sigma) \equiv (1 + \nu_0 \lambda)/2 \quad . \quad c_{\leftarrow}(\sigma) \equiv (1 + \lambda_0 \nu)/2$$

$$c_{\rightarrow}(d\tau - d\phi) = c_{\leftarrow}(d\theta - d\tau) = (d\theta + d\phi)/2 = \sinh \ln \sigma \, d\tau = dr$$

The one-way velocities $c_{\rightarrow}(\sigma) = (1 + \lambda \nu_0)/2$ & $c_{\leftarrow}(\sigma) = (1 + \lambda_0 \nu)/2$ can be viewed as 'mean values' of $\lambda \nu = \lambda_0 \nu_0 = 1$ and $\nu_0 \lambda = \sigma$ & $\lambda_0 \nu = \sigma^{-1}$, resp., and an observer can for this reason by decree assess the velocity of incoming light to be locally $c_{\leftarrow} = 1$. The relations above suggest the following multiple definition of vectorial distance:

$$\boxed{r(\tau) \equiv i \int_{\phi}^{\tau} c_{\rightarrow} d\tau \equiv i \int_{\tau}^{\theta} c_{\leftarrow} d\tau \equiv i \frac{1}{2} \int_{\phi}^{\theta} d\tau \quad . \quad i \equiv r/r}$$

$$\boxed{r'(\tau) \equiv i' \int_{\phi'}^{\tau} c'_{\rightarrow} d\tau \equiv i' \int_{\tau}^{\theta'} c'_{\leftarrow} d\tau \equiv i' \frac{1}{2} \int_{\phi'}^{\theta'} d\tau \quad . \quad i' \equiv r'/r'}$$

This is also our general light-principle which overrules the argument of de Sitter.

§4. FUNDAMENTAL POSTULATES & CONCLUSION

Finally we proceed to state the fundamental postulates of our new theory. First we define operationally what it means that *P*-time is synchronous to *P'*-time:

$$\tau \equiv \tau' \quad . \Leftrightarrow \quad \theta \equiv \theta' \quad . \quad \phi \equiv \phi' \quad . \quad \phi \theta(\tau) = \theta \phi(\tau) = \tau$$

This definition is immediately applicable to our postulates stated below:

POSTULATE 1: A symmetry of *DS* is always integrable into a symmetry of *SF*:

$$\boxed{\sigma = \sigma' \quad . \Rightarrow \quad \theta = \theta' \quad . \quad \phi = \phi' \quad . \quad \phi \theta(\tau) = \theta \phi(\tau) = \tau}$$

Hence it is only a matter of correct synchronization to go from $\sigma \equiv \sigma'$ to $\tau \equiv \tau'$.

POSTULATE 2: The symmetry of *SF* is transitive between different observers:

$$\boxed{\theta(\tau) = \theta'(\tau) \quad . \quad \theta'(\tau) = \theta''(\tau) \quad . \Rightarrow \quad \theta(\tau) = \theta''(\tau)}$$

Our second postulate ensures that time is universal and simultaneity is absolute.

Our general conclusion is that *Alternative Relativity* turns out to be almost indistinguishable from *Special Relativity* as regards experiment and observation. In fact already a new convention will make *LT* fully compatible with $\tau = \text{invariant}$. So the only real difference seems to concern signals, direct versus indirect.

§5. TOM PHIPPS ON RELATIVITY & ABERRATION

When I first read Tom's '*Heretical Verities*'[4], it was like a revelation. Here was the fellow rebel I had searched for so long - not one of those cranks which overflow certain magazines with emotional resentments against established theory, but a very clever and knowing person with a sound and reasonable view of science; especially, I admired his exposition of the very important idea of 'covering' theory. I agree with Tom that the 'revolution' of 1905 was a major catastrophe to physics, and I consent to his diagnosis that most maladies affecting modern science are due to the decline of genuine invariance in favour of covariance which is only spurious. I further support his insistence that the lack of parametrization of the free motion of a field detector is a serious defect of the electrodynamics of Maxwell & Einstein. However, I believe that this defect of the field equations can be mended if they be reconstructed along the lines suggested by my own proof of $LT \equiv GT$ equivalence. So I accept his proposal to identify my object time τ with his detector time τ_d .

Nevertheless, it cannot be concealed that we diverge on important issues, the most basic one perhaps being our choice of procedure for clock synchronization. Tom's method [5] for synchronizing 'clock-gases' without the use of light-signals or transport not only blurs the germane distinction of Popper [6] between *clocks* and *clouds*, but also leads to results that are 'essentially trivial', as he openly admits. What he finds is a description giving privileged status to the frame of the detector, but a frame-time privileged within a certain frame is clearly not a true invariant. Further, his objections [7] against the standard explanation of aberration, although focussing on the central distinction between relative velocity source-detector, v_{sd} , and relative difference in orbital velocity, v_{orb} , seem to me not altogether relevant. First, aberration concerns the difference of angle between two apparent directions, relating to two different states of motion of the observer, rather than a difference between true and apparent direction, of a distant star - i.e., unless we assume the existence of a universal substratum, or medium, defined by the 3° Kelvin radiation; why aberration cannot unveil an aether is explained in great detail by Poincaré [8]. Second, if we want to propose a definition of the 'true' direction of a distant star, as Tom does, then it is very strange to include a reference to the event of emission, when what matters is the state of motion of the observer at the event of reception. I admit that the original explanation by Einstein, 1905, is certainly unsatisfactory, but its shortcomings are eliminated in the very lucid exposition by Whittaker [9]. Of course, *LT* can be used to relate and compare the different states of motion of two observers moving in the same orbit at the same time, i.e. that of reception.

Moreover, the phenomenon of aberration is closely connected with the *DS*. The point to be noticed is that the *DS* involves two different kinds of aberration: an 'invisible' one related to the event of emission, and the 'visible' one related to the event of reception; the former kind is relevant when we e.g. want two lasers in different states of motion to emit parallel beams of light towards a distant target. Now the proper time interval of *SR* is zero for the transmission of photons, hence *SR* cannot distinguish the two kinds of aberration properly, but mixes them up. By contrast, the proper time interval of *AR* for the transmission of photons is *not* zero except by coincidence, so it is simple to distinguish emission from reception; and the two kinds of aberration hence can, and must, be treated separately by *AR*. For this reason it is difficult for me to see any difficulty with aberration at all.

This discussion is not meant to detract from my tribute to Tom Phipps.

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Mogens Wegener
Højmarkvej 1, 8270 Højbjerg,
Danmark

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The A-Priorism of Kant

&

ITS REPERCUSSIONS ON POINCARÉ, EDDINGTON, AND MILNE

Mogens Wegener

Dept. Hist. Ideas, Univ. Aarhus, Denmark

'Reason does not extract its laws from nature, it prescribes them to nature ... In this way, by subsuming all phenomena under its own laws, reason is the source and origin of the general order of nature ..' Kant[10]

'Nothing of all what we have set forth about the universe could ever have been said if we had never seen the sun or the starry heavens; but observation of day and night, of months and seasons of the year, of equinox and solstice, has produced our knowledge of numbers, which has conferred on us the notion of time and inspired us to investigate the universe; whence we have derived philosophy, which is the greatest boon ever bestowed on mortal man by the heavens ..

But, in my opinion, the cause and purpose of vision is this: God invented it and entrusted it to us in order that we should observe the orbits of reason in the heavens and use them to correct the circuits of our own thought which are akin to them, though ours be troubled and they unperturbed, so that - when we learned to know them and to compute them rightly according to nature - we could bring order to our own errant circles by imitating those of God which are perfectly regular.'

Plato[22]

'Does the harmony the human intelligence thinks it discovers in nature exist outside of this intelligence? No, beyond doubt, a reality completely independent of the mind which conceives it, sees or feels it, is impossible. A world as exterior as that - even if it existed - would for us be forever inaccessible. But what we call objective reality is, in the last analysis, what is common to many thinking beings, and could be common to all. That common part can only be a harmony expressed by mathematical laws. It is this harmony, then, which is the sole objective reality, the only truth we can attain. When I add that the universal harmony of the world is the source of all beauty, it will be understood what prize we should attach to the slow and difficult progress which little by little enables us to know it better.'

Poincaré[24]

'Simple, as is the origin of this law (of reciprocal attraction), which relies only on the relationships between spherical surfaces of different radii, nevertheless its consequences are so rich, as regards the variety of their mutual consistencies and uniformities, that not only does it describe all possible trajectories of heavenly bodies by conical sections, but it does also imply relations of such a kind to obtain between these sections, that no other law of gravitation than that depending on the inverse square of the distance can be considered appropriate to a world system.'

Kant[10]

FROM PLATO TO KANT

The merits of Jules Henri Poincaré as one of the greatest mathematicians of all times are globally acknowledged. But the value of his conventionalist theory of science is still greatly underestimated - partly due to misrepresentation by leading historians, partly due to unfair criticism propagated by important philosophers - and his contributions to physics as well as to its philosophy have unjustly fallen into oblivion, as compared to the overwhelming fame of Albert Einstein.

In this lecture/paper it is my intention to stress the importance of Poincaré to physical theory and the theory of physics by hailing him as *the* principal figure in the traditional interplay between classical philosophy and modern cosmology. As an example, I want to install him as the central link in a line of development connecting the main stream of European thought, as represented by the Kantian *Critique of Pure Reason*, to two seemingly incompatible non-standard cosmologies: viz. that of Arthur Stanley Eddington, and that of Edward Arthur Milne.

Within the restricted frame of time/space allowed to me at this very special occasion it is of course not advisable for me to dwell at length on historical detail, neither do I feel able to do so without further study. What I want to do is to draw, with coloured brush and sweeping gesture, some very broad lines in the history of scientific ideas. These, as I see it, opens some exciting philosophical perspectives which might in the end help to throw light on the present impasse of cosmology. But in order not to pretend too much I shall close these introductory remarks by reminding you of the obvious fact, that science is always in need of bold new ideas. This is one of the reasons why we should not forget about its history. -

The story of how Immanuel Kant was disturbed in his dogmatic slumber by the sceptical doubts of an eloquent Scotchman is well-known: finally he was forced to envisage the scandal of contemporary philosophy. A century ago, Isaac Newton had won for physics its most brilliant triumph in history - yet philosophy had been unable to account for this unique achievement, let alone to disclose its legitimacy. In spite of Descartes, the ghost of Aristotelianism was still haunting philosophy; but to Kant, at least, it had become clear that the way of abstraction is blocked: true knowledge can never be obtained by a process of successive approximation. Inspired by the feat of Nikolaus Kopernik the innovator of medieval astronomy, Kant now set himself the task to effect a Copernican revolution in philosophy.

In order to ensure the safe progress of science, Kant proposed a distinction between reality to us and reality in itself, i.e. plain phenomena and mere noumena. Of noumena that remain latent we can know nothing. Of phenomena belonging to the realm of experience, which originate from the joint venture of observation and speculation, or the teamwork of sensation and reflection, we can know everything. The inner nature of reality transcends our inborn intellectual capabilities forever; but apparent nature - the surface of reality - remains transparent to our reason. What we must do, in order to obtain absolute and indubitable knowledge, is only to apply those conceptions, which distinguish our inborn nature as thinking beings, to that manifold of sensations, which is continuously caught in the network defining the structure of our natural intuition - namely, the framework of time and space. True knowledge of apparent nature, reality for us, is then bound to emerge.

Knowledge of this kind, albeit occasioned by experience, derives its validity and legitimacy from another source, viz. the collaboration of reason and intuition. According to Kant, pure reason can collaborate with pure intuition ahead of any mediation of experience, and the result of this activity is pure knowledge *a priori*. Knowledge is *a priori* when it can be derived by strictly transcendental arguments, i.e., formal arguments which hold good independently of any concrete experience. As regards the *a priori* argument, given by Kant, to prove the inverse square law of gravitation, it is clear that his claim - astounding as it is - can be sustained on the assumption that gravitational forces can be described in flat vectorial 3-space: the argument is then on a par with that leading to the so-called 'Olbers' paradox'. Although, of course, we always have to wait for such arguments to be invented, it is nevertheless interesting to speculate how Kantianism might have been received if, *per impossibile*, the Euclidean parallel axiom had eventually been proven.

To Poincaré, the failure of all proofs given hitherto was decisive evidence against the claim of Kant that the structure of space can be demonstrated *a priori*. Although accepting the possibility of a pure intuition of space, he insisted that this space is devoid of any formal structure, hence definable in negative terms only. This brought him close to the position of Plato who frankly admitted that space, 'the uterus of becoming', is nothing but an imaginary container, whose dreamlike existence is hard to believe in: formless, and causally neutral, it is next to nothing. According to Descartes, extension is a substantial property, and space is material; but Poincaré rejected the Cartesian aether-hypothesis, just as it had been rejected by Leibniz, and for the same reason: abstract space is relational, not substantial.

It remains for us to point out that the gist of Kantian *a-priorism* is not bound up to the problem of geometry and, *a fortiori*, not to the idea of an aether. Its real issue is the active rôle of the intellect in the reconstruction* of the world; the activity of reconstructing the world is undertaken by the transcendental subject which can be interpreted as a kind of Platonic Demiurge deprived of mythology. As the Demiurge created *cósmos* out of *cháos* by applying ideas of geometry and categories of logic to a pre-existing 'ocean' of sensible qualities, in the same way the transcendental subject produces its 'world' by applying reason to intuition.

The most conspicuous difference between Kant and Plato is, however, that Plato regarded physics as 'the science of the probable' - not *epistémé*, but *dóxa* - whereas Kant insisted on *epistémé* - i.e., a final and absolute knowledge of nature. At this point modern science is clearly much more close to Plato than to Kant. Plato dreamt of a kinship between mind and nature, between concept and reality; he assumed that harmony is inherent in the world of nature and believed that it can be discovered by human reason because it partakes itself in the same harmony. But this is precisely the idea echoed in the so-called '*a-priorism*' of Kant.

I will elaborate a little further on this idea, as expressed in the language of Poincaré, Eddington and Milne. We shall see that the modern formal equivalent to the ancient idea of harmony is a mathematical one: group theoretical isomorphism. This is also the clue to the art of world-building in modern cosmology.

* That the Kantian construction of the universe is indeed meant as a re-construction seems evident from the intent behind his dusky 'disproof of idealism' in the *Critique of Pure Reason*.

JULES HENRI POINCARÉ (1854-1912)

'Hence, when we ask to the objective value of science, that does not mean: Does science teach us the true nature of things? but it means: Does science teach us the true relations of things? .. In sum, the sole objective reality consists in the relations of things, whence results the universal harmony.'

Poincaré[25]

In contrast to the theme of this conference, *'Science et Hypothèse'*, which refers to the first among the four books on the philosophy of science written by Poincaré, my own reflections will primarily put focus on the second of these, viz. *'La Valeur de la Science'*, which I personally consider to be the most important of his published books, the jewel in a quartet of precious stones; one of my reasons for preferring that book to the other is the priority it gives to time, ahead of space. My exposition of the philosophy of Poincaré is strongly influenced by Giedymin[6] who describes his aim as follows: to examine the evolution of science and to show that there is real progress in spite of radical changes in scientific theories.

According to Poincaré, the search for truth is the sole end worthy of science. Truth must be pursued in a spirit of righteousness, without prejudice and passion. But just as nature in itself is beautiful, so the truth of nature is likewise beautiful; if it were not, it would not be worth knowing, and life would not be worth living. Although there are worlds of difference between the passionate pursuit of beauty, the dispassionate search for truth, and the unselfish devotion to a higher purpose, these three cannot, and should not, be separated. As ideal values, they are of the same kind: whosoever loves the one truly cannot help loving the other two as well. The world is one - for this reason art, science and morals belong together.

Poincaré, being more dedicated to science, speaks mostly of scientific truth. In order to reach its goal, science must strive for unity, simplicity, and objectivity. Now experience is the only source of truth and the ultimate arbiter of our theories, but it is we who decide how to search for truth, and when to trust the evidence; our hypotheses, our criteria and our method are our own choice and responsibility. Elaborating his own version of the widely accepted hypothetical deductive method, Poincaré seeks to steer a middle course between what he considers to be extremes: the pure *a-posteriori*, as propagated by the positivistic empiricism of his own time, and the pure *a-priori*, as advocated by the transcendental criticism of Kant.

Contrary to the extremes he holds theories to be constructions, or artefacts. The whole enterprise of science is constructive, aiming at a reconstruction of the formal relations which inhere in nature; in this sense, science is also descriptive. Science never bothers about particular facts, its only concern being kinds of facts; what it describes is the order or structure of facts, not their essence or substance; disregarding substance and matter, natural science puts focus on order and form. Science seeks regularity in order to predict; only repeatable facts can be predicted; the only facts of relevance to science, therefore, are those which can be repeated; hence, the first step towards science is a preliminary classification of observables. Between the extremes, he also discusses and rejects the radical conventionalism - close to his own position - proposed by some contemporary adherents of idealism.

The object of the scientific method is the selection and treatment of facts. Scientific facts are merely common-sense facts expressed in the language of science, but the language of exact science is artificial: the formal language of mathematics. The final outcome of the process of scientific research is a scientific theory, and a scientific theory is a mathematical structure summarizing relations between facts. In his theory, the scientist expresses his knowledge of the harmony of the universe. Just as an artist selects those features of his model which perfect his picture of it, his refined sense for congruity induces him *a priori* to select precisely those facts which conform to his preconceived ideas and hypotheses of the cosmic harmony. But it is a gross misunderstanding to believe that a scientist creates his own facts; all that is manufactured in a fact is the formal language in which it is enunciated, and it never depends on the scientist whether his prediction of a fact is fulfilled. Therefore empirical reality remains the ultimate test of theoretical speculation.

Poincaré thereby assumes a balanced position - apparently quite traditional, but only apparently - equally far away from all excesses of nominalism or realism. It is customary to describe his position as 'conventionalism', although he did not use the term himself; but this brand of conventionalism is certainly very moderate; I agree with Giedymin that the term 'constructivism' may seem more appropriate. It is clear, in any case, that it presupposes an empirical basis amounting to the existence of a kind of observational 'invariant' beneath all theoretical conventions. Invariant reality can be known up to the structural isomorphism of rival theories. Changes mostly concern ontologies and metaphors, they seldom affect structures. This enables us to make steady progress towards objective knowledge of nature, but our knowledge remains limited in the sense that objective reality can consist in no more than what can be described by a structure of group transformations.

Both physics and geometry study invariants under transformational groups. Whereas geometry studies the properties of certain ideal spaces, physics studies the temporal changes of relations obtaining between objects described in ideal spaces. Now the passage of time is real, whereas 'space' is merely a word that is wrongly supposed to refer to a real thing or frame - real empty space simply does not exist, and what experience tells us is merely the relations holding between solid bodies. The structure of time & space is not forced upon us by nature, it is we who impose it on nature, although not by any *a priori* intuition, but because it is convenient. As regards space we have to distinguish between: a) solid bodies whose qualities are manifest to our senses; b) their quantitative relationships which are measurable relative to standards fixed by convention; c) the ideal spaces of geometry proper.

Geometry is nothing but the study of groups. It is based on assumptions, chosen with respect to their fruitfulness and appropriateness in our description of the phenomena of physics. As definitions, postulates, and rules of inference, these premisses lead to consequences derived by means of exact analysis (cf. Leibniz). Nevertheless, the inventiveness of mathematical construction depends on a kind of imaginative intuition, and this is our only guide to fertile synthesis (cf. Kant). Geometrical space is taken to be continuous by convention and, as a continuum has no intrinsic metric, the concept of metrical congruence depends on convention. On the whole, therefore, the assumptions of geometry are founded on convention; this proves their status to be neither empirical, nor synthetic, nor analytic.

Experiments teach us the relations of bodies to other bodies; but they tell us nothing about the relations between bodies and space, nor about the relations between different parts of space. According to Poincaré, the only relations existing in nature are the non-metrical relations of order which are expressible in topology. Having dismissed the Kantian position, that the geometry of space is derived by synthesis *a priori*, Poincaré upheld *a-priorism* as regards the foundation of analysis and did not interpret the axioms of arithmetic as implicit definitions of primitives. Thus he did not extend his geometrical conventionalism to arithmetics which he assumed to depend on strict intuition *a priori*, presupposing the whole numbers and the principle of mathematical induction; on the contrary, he claimed that the consistency of geometry should be evaluated relative to arithmetics.

From the point of view of Poincaré it seems natural to regard geometries as linguistic frameworks rather than as experimental conjectures; as such frameworks they cannot be put to test, but that does not imply that they are unchangeable. From the point of view of syntax a geometry is nothing but a formalized language; such formal languages may treat of very different objects - points, lines, planes - yet they may be identical in their structure, due to group theoretical isomorphism. The choice of a geometry to correlate experiential facts is an opportunistic affair: does it provide us with the best means to solve the central problems of physics? According to Poincaré, physical reality is knowable merely up to the observational equivalence of alternative theoretical systems and their structural isomorphisms. The question therefore is: can we avoid falsification of our physical ideas simply by constructing a new language which is formally translatable to the old one?

According to Giedymin, Poincaré subscribed to a generalized version of the so-called Duhem-Quine thesis: Falsification is possible only with respect to systems of hypotheses expressed in a fixed language. Instead of blaming one or more of our hypotheses in face of contrary evidence, we may blame the experimental evidence, or we may avoid falsification by changing our language. The language of science is not fixed forever, but may be changed in response to experiment and observation. Changing the lexicon is merely a subterfuge tending to conceal the real problems. Changing the syntax of the language of science goes much deeper. It is not fruitful, however, to change our language merely in order to avoid falsification; sometimes we have to accept facts as final - if we do not, we condemn science to barrenness. But on the whole, the language of science is based on conventional decision.

Poincaré also extended conventionalism to his analysis of the measurement of time, and of the principles of physics; this is the reason for applying the term 'conventionalism' to his epistemology as well as to his whole philosophy of science. According to Poincaré, geometrical space is invented to ensure consistency in our reasonings about solids and their relations; spatial positions are not real properties of bodies, and bodies do not exist in real space, we merely reason as if they did. And he added: temporal dates are not real properties of what happens to bodies, but signifies merely the sum total of relations between events associated to bodies. He further exposed the simultaneity of instants and the congruence of durations to a trenchant analysis: distant simultaneity, e.g., is neither a datum of observation nor a consequence of the temporal continuum - it simply depends on convention. His conclusion was that the metrics of time and space are equally amorphous.

Since the enunciation of physical laws varies with the conventions adopted, and since alternative conventions modifies even the natural relations of these laws, it may be doubted whether there are among these laws any that can play the rôle of a universal invariant which is completely independent of linguistic conventions. However, if we introduce only fictitious beings having senses analogous to ours and admitting the principles of our logic, it appears to be a plausible conclusion that their language, however different from ours, will always be capable of translation. But the very possibility of translation implies the existence of something invariant; to translate between two different languages is precisely to disclose this invariant. The invariant laws, then, are those relating the ordinary facts, while the relations between scientific facts remain always dependent on certain conventions.

Poincaré distinguishes between three kinds of hypotheses: formal principles, inductive generalisations, and realistic interpretations. A formal principle is always a convention; as such it is *a priori* in a relative sense, its status being reminiscent to that of a real definition in the sense of Leibniz. An inductive generalization can be regarded as an empirical law, hence subject to permanent revision, but may at a later stage be promoted to the status of principle; such a law expresses a relation between two terms, a conceptual and a factual. If a law is elevated to the status of a principle, a third term is introduced to mediate between the first two, whereby the first relation is split up into two other relations: a theoretical one between two conceptual terms, and an empirical one between a conceptual and a factual term. A realistic interpretation of the terms is neutral, if it does not affect the formal relations between the terms, although the terms themselves be changed: the same geometry may result, whether we begin with points, or lines, or planes.

The physics of our own time is the physics of the principles, said Poincaré. Thus any law can be broken up into an *a priori* principle and an *a posteriori* law, and in this way the number of scientific principles has increased and still increases, while a conceptual structure is taking form in relative independence to experience; But however far the partition be pushed, there will always remain laws which need to be tested by experience; if not, science as we know it will be brought to an end. Of course, we cannot satisfy all possible principles simultaneously, in face of the experimental evidence, and if a principle ceases to be fertile, experiment will have condemned it without contradicting it directly; it is useless to heap up hypotheses. The obvious reason is that if a principle is wholly exempt from being contradicted by experience, it ceases to be informative: we can infer nothing from it.

In contemporary physics, empirical generalizations are still being upgraded to theoretical conventions. From an epistemological point of view, the difference between geometry and physics is that, while all the principles of geometry are conventional, only some of the principles of physics are. But the rôle of principles in science appears to be growing, whereas our ability to obtain experimental results that can discriminate between theories seems to be diminishing. It is interesting to compare this view of Poincaré to the well-known position of Niels Bohr, that the description of the experimental apparatus must always be given in classical terms, even in quantum physics. Although the exact cut between object and subject, or between reality and apparatus, is made by arbitrary decision, a cut must be made. In contrast to Bohr, Poincaré seems open to a revision of classical physics.

As regards the contribution of Poincaré to Special Relativity, my own view conforms to the assessment of Keswani[11]: Poincaré indeed had the whole theory, and he had it before Einstein, the only important difference being one of emphasis. The fundamental problem, posed by Poincaré, was this: Will not the principle of relativity, as conceived by Lorentz, impose upon us an entirely new conception of time and space, thereby forcing us to relinquish our most cherished conclusions? But how could he later describe the principle of relativity as being unfalsifiable, and yet consider to give it up in face of apparently negative experimental results? There is a simple answer to this question: he did not want to heap up hypotheses! But he never accepted that SR could force him to renounce his conventionalism: even space-time is conventional, and nothing like a real framework, or real entity. As a continuum, space-time has no natural metric, i.e., it is amorphous.

Poincaré was well acquainted with the work of Einstein, but did not credit him for the invention of SR. After emphasizing that the simultaneity of two events as well as the equality of two durations should be so defined that the natural laws may be as simple as possible, he credited Lorentz for having saved relativity by means of his ingenious idea of local time. Lorentz later, paying tribute to Poincaré for his great contributions to physics, praised him for having stated the relativistic transformations in their most convenient form, ahead of Einstein and Minkowski. Lorentz had claimed that the forces of physics should be defined in a way which would make them invariant to his transformations. Poincaré, accepting this claim, tried to modify Newton's law of gravitation and ended up with a Lorentz-invariant action-at-a-distance theory. In the opinion of North[21]: had the general sympathy not been so decisively in favour of a field theory of gravitation, Poincaré's memoirs might well have become a turning point in the history of the subject.

It has been pointed out by Stump[32] that the burden of conventionalism is to explain the conventionality of the basic principles of science in a relationist way without relying on any arguments of underdetermination; in order to be consistent conventionalism must explain the relational origin of both gravitation and inertia. In fact, Poincaré believed acceleration to depend merely on the external relations between bodies; velocity and acceleration being on a par, both has to be relative. As he felt obliged to find a solution in terms of bodies and forces acting upon them he did not consider the possibility of reducing gravitation to space-time structure. But, according to Stump, acceleration cannot be relativized without introducing universal forces, and the Einstein space-time theory of gravitation seems to have effectively disproven the possibility of a pure relationist framework.

Now Roxburgh & Tavakol[30] have written an important paper disclosing some hidden affinities between the gravitational theories of Poincaré and Milne. They see the great value of Poincaré's action-at-a-distance theory in the fact that it has led to the discovery of a whole family of consistent theories which cannot be geometrized in a Riemannian manifold, but only in the more complex framework constructed by Finsler. The cosmological solutions for these theories can be derived by means of a generalized version of the kinematic technique invented by Milne. Whittaker[42] has issued a warning which it is tempting to quote in this context: 'It may be unwise to accept a theory hastily on the ground of agreement between its predictions and the results of observation in a limited number of instances'.

ARTHUR STANLEY EDDINGTON (1882-1944)

'We do not accept the Kantian label - but, as a matter of acknowledgement, it is right to say that Kant anticipated to a remarkable extent the ideas to which we are now being impelled by the modern development of physics.' Eddington[5]

The scientific career of Eddington was very special: he took several degrees; he was appointed Plumian professor of astronomy at Cambridge when he was 31; he made great contributions to astrophysics for which he was deservedly famous; and he wrote a lot of books, scientific and popular, which were much acclaimed. At his height he enjoyed a public authority almost second to none; but the style of his books, though exceedingly well written, was also provocative and earned him much opposition; he exposed himself and became a favourite target of criticism for positivist philosophers armed with heavy irony, but with scant sense of humour. What aroused the hostile feelings of many of his scientific colleagues was his insistence on the possibility of mapping the structure of the universe *a priori*.

Whittaker[43] credits Eddington with the following principle: It is possible to calculate the exact values of all pure numbers, summarizing timeless relations between the basic constants of nature, by a *a priori* mathematical deduction from epistemological principles. By scientific knowledge *a priori* Eddington understood knowledge prior to actual measurement, but not prior to exact specification of the operational procedures of measurement. He claimed to have expressed in symbols of mathematics what the physicist thinks he is doing when he is measuring things. Archimedes, by calculating π , the ratio of the area of a circle to its squared radius, assumed qualitative geometry in order to deduce quantitative geometry. Whittaker describes Eddington as a modern Archimedes: he allowed himself to use everything in physics except the numerical values of the constants of nature, which he claimed to deduce mathematically from epistemological principles in analogy to π .

According to Galileo, the aim of natural science is: 'to measure what can be measured and to make measurable what cannot yet be measured'. Science focusses on the quantitative aspect of nature by effecting a reduction of quality to quantity. To say that science is based on experiment and observation performed by means of apparatus is to say that it is based on counting and on the readings of pointers. Among pointer-readings, the primary readings give the intensities of the qualities to be measured, while the secondary readings give their location in time and space; the experimental setting or context is given by pointer-readings of a tertiary order. Pointer-readings, marking the coincidence of events in space-time and referring to intersections between world-lines, are quantities produced by our own operations. Thus lengths and durations are not properties that inhere in the external world: they are the relations of things in the external world to a particular observer.

All variety in the world, all that is observable, stems from the diversity of relations between entities; therefore, when we consider the intrinsic nature of the entities related, nothing is left but sameness; there is nothing in the external world which can force us to split it up in identical units, but this is our way of thinking. Eddington's theory implies that there exists only one kind of fundamental particle, of which all the rich variety of elementary particles is a manifestation in disguise.

Now it is possible for a group of sensations in a mind to have the same structure as a group of sensations in another mind. It is also possible for groups of entities to display the same structure though their true nature be unknown to us and they be connected by relations unknown to us. So we can obtain structural knowledge of 'things outside ourselves'. The recognition that all physical knowledge is structural makes obsolete the dualism of consciousness and matter, Eddington claims.

A number of experimental observations in physics can be termed structural; it is the aim of Eddington is to construct their theory, and the important result of such a theory is an extensive unification between the different branches of physics. Eddington does not search for new laws, he wants to explain those already known, and it is the invariance under different circumstances of elementary particles with few attributes that provides him with the ultimate numerical standards of nature. The pure numbers of nature arise as ratios of the numbers of dimensions of certain phase spaces and the task is to calculate the numbers of dimensions of such spaces. To solve this task Eddington invented his famous calculus of *E*-numbers, which is a generalized version of the even more famous Hamiltonian algebra of quaternions. Now Hamilton originally interpreted his quaternion algebra in Kantian terms as a 'science of pure time'. According to Kant, arithmetic maps the structure of our intuition of time, whereas geometry maps the structure of our intuition of space. Eddington, by analogy, viewed *E*-algebra as 'the science of space-time'.

According to Yolton[44] the modern edifice of natural science has developed so far that most of the relevant data in many fields have already been collected; the remaining task is to unify them and to formulate them in a deductive system. When new data emerge, it is sometimes found that another system is required; however, temporary set-backs cannot block the general trend towards unification. So detailed laws governing the quantitative results of observation are inferable solely from our operational specification of the relevant observational procedures, and fundamental hypotheses can often be replaced by epistemological principles. What cannot be foreseen are those facts which distinguish the actual universe from other possible universes obeying the same laws; they are not given once and for all, but are being born continually; hence the actual course of events is unpredictable. Yolton opines that Eddington has made no 'real' *a priori* deduction: the codes of empirical science are not violated by putting focus on its theoretical aspects.

Eddington has had quite a number of important followers joining his search for a deductive explanation of the strange numerical coincidences of the universe: Paul Dirac, Pascual Jordan, Erwin Schrödinger, Hermann Bondi, Peter Landsberg. A small society, *ANPA*, standing for *Alternative Natural Philosophy Association*, has been formed by scientists devoted to the quest for explaining these numbers, and Eddington has recently been conferred a posthumous honorary membership. Ted Bastin & Clive Kilmister, prominent members of *ANPA*, have written a series of papers on Eddington's *Fundamental Theory*, which has since been rounded off by the monograph of Kilmister & Tupper[11] on *Eddington's Statistical Theory*. Assuming the quantitative aspects of the universe to be finite and discrete in a fundamental sense, David McGoveran of *ANPA* has recently used binary algebra and computer theory to improve the combinatorial hierarchy of F. Parker-Rhodes, now accepted as the common ground and point of departure for further research.

EDWARD ARTHUR MILNE (1896-1950)

'The so-called principle of induction .. has no content ... It is a piece of outmoded furniture, and in fundamental investigations it had better be scrapped.'

'There is no entity "physical space"; there is only the abstract space chosen by the physicist as a structure in which to plot phenomena; and some choices give simpler theorems than others (thus making the laws of nature look simpler).'

'The essence of scientific freedom is the right to come to conclusions which differ from those of the majority.' Milne [20]

As a scientist Milne never attained the fame or prominence of Eddington, nor did he become victim of so bitter and fierce an opposition; but that in itself does not make him less interesting, nor less important. His feat as a cosmologist was to construct an exceedingly simple model of the universe implying the uniform expansion, in accordance with a cosmological principle demanding a specific type of cosmic symmetry, of a primary substratum of so-called fundamental particles; he further showed that the superposition of a secondary set of arbitrarily moving accidental particles on this substratum must give rise to spontaneous accelerations. In this way he fulfilled the relationalist programme of Poincaré.

The main idea of Milne is that the laws of nature can be deduced rationally, starting from an individual observer's awareness of a temporal sequence of events and his tempo-spatial coordinates as defined by means of radar-signals and clocks. His central hypothesis, that the laws of nature are akin to geometrical theorems, places him nearly on line with Eddington; but Milne did not depend on Eddington. His claim, that it is possible to deduce the inverse square law of gravitation, together with the sign of gravitation, *a priori* from some very simple premisses that effectively reduce gravitation to inertia, sounds shocking to most scientists. What arguments did he adduce in support of this startling point of view?

At the dawn of history, the theorems of geometry were considered to be principles of nature; all we know of Egyptian mathematics, at least, is consistent with the view that the Egyptians regarded such regularities as those summed up in the Pythagorean proposition as laws of nature. These regularities were discovered by drawing up different triangles, measuring them, and experimenting with them; as observational laws they were nothing but brute facts. The Greeks, by deducing these laws from combinations of simpler statements, postulates, or axioms, later turned geometry into an exact science wherein everything depends on pure theory. They thereby showed the possibility of eliminating brute fact from science.

In modern presentations of geometry, the axioms are neither brute facts nor statements which may be true or false; instead they are definitions, i.e., minimal descriptions of what we are talking about; they delimit the subject of investigation. The theorems which are derived from the axioms are valid precisely if the process of inference contains no flaw; their truth, then, does not depend on verification. The tendency of all exact sciences is to pass from the Egyptian inductive phase to the Greek deductive phase; the only question is how far this can be carried out. The extent to which the process can be carried out is simultaneously our measure of the degree to which we can regard the universe as rational, says Milne.

The laws of geometry are derivable by pure deduction; this is evident to all. Why not assume that the laws of dynamics are also derivable by pure deduction? Whether strict deduction is possible is a question that cannot be decided *a priori*; one cannot begin by stating a programme of this kind, and then just carry it out, it derives from the *a posteriori* experience of pushing deduction as far as possible. When we introduce fully operational definitions, a just-sufficient description of the relations obtaining between real entities is provided; further appeal to brute fact is unnecessary because our principles cannot be verified by induction, but experience is needed to test whether a specific model of the universe is realized in nature.

Together with McCrea, Milne undertook to revive the classical cosmology of Newton in a climate completely dominated by the ideas of Einstein, cf. North [21]; how far this development can be taken has been shown by Landsberg & Evans [14]. More interesting to our discussion, however, are the brilliant attempts of Walker and of Schutz to transform the kinematics of SR into an exact deductive science. Their investigations have in a convincing way disclosed the unique significance of the method of radar-signalling to enlighten problems of modern relativity theory; but to achieve the same for dynamics as for kinematics is a great step, indeed.

Further, it is a question whether the results obtained by Walker and Schutz have benefitted sufficiently from the ingenious conventionalistic ideas of Poincaré. What they have obtained is a mapping of the topology of current relativity theory - what remains to be done is to expose the conventionality inherent in the metric. This reflects, for instance, on the standard definition of simultaneity at a distance: personally, I believe that Poincaré would have welcomed an attempt to show that Einstein's dissolution of distant simultaneity is not an inevitable consequence of topology, but depends on his conventional choice of space-time metric.

Milne's technique of radar-signalling has been further developed and refined by Whitrow [41] and Walker [36-39] as well as Törnebohm [33-35] and Schutz [31]. A popular version of the same method is found in the so-called *k*-calculus of Bondi. Lucas [15], referring to Whitrow & Milne, approves 'their transcendental derivation of the Lorentz transformations' as probably the best of all possible ways in which co-existing 'bewindowed' Leibnizian monads could re-establish their lost harmony. According to North [21] the independent derivations, by Robertson and by Walker, of the so-called RW-metric are based on assumptions inspired by Milne.

In cosmology, we push the deductive aspect as far as possible. Now it seems as if Milne was able to make his mathematics yield more than he had put into it: his output appears to exceed his input. If this is right, then it is no longer true that only synthetic propositions contain new knowledge; analytic propositions may also do that when they add to their premisses the leaven of the deductive process. If we assume that the universe is rational, it need not be in vain to hope that the constants of nature can be deduced *a priori*, as contended by Eddington.

The hard-baked, or hard-boiled, scientist will traditionally hold that science and religion, whilst on nodding terms, have no immediate bearing on one another. On the contrary, Milne says one cannot study cosmology unless one has a 'religious attitude' to the universe. Cosmology presupposes the rationality of the world, but it can give no reason for it except the creator of nature being a Rational Creator. To Milne, the Creation of our universe remains the ultimate irrationality. -

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The Radar Technique as a Theoretical Device:

*Its Application to the Frame Problem of
Relativity Theory & Relativistic Cosmology*

Mogens Wegener
Højmarkvej 1, 8270 Højbjerg,
Danmark

SUMMARY

*This paper is dedicated to the honour of Ths. E. Phipps.
Prokhovnik mentions three different approaches to relativity.
Focussing on the second approach the paper exposes some of the
philosophical perspectives latent in the technique of radar-signalling.
Beginning with Milne's 'Kinematic Relativity', it further discusses the
axiomatizations of Whitrow, of Walker, of Schutz and of Törnebohm.
Alternatives to axioms distinctive of Special Relativity are proposed
in order to open up for a new theory based on absolute time.*

The subject of this paper invites to technicalities. Being firmly resolved to refrain from indulging in formal exercises, I have decided to offer a purely verbal presentation in the hope of making a better appeal to the intuition of my reader. What I intend is to give a short discussion of some problems relating to my topic and to sketch some new ideas suggesting the possibility of a classical alternative to Special Relativity (*SR*), ideas that may inspire the axiomatization of a new theory. My point of departure I shall take in a fine book of the late prof. S. Prokhovnik: *The Logic of Special Relativity* (Cambr. 1967), thereby exploiting the opportunity to honour the memory of this brilliant physicist and theoretician.

As is well known, Prokhovnik distinguished between three apparently very different approaches to relativity theory and cosmology; namely:

- 1) *The Logic of Space-Time*, which is the *orthodox* or *geometric* approach.
- 2) *The Logic of Relative Motion*, i.e. the *photon-theoretic* or *kinematic* approach.
- 3) *The Logic of Absolute Motion*, i.e. the *aether-theoretic* or *dynamic* approach.

Of these approaches, the first was defended by Poincaré, Einstein, Minkowski, Robertson and Weyl, the second by Poincaré, Milne, Whitrow, Walker, Schutz and Törnebohm, and the third finally by Poincaré, Lorentz, Ives, Builder and Duffy. Prokhovnik attempted unify the various approaches within a coherent synthesis. In the opinion of most contributors to the biennial *PIRT*-conferences, this bold project was successful, but it is important to realize that the success had a price: due to the aesthetic beauty of the synthesis, the particular issues characterizing the three different approaches inevitably became somewhat blurred.

I deliberately mentioned Poincaré, the great mathematician and philosopher of science²⁰ and inventor of the Lorentz Equations as we know them today, as a representative of all three approaches. This vagueness is due to the great diversity of the interpretations of his theoretical achievements. However, there is evidence that his mathematical acumen in combination with his conventionalist philosophy made him sceptical towards the aether hypothesis. Further, I feel convinced that his reluctance to discard relativistic invariance as based on absolute simultaneity was well founded in his deep insights into the requirements of theoretical physics. For these reasons it is perhaps not altogether wrong to see Poincaré as the initiator and champion of the kinematic approach - that which I am going to investigate.

But I spoke of the price paid by Prokhovnik for establishing his synthesis. Prokhovnik found a significant limitation to be inherent in the so-called kinematic, or photon-theoretic, approach which is based on the symmetry of signal-functions. It had proven extremely difficult to extend the symmetry unambiguously to more than one spatial dimension. This short-coming Prokhovnik changed into a virtue by posing the existence of a universal reference frame. Kinematic symmetry would then obtain between fundamental observers situated at rest in the universal frame, whereas relations involving accidental observers moving at random in the frame would have to be asymmetric. The universal frame need not be stationary itself, but may expand or contract according to some general function of distance.

One cost of this ingenious synthesis is a blurring of the second approach. The idea of kinematic symmetry is prematurely taken to be invalid for accidental observers in order that it may appear reasonable to pose a universal frame of rest. If the existence of a universal reference frame is not merely fact-like, but law-like, there is obviously no point in searching for a general symmetry of signal-functions. Conversely, if we succeed in finding a general expression of kinematic symmetry then it seems that the universal rest-frame, as fixed e.g. by the cosmic background radiation, may be independent of the laws of nature, hence nothing but brute fact. The evidence for the existence of a universal substratum is indeed overwhelming, and I am not qualified to say that its significance does not point beyond mere fact; but to invoke the existence of an 'aether' is to go against 'the spirit of relativity'.

These remarks are intended as a reminder of the conclusion of Bergmann² who spoke more drastically of a veritable 'breakdown of the principle of relativity'. For my own, I am not against an aether-theory, although I prefer pure relativity; but if the relativity principle does not stand up to test, it will have to be rejected. However, as I have pointed out in an earlier paper: the proper transformations to be applied in the context of the hypothesis of an aether are, in my opinion, not the Lorentz transformations, but rather the less famous Voigt transformations¹⁹⁽¹⁹⁸⁸⁾. Something like a combination of both seems appropriate to a world-model uniting the stationary properties of a *steady state* universe with the no-horizon feature of a uniformly expanding *big bang* universe; this model solves the number problem by placing a potential infinity of objects within the limits of visibility¹⁹⁽¹⁹⁹⁴⁾.

But before we denounce the viability of pure relativistic invariance we shall have to probe more fully the possibilities latent in the idea of kinematic symmetry. To achieve this it may be expedient to consult Prokhovnik's discussion once more. It turns out that his whole argument depends on Einstein's two principles for *SR*:

- i. *The laws of nature are equally valid for all inertial frames of reference.*
- ii. *The velocity of light (i.e. in vacuo) is invariant for all inertial systems, being independent of the velocity of its source; more exactly, the measure of this velocity (of light) is a constant, c , for all observers.*

- But Prokhovnik adds a third assumption, assuming it to be consistent with i & ii:

- iii. *The time taken by a light-signal to travel, in vacuo, between two points A and B (in relative motion or not) is related in some consistent fashion to the distance between its source and destination; and this relation is the same whether the path is from A to B or vice versa.*

My obligation to truth as well as my predilection for clarity forces me to censure these formulations. As they derive from Einstein himself my only discord with Prokhovnik is that he, just like so many others, has echoed them uncritically. My first objection concerns the concept of a reference frame. That the pre-existence of such frames is taken for granted is metaphysics and, indeed, bad metaphysics. Frames of reference, whatever they are, ought not to be assumed without question; in so far as they are needed at all they should rather be constructed from scratch. It is often said that the procedure of Poincaré is that of a mathematician whereas the procedure of Einstein is that of a physicist. How far the procedure of Einstein is from standard physical practice can be fathomed when the concept of a reference frame is reflected upon. Normally a frame is imagined as an infinite and infinitely dense grid centered at the observer and being built up of rigid rods without width with an infinity of infinitesimal clocks placed at relative rest in all points of space. What a phantasm! Yet Einstein would even make us believe that we can abstract from the inevitable interference of different grids in relative motion! What a chaos! Nay, let us get rid of this vicious and detrimental illusion as soon as possible.

This we can do by following the lead of Poincaré, who stated his version of the *relativity principle* by talking of *inertial observers* rather than *inertial frames*. What a simple solution! And how much more relevant to the practicing physicist! But the abstract reason behind this move towards concreteness is no less ingenious: Poincaré, before Einstein and anybody else, realized the rigid rod to be redundant. Our use of rigid rods to measure distances in space is superfluous when we define spatial distance as *light-time distance*. This involves an exchange of *radar-signals*. Light-time distance is, as the words disclose, the product of the velocity of light - assumed to be a universal constant - with the temporal interval, as counted by the standard clock of the observer, between the instants of emission and reception of a radar-signal which is reflected instantaneously from the distant object considered. It should be noticed that, although the concept of light-time distance is dependent on the universal invariance of the two-way velocity of light, it has no implications whatsoever as regards the one-way light-velocity, and especially not concerning the supposed independence of this velocity of the motion of the source, cf. ii.

But let us proceed with our criticism. Granted that there *are* laws of nature: Why take them to be equally valid for all 'reference frames'? Does 'equally valid' mean 'invariant' in the strict sense, or merely 'covariant'? Presumably 'covariant', if we have to conclude from a prior acceptance of the integral Lorentz Equations. But then the question is: Why accept the Lorentz Equations *a priori*? The obvious answer is that the Lorentz Equations are not accepted *a priori*, but *a posteriori*.

The Lorentz Equations are forced upon us by experience, we are unanimously told. Well, let us see if they are. At least it should be evident that although the Lorentz Equations can be derived from the above principles i&ii of Einstein, there is no clear implication the other way round: we cannot derive the principles i&ii from the Lorentz Equations without imposing any further constraints of interpretation. In fact, if we change the principles i&ii into the principles I&II below, excluding all further assumptions which are not derivable from those principles, they are still compatible with the Lorentz Equations, i.e. when stated in their differential form:

I. The laws of nature are invariant for all inertial observers so that it is impossible to distinguish motion from rest by purely formal means, the predicate 'inertial' being interpreted in a way excluding the influence of external forces.

II. The signal-functions describing the exchange, in vacuo, of photons among inertial observers allow the one-way velocity of light to vary in agreement with the absolute simultaneity of universal time, its two-way velocity remaining constant.

Now let us start again from scratch. The aim of physics as an exact science is to give a mathematical description of the laws of nature thereby enabling us to make reliable predictions based on solid experience. Although the laws of nature in their purest form are taken to be timeless invariants, the very distinction between experience and prediction presupposes the absolute separation of past from future, just as much as all hope of scientific progress presupposes an absolute flow of time. I shall therefore insist that if science is to fulfil its goal it cannot evade the duty of giving an account of nature that is consistent with our experience of time-in-flux. The hard-boiled scientist will reply that the time of physics is what we measure at our standard clocks, further that the metaphor of 'the river of time' is nothing but a commonsense cover of blatant nonsense. To which I shall retort firstly, that time is fundamental to physics in the sense of being the one and only truly independent parameter of its mathematical equations; secondly, that a clock is an instrument of counting, not of measuring; and thirdly, that modern tense logic is able to convey a very strict rational sense to the supposedly vague metaphor just mentioned.

But let us take a step further. Another way of stating the task of physics is to say that it should provide us with an adequate mapping of the structure of the universe in which we participate. This job is fulfilled when it has presented us with an abstract structural model imitating the most general properties of the universe. In this sense physics is the lofty art of depicting the world in the form of a model, and the ultimate goal of physics is to become *cosmology*, a theory of 'everything'. The noble craft of constructing *world-models* finds a metaphysical paradigm in the philosophy of Leibniz which has inspired the most recent interpretation of modal logics with its 'possible worlds' semantics. According to Leibniz, any possible world constitutes its own *totality* of being or truth to the exclusion of all other totalities. What distinguishes one possible world from another is their logical incompatibility, and it is a thesis of logic, not of physics, that only one universe does in fact exist. Now God in his infinite wisdom - eternally prior to his temporal act of creation - considers an infinite set of possible worlds as existing virtually, or conceptually; from all this infinitude he chooses the only one to be created by his infinite power, and out of free spontaneity unforced by necessity, that is, out of infinite goodness, he evidently chooses the very best, which is that governed by the best laws.

What is problematic to modern standards here is not the invocation of God, but rather the unfounded hypostasis of an infinitude of 'virtually existing' worlds. Apart from this metaphysical garniture, however, Leibniz also had a logical point. Describing a possible world as a maximal consistent totality of propositional truth, he further defined the *possible* as that which is true of some possible world, and the *necessary* as that which is true of all possible worlds, whereas the *actual* of course is what is true of our own world which remains the only world in existence. Now this whole construction can be made relevant to science in the following way: A basic premiss of physics is that nature is in point of fact ruled by laws enabling us to distinguish two types of events: those which are *permitted*, i.e. possible, from those which are *forbidden*, i.e. impossible. Therefore the whole infinity of possible worlds can be divided into two subsets: a minor one obeying the *laws* known to be valid for the actual world, and a major one obeying other, perhaps unknown, laws. But which laws are in fact valid for the real world? If we knew already, further research would be superfluous, all experimental laboratories could be closed down. For this reason it is important for us to compare and evaluate different subsets of possible worlds, I mean: worlds governed by incompatible, yet very similar, laws. Only in that way can we make a rational decision as to which laws we can accept provisionally - they be Aristotelian, Newtonian, Einsteinian, or whatever else.

A world in which nothing happens is not a possible, i.e. consistent, world. Now what happens is called: *events*, and events take *place* in the course of *time*; therefore *time* is the fundamental feature of any possible, or conceivable, universe. Is it possible to conceive of a world without *laws*, wholly devoid of all regularity? It does not seem so, as the consequence would be a total suspension of all identity: neither experience nor prediction would be possible as nothing could be recognized. What we call 'laws of nature' are regularities which are 'universal' and 'invariant'. The use of such expressions emphasizes the obligation of natural science to describe those features of the world which are common to the experience of rational beings. This obligation implies a commitment to treat all rational beings alike as if they were *equivalent* as *observers* to, or participants in, the great spectacle of nature. When it is interpreted in this context, the (restricted) *principle of relativity* can be understood as a postulate claiming all (inertial) observers to be in fact equivalent. The invariance of the laws of nature implies the relativistic equivalence of scientific observers, and conversely; and to assess whether relativistic equivalence obtains is therefore to judge how far the invariance goes, i.e. to see which laws are true laws. This means that the very concept of a science of nature necessarily presupposes the possibility of *communication*, by means of *standard signals*, between the observers. The reason why the *radar technique* is so fundamental is that it is the systematic application of communication theory to the task of solving problems of physics.

Although some inspiration may have come from Poincaré, or from Einstein, the signal method, or *radar technique*, was first applied systematically to problems of relativity theory and relativistic cosmology by E.A. Milne & G.J. Whitrow⁹, and the *kinematic theory of relativity (KR)* took form in the years between 1935 & -49. Based on an idea of Milne it was developed as a non-geometric alternative to *SR*. Minkowsky had stated that 'space by itself and time by itself' are doomed to fade away into mere shadows and only their union will preserve an independent reality.

This inspired Einstein's program: to reduce all of physics to 'space-like concepts'. Milne rejected the view that *space-time*, as the frame of nature, does really exist; against Einstein he denied, with Poincaré, the physical reality of geometrical space. In the same vein he did not accept the conceptual priority of frames of reference, but left it to the observers to construct them by means of clocks and radar signals. To this purpose he defined a *clock* as a means of associating events with numbers. A clock is basically not a measuring instrument but a device for counting time, the point being that there is no guarantee of the identity of our standard interval of temporal duration, by a repeated comparison, except our own conventional decree. The duration of a temporal interval clearly differs from the extension of a spatial interval, yet the two are comparable if we take light as our *tertium comparationis*. Nevertheless, it would not do to use a spatial standard to define the temporal one, as no experiment can be devised to control the rigidity of our standard rod.

Milne did not reckon the velocity of light to be an observational magnitude. Following Poincaré, he defined the velocity of light within a reference frame as the quotient between the unit of time and the unit of length characterizing that frame. Operationally, the length of a rod is measured by using a clock situated at the near end of the rod to estimate the delay, as reckoned in standard units of time, of a radar-signal of light reflected instantaneously from a mirror placed at the far end. This procedure is very precise, due to the precision of modern atomic clocks²²; today we can count time with an accuracy of one part in 10^{12} , or more, and this makes it feasible to determine the distance to a planet to within a few centimetres. It is thus reasonable to confirm the privileged status of time as the fundamental parameter of physics by accepting atomic clocks as representing the best possible approximation science can offer to the ideal of an all-comprehensive cosmic time. In 1967 the 'International Conference on Weights and Measures', giving authority to this view, defined the second as the duration of 9.192.631.770 periods of the radiation corresponding to the transition between the two hyper-fine levels of the ground state of the caesium-133 atom. At the same occasion explicit reference was made to the postulate that the velocity of light takes a universally constant value. As a consequence, the spatial unit can be defined in terms of the temporal one.

The bearing of all this is that the relativistic equivalence of observers is seen to have the following underpinning: 1) light from atoms of the same type normally show the same frequency under the same conditions, thus enabling us to construct clocks that are as good as identical; 2) radar-signals of reflected light appear to be delayed by the same amount over the same spatial distances as measured in *vacuo*. The fact that 1) is used to define a unit of time which is universally applicable by all inertial observers may be seen as a consequence of the relativity principle in exactly the same way as 2) is interpreted as a consequence of the light postulate. Current scientific practice, however, makes a strange difference in its treatment of these two pillars of modern physical science: Under the influence of Einstein and the established tradition of *SR* the relativity principle is interpreted as asserting the invariance with respect to inertial motion of the fundamental laws of nature. However, exception is made to one law, viz. that which rules the rates of clocks in relative motion, so that a vast majority of scientists is ready to accept the strange possibility, nay necessity, of relative motion being the cause of absolute effects.

Contrary to this loose interpretation the light principle is interpreted very strictly as claiming not only the constancy of the average two-way velocities of photons, but also the constancy of their one-way velocities, so that an individual photon is ascribed the same invariant velocity with regard to all inertial frames irrespective of their relative motions. But both interpretations are harshly counter-intuitive.

The famous french philosopher Bergson³, who tried to express the feeling that something may be seriously wrong with the standard version of *SR*, was made a fool of by the scientific community. The huge literature surrounding the so-called clock paradox of *SR'*, including the notorious correspondence in *Nature* initiated and perpetuated by Dingle, might have been received as another sign of warning, but nothing of that kind happened; on the contrary, the opposing fronts stiffened. This was the situation in which Milne intervened; firmly resolved to be unpolemic he criticized the standard version of *SR* indirectly by showing how the theory could be reconstructed kinematically by means of the *radar method* in a way completely obliterating all need for a geometrical solution based on the space-time hypothesis. His point of view was later supported by Walker who in a series of papers on the topic of relativistic mechanics⁵, *cf. refs.* showed how, in his opinion, all the problems that were attacked by the method of 4-space geometry could be solved simpler and in a more economical way by applying the classical method of 1-time and 3-space. Incidentally it was as a by-product of work inspired by Milne's *kinematic relativity* that Walker found the metric that was since named after Robertson and himself¹¹, and the *Robertson-Walker metric* is in fact derived from assumptions of symmetry that are akin to those which are embodied in the kinematic 'substratum' of Milne. Now I want to suggest that a study of the symmetry properties of this substratum might give us the key to a solution of our interpretational difficulties with *SR*.

Whereas *SR* involves the consideration of an infinite set of inertial frames in relative motion, *KR* by contrast introduces an all-embracing universal frame which leads forth to an important modification of the very concept of an inertial frame. Traditionally, the geometry of space-time is assumed to be a structure of so-called point-events, and a frame is then defined as a series of successive cuts in space-time perpendicular to the world-line of the observer constituting its spatial origo. This definition is very abstract and utterly remote from that of the physicist which involves an infinite set of stationary particles, or auxilliary co-observers, provided with slave-clocks adjusted to follow the master-clock of the observer in the origo. By contrast, Milne's substratum is a unique frame exposed to uniform expansion: defining a linear equivalence he then generalizes it to a spatial one, his ingenious idea being to put 'a little motion' into geometry in order to make kinematics of it. The linear equivalence can be imagined as a series of tiny pearls distributed evenly, with equal intervals, on an infinite and perfectly elastic string. Each pearl is an infinitesimal observer-particle or Leibnizian monad⁸, able to communicate with all other observer-particles, or monads, by means of signals involving the interchange of photons. The properties of the equivalence is completely defined in terms of the signals exchanged between its members, and the same even holds for the members themselves: a particle is defined as an unbroken series of observations, or events, the only difference between *SR* and *KR* being that, whereas the events of *SR* are freely hovering point-events, those of *KR* are object-events, or particle-events.

Identifying a particle with its own clock by assuming a bijection to connect the events forming the inner contents of the particle with the real number system, Milne raised two fundamental questions of time-keeping. Of these the first concerns the definition of clock-congruence, $A \equiv B$, i.e. what it means for two distant clocks to keep the same time, while the second concerns the condition of the transitivity of clock-congruence, $A \equiv B \ \& \ A \equiv C \Rightarrow B \equiv C$, i.e. how we can be sure that two clocks which both agree with the same third clock will also agree with each other. Together the two questions exhaust the important issue of clock synchronization. In order to solve these questions Milne assumed the set of all particles to constitute a universal structure composed of binary relations which represent the continued interplay of virtual signals cast forth and back between the observers involved. Mathematically, the properties of this structure of equivalent observers, particles, and clocks, find their expression in the corresponding properties of signal-functions. A signal-function connects the event of signal-emission at one particle to the event of signal-reception at another by expressing the number associated with the second event as a function of the number associated with the first event, or vice versa. Now, given epochs of emission and reception, read off by an observer at his own clock, of an unbroken series of radar-signals reflected instantaneously from another particle, the internal clock of that other observer-particle will be congruent with the first clock if, and only if, the epochs of reception constitute the same function of the epochs of reflection as the epochs of reflection do of the epochs of emission: hence the clocks will be congruent if the associated signal-functions be symmetric. Further, given that three observer-particles are permanently in line, as evidenced by their signal-relations, the commutativity of their associated signal-functions will be a sufficient condition for the congruence of their clocks to be transitive.

The linear equivalence, as defined by the symmetry and commutativity of the involved signal-functions, is readily generalized from 1-space to 3-space, and the substratum is simply the physical counterpart of this mathematical structure. Milne thought of the substratum as being realized by the system of galactic nuclei, and he evidently believed only a single, universal, and unique, substratum to exist; in this respect he anticipated the point of view so well elaborated by Prokhorovnik. The same assumption was implicit in the axioms for cosmology given by Walker¹⁷ who envisaged the universal structure in the likeness of a single expanding frame. From the symmetry of signal-functions Milne & Whitrow¹⁰ now proved that clocks of equivalent particles, in apparent conflict with *SR*, are congruent under arbitrary regradauations of their time-scales, corresponding to arbitrary expansion-functions, and that the concept of time-dilatation thus simply does not apply to such clocks! Making use of his own vocabular, Törnebohm later showed that an invariant scale of time and distance can be defined for not only what Milne called fundamental, i.e. equivalent, particles, but for accidental, i.e. non-equivalent, particles as well; he therefore proposed that the terms 'dilatation' and 'contraction' be abandoned¹⁶. His solution implies the convention that an accidental particle successively picks up the time of that fundamental particle with which it instantaneously coincides; this solution, based on assumptions regarding light-propagation equivalent to those of standard *SR*, defines the temporal coordinate no longer as the arithmetic, but as the geometric, mean of the advanced and retarded epochs of a reflected signal.

Although foreshadowed in the works of Milne and of Törnebohm, the first important extension of the concept of equivalence was apparently made by Schutz. In an axiomatic treatment of the foundations of *SR*¹⁵ he introduced the intuitively appealing term 'spray' to denote the idea of classes of equivalent observer-particles. So the difference between his presentation of *SR* and earlier treatments is that he did not assume the existence of only one privileged equivalence class of particles, but generalized the concept of an equivalence to comprise any class of observer-particles in inertial motion of which all the members coincide at the same instant. In this way all bonds between *SR* and the old aether hypothesis were finally cut off as it seems; but the imagery of frames of reference being retained, this appearance is a mere illusion - for when we associate a particle with a 'frame' of reference, what are we doing, if not feigning it to be surrounded by its own private aether? *In fact, reference frames are nothing but vestiges of ghostly aethers; but is not an honest aether to be preferred, rather than to change science into a haunted house?* My criticism is not directed against Schutz, but rather aims at all adherents of *SR*. *What I want to suggest is that the idea of a spray should replace that of a frame.* Now a spray is distinguished by properties identical to those of an equivalence. Therefore, if we have to consider the signal-relations between the members of a given spray and some particle not belonging to the spray, the natural way to do it is not to take over the assumptions concerning the transmission of light signals which happen to hold within frames consisting of particles at relative rest, but to generalize, if possible, those properties that pertain to relativistic sprays.

The alternative to *SR* which we are searching for - call it *AR*, standing for *Alternative Relativity*- must have some ground in common with the earlier theory. Suppose that the idea of spray is imported from *SR* into *AR* without alteration; then we dispose of a very simple *tertium comparationis* between the two theories. The two subsets of possible worlds - one governed by the laws of *SR*, and the other by the laws of *AR* - have something in common: a structure. Now it can be proved that this structure is exactly that captured by the differential Lorentz Equations! It seems easy to conclude from this - *ceteris paribus* - that there can be no real difference between the two sets of laws, everything now depending on how the Lorentz Equations are integrated: the whole difference is then one of convention. But if that were the case, the standard interpretation of *SR* would be ambiguous, as an invariant time and distance would then be definable for all inertial observers; however this is merely what Törnebohm since decades has claimed to be the fact. *Even then there is a possibility of real observational differences between SR & AR.* It cannot be demonstrated *a priori* that *SR* is inevitable in the sense that all future theories are nothing but different interpretations of the same experimental basis. What can be said, nevertheless, is that no possible experimental differences can influence what is directly demonstrable from the differential Lorentz Equations; this leaves the domain of optics to define the scope of freedom for the differences. *A natural assumption is that a difference between direct and indirect signals might show that the velocity of light - against SR - depends on the motion of its source.* This - as hinted at earlier - would further involve a conceptual difference between the one-way and the two-way velocities of photons. Still, the functional form of the difference might make it immune to the famous argument of de Sitter.

Obviously, the unacceptable feature of the traditional concept of a frame of reference is not the definition of light-time distance as half the difference between advanced time and retarded time concerning the reflection of a radar-signal from the distant object concerned; this definition connects the measure of distance with a temporal interval counted on a single clock, viz the master-clock of the observer. Nay, what makes the frame concept really pernicious is the associated fiction of an infinite and infinitely dense set of comoving clocks distributed spatially around the origo, each clock keeping a fixed distance in a fixed direction from the observer. But even this would be bearable if it were not assumed without further reflection that, for all the slave-clocks to keep pace with the master-clock in the origo, they would need to be adjusted to that clock by using the standard coordinate of time. The point to be considered is that, although the velocity of those light-signals that are required to correlate slave-clocks *within* a given frame to their master-clock is certainly constant as long as these clocks are relatively stationary, we have every reason to believe that the velocities of light-signals interchanged *between* observers belonging to different frames cannot remain constant due to their relative motion. As Prokhovnik admits: 'One of the thorny problems of *SR* .. is to imagine a mode of light-propagation such that its velocity is the same for *all* inertial observers'. But, say I, the unanimous assumption of the scientific establishment that a photon having the velocity $c_0 = 1$ relative to one frame must needs show the same velocity relative to all other frames is wholly irrational and deeply counter-intuitive.

It is a fact, that the perception of a single photon is an individual quantum event in which no more than a single observer can participate - so the ascription of a velocity to a photon relative to more than one observer appears wholly fictitious. *Indeed, the question is whether we should ascribe any velocity at all to light-quanta.* At least 'from the point of view of operations it is meaningless or trivial to ascribe physical reality to light in intermediate space, and light as a 'thing travelling' must be recognized to be a pure invention', as Bridgman once shrewdly remarked. But the relativistic community regrettably neglected his warning⁴: that scientists are obliged to discern real operations from those made with pencils on paper only. It is interesting to notice that Rømer - who was the first scientist to measure what was later called: '*the velocity of light*' - preferred to speak of: '*the delay of light*'. Reflected light is delayed, otherwise we could never send a signal and have it back. But what is the reason of assuming that the interval of the delay must be the same in both directions: to and fro, forth and back - i.e.: what is the reason of assuming that the instant of the reflection must be that implied by the standard definition? The only reason I can see is one drawn from a lazy imagination: the delay must be the same in both directions because a frame is imagined in analogy with an aether! Reichenbach¹⁴, Winnie²³, and some few others, did not eschew intellectual efforts - they acknowledged that the coordinate of the event of reflection can assume any value in the open interval between the advanced and retarded times of the signal. Still later Øhrstrøm²⁴ pointed out that the permitted interval may even be closed, so that the delay might be zero in one direction and total, or double, in the other. But it is left to myself to suggest that the necessity of a point-event involving the coincidence of particles in relative motion to possess a unique pair of advanced and retarded times relative to a given observer may stem from prejudice only.

In order to overcome the doubt, uncertainty, and perplexity, caused by the conventionality of simultaneity Whitrow²¹ has offered a series of axioms designed to corroborate and vindicate the definition of time coordinate issued by Einstein. By successive exploitation of these axioms he has succeeded in deriving a number of interesting coordinates of decreasing generality, the more specific instances being applicable to models of the universe distinguished by different expansion-functions. But it is rather confusing to see him subscribe to the idea of a 'big bang' origin of the world and at the same time to witness his attempt to vindicate the standard definition by requiring the time coordinate to be invariant to shifts of time-zero. Anyone, of course, has the liberty to choose the standard definitions for his own use, but the question is what this choice means to the interpretation of experiment; and if I am right in contending that there is a real difference between *SR* and *AR* manifesting itself as a decisive disparity between direct and indirect light-signals, then this is sufficient reason for us to question the validity of his axioms *VI & VII*. However, the alleged disparity does not concern the interchange of signals between members of the same equivalence, or spray, and this is what counts in cosmology. On the whole, therefore, his array of assumptions is more relevant to a comparison of different world models than to a solution of the problems of terrestrial physics. Anyway, his impressive battery of axioms does not count a whit against *AR*.

An argument of a different type, meant to support the standard definition and to destroy the conventionality of simultaneity, is that devised by Malament⁷. Formally impeccable, it presupposes the invariance of the temporal coordinate to a reversal of time. But, unfortunately, if a time reversal is to be effected in more than one frame at a time it also presupposes that kind of absolute simultaneity which the universal application of the standard coordinate apparently eliminates. The whole reasoning further seems question-begging in the sense that it seemingly amounts to no more than a trivial resolution to ignore the conventionality thesis. Finally, not only the standard coordinate of *SR*, but also the non-standard one of *AR*, is invariant to time-reversal; this is due to our symmetry of signal-functions. *In fact, the only effective way to attack the conventionality of simultaneity is to insist on a universal time and absolute simultaneity and to show that light-signals are delayed precisely so much as to make such a time and simultaneity definable.* The first, but decisive, step in this argument is to demonstrate that there is no reason at all for ascribing a fundamental significance to the standard *t*-coordinate. It is simply an unfounded prejudice that frame time is the proper one to apply to events occurring at a distance, whereas proper time cannot be applied at a distance due to lack of an operational definition: we can prove the opposite to be the case! Observers in relative motion who want to establish a meaningful interchange of observational results need in principle only one clock each plus a radar instrument. Now, to the purpose of synchronizing their clocks and calibrating their radars they can *not* use the standard coordinate for time at a distance, which is the *arithmetic* mean between the instants of emission and reception of the radar-signal, but *must* instead recur to the *geometric* mean, as convincingly demonstrated by Törnebohm. The same insight is expressed in the so-called *k-calculus* of Bondi, which is merely a simplified version of the refined algebra for signals invented by Milne & Whitrow. What, then, is the secret reason of introducing the standard definition at all?

The odious thing with SR is that it mixes up two types of synchronization: the first yielding a frame-external synchronization of equivalent master-clocks by taking the geometric mean of the epochs, and the second yielding a frame-internal synchronization of non-equivalent slave-clocks by applying the arithmetic mean. Small wonder then that SR, by confounding these two types of synchronization, to some takes the appearance of eliminating absolute simultaneity and universal time. But the relativization of frame time does not imply a relativization of proper time. As admitted above, we are free to use standard frame time if we insist to do so. However, if we do so, we should not imagine only a single stationary slave-clock in each point of space around the master-clock of the observer, but at least two clocks going at the same rate: one of them with a fixed zero of time, showing the relative standard time of the Lorentz Transformations, and the other with a fleeting zero of time, displaying the absolute standard time of the Galileo Transformations. What then is the difference between these two clocks? How can both be standard? First it should be realized that I refer to two standards, an old one and a new one, the difference between them precisely amounting to the relativistic standard delay. Secondly it must be understood that they are different because they count the time of different events: Whereas the Galilean slave-clock shows the standard coordinate (for its event of coincidence with the object, as estimated by the observer in origo) calculated by taking the arithmetic mean of the advanced and retarded epochs of an indirect signal, i.e. one reflected by a stationary mirror being fixed to the clock, the Lorentzian slave-clock shows the standard coordinate (for its coincidence with the object, as estimated by the observer) calculated by taking the arithmetic mean of the relevant epochs of a direct signal, i.e. one reflected by a comoving mirror being fixed to the moving object. Clearly, the arithmetic mean of two given epochs will differ from any other mean, in particular the systematic one proposed by AR, of the very same epochs; this explains the difference between t & τ when both refer to the two relevant epochs of the same direct signal. But this, of course, does not prevent the possibility of a numerical identity between the coordinates $\bar{t}$ & τ , where τ is the systematic mean taken of the relevant epochs of a direct signal, as above, whereas $\bar{t}$ is the arithmetic mean taken of the relevant epochs of an indirect signal. Thus we can readily accept $t - \tau = \Delta$, with t representing a Lorentzian coordinate (arithmetic mean corresponding to direct signal), and yet insist on $\bar{t} = \tau$, with $\bar{t}$ representing a Galilean coordinate (arithmetic mean referring to indirect signal). The holy dogma of SR that it makes no difference to the advanced and retarded epochs of a signal-event whether the light be reflected from a stationary mirror or from a mirror in motion, is thereby exploded. What difference, then, does it make? Precisely that which guarantees an absolute simultaneity-to-definable!

Let me make my position clear: I certainly do not dispute the consistency of the Lorentz Equations - neither in their differential, nor in their integral form - but I do insist on changing their interpretation radically. It all hinges on the difference between direct and indirect signals: when this distinction is accepted it becomes evident that the Lorentz Equations can no longer be ascribed a privileged status excluding the Galileo Equations from consideration, but that they should rather be seen as complementary to the latter for the reason that they calculate the exact deviation of Lorentzian quasi time t from Galilean proper time τ .

Now I can hear the orthodox grumbling: 'What heavens is new in all this? Did not Ritz, at the turn of the century, propose qualitatively the same theory? But experiment has disproved his idea of a ballistic propagation of light long ago!' To this devastating criticism I shall reply as follows:

- 1) A photon is not a 'particle', but an individual quantum of energy.
- 2) Photons aiming at a receding object will catch up with it sooner or later, even if the receding object is accelerated to so-called 'super-luminal' velocities.
- 3) The observations of super-luminal jet-streams from galaxies¹², and recent radar-measurements of planetary distances¹⁸, are evidence in favour of *AR*.
- 4) My principle for the propagation of photons makes *AR* agree with the observations of binaries supposed to corroborate the standard light principle.
- 5) *AR* is fully compatible with the differential Lorentz Transformations, hence *AR* and *SR* agree concerning the experimental consequences of dynamics.
- 6) *AR* is almost indistinguishable from *SR* by experiment and observation, the only question of importance being that of direct versus indirect signals.
- 7) To refute *AR* it must be shown that photons are not delayed as predicted - that there is no difference of delay between direct and indirect signals.
- 8) For such a refutation to be decisive, the source motion must be inertial and the experiment must be performed *in vacuo* to avoid extinction⁶.
- 9) The use of invariant proper time is in itself compatible with *SR*.

A final remark: I admire the work of Tom Phipps very much and has been very inspired by the reading of his book as well as by our personal correspondence. Unfortunately, however, we have not yet succeeded in reaching a final agreement. Tom, in his reconstruction of relativity theory, accepts the meson decay data of the CERN-experiment as indubitable evidence of a retardation of clocks by motion. The differential of proper time is inexact, its integral on a closed curve is not zero, hence the possibility of obtaining a real invariance of proper time seems precluded. *But, in my view, the outcome of the CERN-experiment is irrelevant to kinematics: rather it should be seen as the clue to a temporal theory of dynamical phenomena.* According to this theory it is illusive to speak of clock-retardation as being 'caused' by motion, or gravitation, and a proper explanation must go the other way round: dynamical phenomena must be described as the effects of local breakings of cosmic symmetries 'caused' by the drifting of atomic frequencies from the cosmic rhythm! This presupposes that we can use *invariant proper time* as an absolute reference with respect to which it makes sense to speak of atomic clocks as being retarded.

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ALTERNATIVE MATHEMATICS PROJECT TWO: THE MOVIE

OR STRATORS: AN ANALYSIS FOR CHAOS?

Edward Grey

Crescent Cottage, Surrey Street, CROMER, Norfolk, NR27 9EZ, UK

This paper is concerned with a mathematical concept which is derived from a familiar everyday phenomenon. Many mathematical concepts are very abstract and it is difficult to see where the idea originated from but others are easily seen to have arisen from some obvious source. The cine-film has been around for most of this century and yet there is no mathematical model which corresponds to it in detail. Consider how such an entity might be constructed. Following the form that a film takes closely would give a set of mappings from points in a subset of a plane to itself. Each mapping would correspond to how a single frame of the film could be got from the first frame. A restriction to events which naturally follow one another is needed with this model. However the concept can be greatly extended by starting with a set of points in a space which has some dimension say 'N' which need not be two. Instead of a set of mappings of this sort a further generalisation is made by mapping a pair consisting of a point of the space together with a number to another point of the space for each point of the space.

The number which no longer need be a non-negative integer corresponds to 'time'. A further generalisation would be to replace the number by a finite set of numbers. If there are 'P' numbers in this set we will call the concept we have finally arrived at a non-uniform strator of spacial dimension 'N' and of temporal dimension 'P'.

If the time variables are taken to be real numbers and all the mappings are continuous and at least once-differentiable with

respect to both the space variables and the time variables then a further entity can be defined. This is the equivalent of a derivative of the strator with respect to its time variables. This entity will be called the flux of the strator. A new strator can be formed from two strators which have the same space and time dimensions. This will be called the merge of the two strators. It is obtained by summing the fluxes of the two strators and then finding what strator would correspond to this new flux. Another operation which corresponds to self-interaction can be defined for non-uniform strators.

In the above it is assumed that the points in the space have coordinates which can be represented as an ordered set of 'N' numbers. If a change is made to new coordinates then the fluxes of strators involved almost transform like tensors. In order for them to do so it is necessary for the fluxes to be independent of the time variables. Such a strator which has a flux that is time independent is called uniform. A uniform strator of temporal dimension '1' corresponds to an iteration of some mapping since the infinitesimal change from one frame to the next is always the same in this case. Since non-uniform strators can in most cases be represented by uniform strators by increasing the temporal dimension, the latter deserve special attention.

Aspects of the mathematics of uniform strators.

A uniform strator of spacial dimension '1' and temporal dimension '1' can be represented by $F(r;x)$. If this can be rewritten in the form $f(p(g(x)))$ where $p(x) = x + r$ and f is the inverse of g ; then given $s(x) = x + 1$ it is easy to see that this is $f(s(g(x)))$ iterated 'r' times. It is however extremely difficult to get an arbitrary uniform strator into the above convenient form. Let $u = F(1;x) = f(s(g(x)))$ as above; then the flux of this uniform strator is given by $1/(g'(u))$.

If we count this uniform strator as a function of 'x' say $G(x) = F(1;x)$ then the flux is denoted by $\nabla G(u)$. Finite difference methods can be used to evaluate the operator ∇ in certain cases.

Examples of the use of $\circ$ - are: $\circ$ - $(ax + b) = (\ln(a))(x + b/(a - 1))$ and $\circ$ - $P(x) = (\ln(n)).x.(\ln(x))$. Where $P(x)$ is the 'n' th power of 'x'.

A change of coordinates corresponds to an operation on $G(x)$ above and takes the form $HoGoK(x)$ (where $H(x)$ is the inverse of $K(x)$). Since $G(x) = f(s(g(x)))$ (where $f(x)$ is the inverse of $g(x)$ as above), $g(x)$ is changed to $goK(x)$. Therefore $\circ$ - $(HoGoK(x)) = 1/(d/dx(goK(x))) = 1/(K'(x).(g'oK(x))) = (H'oK(x))/(g'oK(x))$. It is seen that $\circ$ - $G(x)$ transforms under a change of coordinates like a tensor apart from the $K(x)$ argument.

Let the inverse of $\circ$ - be denoted by $\circ$ -. Example $\circ$ -($k(x) = x + b$) where $k(x) = b$ is a constant function and $\circ$ -($(ax) = \exp(a).x$). It can be seen that to obtain the value of $G(x)$ iterated 'r' times we need to find $\circ$ -(r)- $G(x)$ i.e. operate with $\circ$ - first then multiply by 'r' then operate with $\circ$ -. In this formula 'r' can take any value including irrational and complex values .

The merge operator is represented by an asterisk and is defined for two functions $F(x)$ and $G(x)$ by $F(x) * G(x) = \circ$ -($\circ$)- $F(x) + \circ$ - $G(x)$). This is a new type of composition of two functions which commutes. If F and G commute under composition then $F(x) * G(x) = FoG(x) = GoF(x)$. The operator '*' can be used to form series expansions of a particular function.

Let $u = F(x)$. It can be shown that if $\circ$ - $F(x) = Q(x)$ then $du/dx = Q(u)/Q(x)$. Let $z = \circ$ -(r)- $F(x)$ then $dz/dx = r\circ$ - $F(z)/r\circ$ - $F(x) = r.Q(z)/r.Q(x) = Q(z)/Q(x)$.

For functions $L(x), M(x)$ and $F(x)$ it is generally true that $LoF(x) + MoF(x) = (L + M)oF(x)$ provided that the domains and ranges of the functions involved are related correctly. It follows that $LoF(x)$ is some linear operator on $L(x)$. The exact form of this operator can be shown to be $\exp(\circ$ - $F(x).D)$ where D represents d/dx .

Many other aspects of strator theory are generalisations of the above results.

Part 3: Alternatives

**THE QUANTUM STATE OF THE VACUUM
AND ITS INTRUSION INTO ENERGY TECHNOLOGY**

Harold Aspden
Acres High, Hadrian Way, Chilworth,
Southampton SO16 7HZ, England

Abstract

The author discusses how his theory by which the vacuum is quantized by motion related to the Bohr magneton can give basis for a regenerative process by which the aether can shed energy to our material environment in defiance of accepted physical law.

Introduction

One of the topics which has preoccupied ANPA for several years is that fundamental question: 'What is it in Nature that determines the values of the universal dimensionless constants?'

Much of that effort has been spent on the combinatorial mathematics that has evolved from the pioneer work of Eddington which had its heyday when the reciprocal of the fine-structure constant had a value indiscernible from 137, which was recognized as a combination of $1 + 6^2 + 10^2$.

Eddington was greatly influenced by Einstein and the ideas that became prevalent about the geometry of multi-dimensional space-time and there was little on offer as an alternative for explaining how Nature does determine the value and the universal constancy of quantities such as α , where α^{-1} is $hc/2\pi e^2$ in the system of units in which the vacuum state has unit permittivity and permeability.

In the onward development of such theory the choice of route to follow depended upon whether one accepted the Einstein philosophy with its mathematical connections or whether one held to what seemed to have become the heresy of a belief in the aether as a real medium. The former route is that which has been pioneered within the ANPA forum, whereas the latter aether route is one which this author has been drawn into by circumstances in no way motivated by any desire to question relativistic principle.

On the contrary, this author has entered this field solely because his research, founded in technological investigations, has led, first, into an aspect of ferromagnetism that implies the need for an aether and, second, into a model of that aether which has structure of a kind which made it very easy to deduce a value for the fine-structure constant α .

It is not intended in this paper to go again over the ground leading to that discovery. It is all of published record and, as it stands on foundations which are not shared by Einstein's theory, it is a self-contained account that sits quietly on its own in what could be termed a 'leper colony' section of the scientific literature.

What this paper will discuss is the mounting evidence which is developing in support of this author's aether proposition, by reference to the emerging prospect of tapping into that sea of energy in the aether to extract useful pollution-free energy that will power the world as we enter the 21st century.

Cosmological Impact

It will be remembered that the aether was once seen as the medium that sustained electromagnetic wave propagation. It needed to be of a fluid nature to allow passage of planets through space and yet it had to have the properties of a solid. It was Sir George Gabriel Stokes (Trans. Camb. Phil. Soc. viii (1845), p. 287) who offered the answer:

".. such substances as pitch and shoemaker's wax, though so rigid as to be capable of elastic vibration, are yet sufficiently plastic to permit other bodies to pass slowly through them."

These words are quoted from Sir Edmund Whittaker's account in his 'History of Theories of Aether and Electricity' (Vol. I) page 128, where he also notes that Stokes had suggested:

".. that the aether may have a combination of qualities in an extreme degree, behaving like an elastic solid for vibrations so rapid as those of light, but yielding like a fluid to the much slower progressive motions of the planets."

This observation by reference to Stokes was echoed in Max Born's book 'Einstein's Theory of Relativity' (p. 117 of the Dover 1965 edition) by the words:

"Therefore, the ether may function for light as an elastic solid and yet give way completely to the motion of the planets."

We can, of course, now take note that today we know about fluid crystals, formed by exciting electric fields in the liquids used in the displays of pocket calculators. If the strength of a field can determine whether a medium is solid or fluid, surely that gives basis for thought concerning the revival of aether theory!

At least, in this writer's opinion, it seemed reasonable to develop on the theme that the vacuum medium, the aether, could crystallize into a lattice form and the following words were used in a paper in Physics Letters, 41A, 423 (1972) authored jointly by the author and Dr. D. M. Eagles:

"The lattice is sufficiently rigid to transport electromagnetic waves but the particles readily regroup to define new lattices and so avoid detection."

That paper had the title: 'Aether Theory and the Fine Structure Constant'. It showed how the lattice dimensions and its physical properties gave basis, within part per million precision, for the theoretical derivation of the fine structure constant.

Such an aether lattice has simple cubic form, 'has an affinity for matter and shares the Earth's motion'. It is a medium in which the lattice in motion with body Earth or within a comet or other astronomical body has kinetic energy but yet conveys no linear momentum. Its role in the creation of stars is to allow energy nucleated by that creation to promote translational motion of the star with no momentum reaction seated in the locality of that star. Indeed, one can estimate the virtual mass density of that aether lattice medium by equating the sun's kinetic energy of its motion through galactic space and the energy released by its

nucleation under gravity, as represented by its negative-valued gravitational self-potential.

Alternatively, one can rely on the theoretical derivation of that mass density provided in the above-referenced paper. That paper derives a ratio r/d as 0.3029, where the virtual lattice unit mass m is $(2r/3d)^2$ times the mass of the electron and d is the lattice spacing. The mass density of the lattice m/d^3 is then determined since r is given in the paper as $1.93 \cdot 10^{-11}$ cm, which is the half-radian proportion of Compton electron wavelength. The lattice mass density is found to be 143.7 gm/cc.

Now, where does this commentary lead? Well, this paper is being written on 23rd July 1994 in a week following a sequence of collisions of Shoemaker-Levy 9 with Jupiter. Those collisions allow astrophysicists to learn something about the lower atmosphere of Jupiter but, of more importance, it provides vital evidence of the role which the aether plays in bringing about additional anomalous energy release by the comet upon collision.

Comet Shoemaker-Levy 9, if having the mass density of ice, should have hit Jupiter with an impact energy some 145 times that predicted from observation of its size and speed. It would be as if the comet has a diameter some 5.25 times greater than that measured, that is a volume greater by a factor of 145. Yet there would be no impact momentum attributable to 99.3% of that energy such as could, for impact at the surface of a planet having a solid form, contribute to the formation of a crater, unless the heat concentration is so intense that the surface material is vaporized.

In this latter regard, it was noted at page 189 in the author's 1980 book 'Physics Unified' that aether energy was the cause of 'the vast destruction at Tunguska in 1908 when what appears to be a comet collided with the Earth and yet appeared to impart no momentum able to leave a crater.'

Recently, the author has issued his Energy Science Report No. 6 under the title 'Power from Space: Inertia and Gravitation' in which, on page 7, it is stated in connection with understanding gravity that:

"Our starting point is that there is a mass property throughout empty space and, for some reason, we cannot sense the linear momentum property. It is almost as if one is dealing with a perfectly incompressible fluid in which energy can be stored by motion but transfer to matter of a net linear momentum is impossible, though spin of a spherical body of the fluid can occur with energy storage and angular momentum.'

This latter Report was published in April 1994 when the author had no knowledge of the existence of Shoemaker-Levy 9 or the evolving opinions later expressed by Paul Weissman in the 14th July 1994 issue of 'Nature' that predicted the collision with Jupiter would be a 'Big Fizzle'. This prediction was based on the collective analysis of observational data which indicated an upper limit of about one mile as the size of the body of ice that constituted the comet.

In the event what happened defied what was predicted in 'Nature'. In the words reported in the U.K. newspaper 'The Times' on 20 July 1994:

"Yesterday fragment K (of Shoemaker-Levy 9) hit the solar system's biggest planet at about 11.20 British Summer Time with such force

that some observers believe it could have been more than six miles wide - more than five times the size predicted."

This author's aether theory, as summarized in data presented in that referenced 1972 Physics Letters paper, does, as indicated above, suggest that the impact energy would be that of an object some 5.25 times the size observed.

It is submitted therefore that the comet Shoemaker-Levy 9 collision provides important evidence supporting the author's theory, evidence which should encourage onward research based on the underlying technological implications implicit in the author's description of the aether and it is this that forms the subject now to be discussed.

The Bohr Magnetron Interaction

In the above summary account it was indicated that a radius r applied to the fundamental elementary constituent of the vacuum medium, this radius being a half-radian proportion of the Compton electron wavelength. This arises because that vacuum constituent is a unit e of electric charge which moves in an orbit of radius r at a speed $c/2$ so as to describe that orbit at the Compton electron frequency.

Now, of itself, this will not endow the aether with a magnetic condition, because, as stated in that Physics Letters paper, the lattice formed by the collective charge shares that motion as a Heisenberg jitter (Zitterbewegung) and is, in fact, the frame of reference for electromagnetism.

To set up a unit of magnetic moment in the aether itself one can imagine a disturbance attributable to a unitary charge e having a motion at radius r in a position diametrically opposite to a charge sharing the lattice motion. Such a disturbance would develop the magnetic moment set up by a charge e moving at speed c relative to the lattice in an orbit of radius $2r$ relative to that lattice. This implies a magnetic moment of $(e/c)(4\pi r^2)$ times the Compton electron frequency $m_e c^2/h$, which is $eh/4\pi m_e c$, the value of the Bohr magneton, given, as stated in the Physics Letters paper, that r is $h/4\pi m_e c$.

The Bohr magneton is, therefore, the natural quantum of electromagnetic action by which the aether as conceived by the author can communicate its influence energy-wise in interacting with atoms.

It is the magnetic moment of the relevant electron states producing ferromagnetism in iron that is regulated by that aether interaction and what this means is that if we can get the ferromagnetic action in an iron core to do work, that work will derive its power source from the aether.

Thus, whereas, the collision of comet Shoemaker-Levy 9 with Jupiter shows us that the energy of the linear motion of an aether lattice through space can be shed in such a cosmic event, so we can look to the underlying rhythm of the Heisenberg jitter motion, as the orbital gyrations of the aether lattice, to be a source of spin angular momentum energy supplied by the aether in quantifying the related spin magnetic moment.

This is the feature providing the quantum link between matter and aether which one can seek to exploit, whether by inducing bulk aether spin in rotating Faraday-disk-type machines or by solid-state techniques involving ferromagnetic cores excited in a special way.

Having spent so much effort over the years endeavouring to interest scientists in this lattice aether theory, the author, confronted with the indifference of the scientific community, has now resorted to the last-effort pursuit of new energy technology aimed at proving the theory by showing how that aether energy can be tapped.

To this end, and following the ANPA-1993 conference at which this author spoke about the creation and mutual transmutation of the hydrogen isotopes by energy shed by this aether, the author has engaged first on an experiment which proved that the aether could augment the energy stored in an air gap in a transformer core. Such research is relevant to the possible harnessing of aether energy by reluctance-type motors of special design.

In this, the author was guided by an experiment reported by Cambridge Professor E. B. Moullin at page 173 in the 1955 edition of his book 'The Principles of Electromagnetism' (Clarendon Press, Oxford).

Moullin's experiment shows that if the flux density set up by a.c. excitation in a core with an air gap is sustained at a constant magnitude, so the magnetizing current increases in less than linear proportion as the air gap increments in linear progression. This means that as the magnetomotive force increases to overcome the reluctance of the air gap, so the aether contributes its own magnetomotive force to assure that the magnetization driven through that gap from the core is sustained. In short, the field energy set up in that gap at flux maxima, which is the inductance energy of the system, is greater than the input energy supplied to the magnetizing coil.

Since I reported my own experimental findings confirming this, many researchers in USA have verified this observation by tests of their own and there is now much effort being devoted to building reluctance-type motors which seek to harness the aether energy that has become potentially available.

It is this that brings me now to a topic that was a spin-off from a coffee break discussion with Professor Clive Kilmister at that ANPA-1993 meeting.

The Potter Debate

At this point, it must be kept in mind that it is well known that a ferromagnet comprises domains all of which are polarized to saturation and this means that when a magnetizing field is applied those domains all readjust to carry the magnetic flux without needing any significant input of power. This is why the magnetic permeability can be so very high.

It is what happens when a stage in magnetization is reached where all the easy-axis reorientation of domain flux change has occurred that we need to address. That is the circumstance where onward magnetization obliges the intrinsic domain flux in adjacent domains to turn into one another. They are like individual solenoidal current sources, each in their own right, and they can bring to bear, in their collective interaction, magnetomotive field forces which augment those set up by the applied magnetizing current.

Imagine a secondary winding positioned on a transformer core limb separate from that occupied by the primary, with an intervening air gap to divert flux as well. This can set up a situation where the back-magnetomotive forces cannot distinguish between the forward action of the primary and the augmenting forces

set up by domain flux rotation. This is a likely recipe for a method of tapping that aether energy resource.

Now complicate the situation a little by supposing that we have a core subjected to the action of an adjacent permanent magnet and we have a solenoid wound around that core carrying current developing a field opposing that of the magnet. Will the resulting flux in a gap between that core and the magnet be affected by an aether energy contribution? Indeed, will such a system satisfy our understanding of energy conservation as confined to the material system or will there be non-conservation in this respect?

This was, in a sense, one of the questions in issue in what I have termed 'The Potter Debate'. Frank Potter is someone in the south of England who has, for several years, been pressing for answers to questions of this kind, involving Professor Kilmister in the theoretical issues that apply to that pursuit.

The ANPA-1993 meeting led to my involvement in seeking to answer the questions raised by Potter and I was interested because I faced a similar problem posed by reports concerning what is termed the 'Adams motor'.

New Zealander Robert Adams had, in late 1992/early 1993, published research findings showing that a magnetic reluctance motor having permanent magnet rotors interacting with salient soft-iron stator poles could operate with 'non-conventional' efficiency if solenoids on those stator poles were pulsed in opposition to the rotor magnets at times when the poles were separating from their in-register position. The magnets do the work to drive the motor and the power input merely suppresses the action of the magnets at times when they would otherwise drag the rotor in a reverse sense.

My calculations, which I have reported in detail elsewhere* in addressing the questions raised by Frank Potter, satisfied me that there is a case for believing that there could be truth in the Adams claims. In fact, at this time, we await the clear experimental confirmation that the machine proposed does over-perform in the sense that it suffers magneto-calorific cooling whilst delivering more mechanical power output than electrical power input. However, having embarked on the search for the truths of that situation I shall see my own experiments on that topic to a decisive conclusion.

The Philosophical Question

The non-conservation of energy is a theme that must be viewed with caution. The correct way of examining this subject is to begin by affirming that energy has to be conserved in any physical process and then noting that we must not exclude from the ambit of our deliberations the existence of that real aether medium.

Furthermore, we must not let ourselves be drawn into a misguided effort to save the second law of thermodynamics, should we insist on applying that law to a province of science that lies outside its jurisdiction.

* H. Aspden, 'Power from Magnetism: The Potter Debate', Energy Science Report No. 4, Sabberton Publications, P.O. Box 35, Southampton SO16 7RB, England.

That law concerns effects beset by temperature values expressed in Kelvin. There are energy exchange processes in Nature that are not functionally related to such a temperature.

An electric battery can discharge in running an electric motor without there being any need to invoke the second law of thermodynamics. Temperature as such is not involved.

Similarly, an electron conveying heat through a metal conductor subjected to the deflecting influence of a magnetic field can develop an EMF productive of electrical output power drawing on that heat, but here the governing temperature influence is represented as a gradient and there is no critical dependence on an absolute temperature value. Just as the Hall Effect uses a magnetic field to deflect electrical input power into a transverse electrical output without invoking the second law of thermodynamics, so that heat to electricity conversion of that deflected electron has no definitive end temperature at the point of conversion and so cannot be restrained by the second law of thermodynamics. Whatever energy is shed by that electron in building up the output EMF so the attendant cooling must occur and still allow the electron to aid cooling further by reabsorbing heat from the atoms in the metal to move on in the heat flow path and be diverted again and again.

If philosophical doctrines are brought to bear to deny the existence of the aether as a medium that participates in energy exchanges, in contravention with the ever-increasing entropy syndrome demanded by that second law of thermodynamics, so one should respond to that challenge. It blocks the route forward to tapping that aether energy and to recycling ambient energy, both of which are clearly possible, given that Nature, by its processes of particle creation, points the way forward.

In summary, therefore, the author contends that our environment, including the aether, is a system tending to preserve equilibrium but that it can be influenced to go either way, in shedding energy from aether to matter or in shedding energy from matter to aether. In a sense, this amounts to saying that Nature has a way of accepting increasing entropy conditions and recycling energy by creating matter as protons and electrons, but with appropriate intervention we can speed up that recycling process by peripheral activity spawned by magnetic and electric field perturbations.

To progress in such a quest one needs the guidance of a valid aether theory. This author has such a theory and it now remains to demonstrate the energy recovery processes that will confirm that theory. Shoemaker-Levy 9 affords a partial confirmation. Driving an engine on aether power would, no doubt, impact the scientific foundations of natural philosophy much as comet Shoemaker-Levy 9 has left its 'energy' impression on Jupiter.

PROCEEDINGS OF
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FROM QUANTUM REALITY TO THE CONSCIOUS BRAIN:
A NEW PERSPECTIVE

Emmanuel RANSFORD

FOREWORD

Ever since the inception of quantum physics in the mid Twenties, it is not too strong to say that our picture of the sub-atomic world became conspicuously askew, intuitively baffling and intellectually frustrating. Some seventy years on, and in spite of strenuous efforts, this picture is still beset by nitty-gritty conceptual difficulties and paradoxes. It is not clear any longer whether physical reality does make sense. Does it even exist at all?

In an endeavour to turn our image of the micro-world round, I shall look at it from a novel perspective. Arguably, a lot of our trouble stems from the current conventional view on the so-called 'measurement problem', as exemplified by the Copenhagen interpretation. My approach is first and foremost an attempt to think this measurement problem afresh. It hinges on a new insight regarding the so-called 'collapse' of quantum states. It will be presented in Part One (entitled: *"On the Ultimate Nature of Quantum Reality"*).

In Part Two (entitled: *"Towards Solving the Mind-Body Problem"*), I set out to put forward a rational, if unconventional, model of the conscious brain. This model - which rests on the so-called *im-im* hypothesis - can potentially be put to the test. It can be seen as a partial (yet *not necessary*) consequence of Part One, inasmuch as the *im-im* model is naturally rooted in the actual features of the sub-atomic world.

The two Parts are independent wholes: they can be read separately. They nevertheless share a (few) new words and expressions. I thought fitting to introduce them, to put a flag as it were on some specific concepts, without any risk of confusion. These neologisms are rather uncomplicated, and I hope that they will not put the reader off.

PART ONE:

ON THE ULTIMATE NATURE OF QUANTUM REALITY

I.1. THE SETTING

Virtually any of us knows that quantum mechanics deals with wave functions and more generally, with state vectors. In the language of the theory, they represent elementary particles and other quantum systems.

Quantum mechanics also deals with *observables*, which refer to properties that can be observed or measured on a quantum system, such as its position and velocity. Any observable is matched in the theory to a specific operator.

An *operator* is an abstract entity; it operates on a Hilbert vector space, it has eigenvalues and eigenvectors (or eigenstates). All this is widely known. It can easily be found in any didactic book on quantum theory, and needs not to be developed here.

For my own purpose, I shall highlight the few points hereafter:

a) Observables relate to such physical attributes as : position, energy, speed (or rather, momentum), polarisation, spin, angular momentum and the like. I shall henceforth put them in two separate categories, namely: the *H-observables* and the *N-observables*. The former observables relate to energy; whilst the latter relate to any other *nonenergetic* physical quality (such as position and momentum).

I likewise distinguish *H-operators* and *N-operators*. Quite simply, H-operators are Hamiltonians, whereas N-operators are the remainder (e.g. position operators).

b) Broadly speaking, a wave function can put on two guises, with respect to a given observable: it is either in a pure state, or it is in a mixed one. A quantum system is in a *pure state* regarding an observable *iff* (1) it occupies an eigenstate of the matching operator. (It has therefore a sharply defined value for this observable, this value being the apposite eigenvalue.)

Conversely, a system in a *mixed state* (oft called a *superposed state*) is a linear combination, or superposition, of such pure states. It has no clear-cut value for the observable concerned. In that sense a mixed state is rather ill-defined, or fuzzy.

In this paper, the distinction between *H-pure* and *H-mixed* states on the one hand, *N-pure* and *N-mixed* states on the other, is pivotal (these various states relate to the H-operators and N-operators, or observables, respectively).

The fact of being H-pure or H-mixed can be called the *H-status* of a state (hence this H-status is twofold: pure or mixed).

c) A quintessential quantum feature is "quantumhood". *Quantumhood* refers to the battle-tested utter impossibility to split or conversely, to mingle, state vectors in a haphazard way. For instance, it flatly rules out half-photons and proton-neutron hybrids or compounds; which cannot be found in actuality. (Quantumhood can also be labeled as the 'quantisation constraint'.)

d) Quantum theory allows for two - and only two - evolution laws; which are:

- The *wavelike movement*, or 'wavy motion' in short. It complies with the mathematical principle of least action.

- The *wave function* (or *state vector*) *collapse*. I find it convenient to also call it the *paralling*, or the *paral phase*. It is a sudden non-deterministic event, in sharp and unmistakable contrast with the smooth and tractable 'wavy' (i.e. least action) motion.

An exclusively 'wavy' evolution - from a given initial state to a given final state - is said to be *unitary*. Accordingly, these two end-states (that is, both initial and final) can be said to be *uni-equivalent*. It plainly means that there is a time-reversible unitary transformation which links them up mathematically (in the so-called 'Schrödinger picture', for the detail).

I.2. TWO USEFUL FINDINGS

Two simple results will prove of paramount importance in this paper. They are:

a) *All the uni-equivalent states of an isolated system share the same H-status.* It means that any free system in a H-pure (or conversely, in a H-mixed) state will remain such as long as its evolution is exclusively wavelike.

Let us briefly see how this can be proven. First we consider a free system, taken in a H-pure

(resp. H-mixed) state at a certain time. Then we show that it is contradictory to assume that there exists a H-mixed (resp. H-pure) uni-equivalent state for the system.

The contradiction is easily arrived at. It stems from the fact that this assumption implies that the norm of the state vector - which is always equal to one - is unlawfully made to differ from unity at some other time.

b) ***Wavelike motion can be breached only by paral phases.*** This result is straightforward. For a given evolution, the least action movement is either enforced throughout, or it is breached. Obviously enough, isn't it? The point is, when breached, quantum theory provides only one alternative (namely, the collapse, or *paralling*) - which thus becomes mandatory. This ascertains that the wavelike motion is breached *iff* at least one collapse occurs during an evolution.

These two findings will be instrumental in reaching two conclusions, which are:

- i) The paral phase is far more pervasive than is commonly held. It is not locked up in the sole quantum measurement; or observation, processes.
- ii) The alleged {wave / particle} duality is spurious. Indeed, it harks back to the {pure state / mixed state} duality; which in turn mirrors the {collapse / wavy motion} duality.

I.3. THE DILEMMA

As we saw, nature did not content itself with just one evolution law (namely, that of the wavy motion, which is overwhelmingly predominant). Instead, it introduced a second law. *Why is it so?*

The answer lies in the rather unexpected fact that the wave function is potentially *self-contradictory*. This startling fact stems from two attributes of the wave function which are inherently conflicting. These attributes are:

- a) The **extension** or spreadedness - and more generally the **dispersion**, spatial and otherwise - of the interfering quantum waves ; belonging to the same elementary particle (or *wavicle* as we might call it lest it be confused with classical particles).
- b) **Quantumhood** or the quantisation constraint; which prevents the wave function from being split (and/or mingled) haphazardly.

It is a matter of course that a log can always be chopped *because* it is not point-like. The extension of the wave function similarly entails that it can always be split. However, such a splitting is anathema : it is ruled out by quantumhood, and therefore never arises. (2)

What happens, then, if we insist on splitting the wave-function? This is a key question, which we shall examine in the next Section.

Meanwhile, let us explore the theoretical meaning of the sentence: "*we insist on splitting the wave function*". (It will ultimately turn out that performing a measurement is a way to do so.)

To that end, let us go back to the H-status of an isolated system. If this system is in a H-pure state, it will never leave it spontaneously (it is acknowledged to be in a stationary state). Under such a circumstance, quantumhood is not threatened. Consequently, the system can smoothly proceed on, by means of its wavy motion.

If the system is originally in a H-mixed state, the situation is utterly different (as we know, such a system overlaps with more than just one eigenstate of its Hamiltonian). It is in danger of

such a system overlaps with more than just one eigenstate of its Hamiltonian). It is in danger of being split, *against* quantumhood: and here is the snag. Let us see why.

A basic feature of Hamiltonians is that their eigenstates are prone to absorb, or 'swallow' as it were, bits of neighbouring wave functions (this is what makes the energy operators so special).

Accordingly, a H-mixed state always tends to be severed by the various H-eigenstates involved. They somehow conspire to absorb it, in proportion to the related intensities of overlap. (This will be illustrated soon.)

This 'H-driven' tendency puts quantumhood in jeopardy. The contradictory nature of the wave function is then made explicit. In essence, this situation is what I call a *paralling condition*. Thus, *a system is in a paralling condition iff it is in a H-mixed state*.

A paralling condition tends to elicit a collapse, or a *paralling* (hence its name). Yet this necessary condition is not sufficient. To show and exemplify this, let us scrutinise an isolated atom taken in its ground (i.e. not excited) state.

In fact, such an atom may be in a H-mixed state, which explicitly involves its peripheral electrons with the relevant energy levels. However and by definition, it cannot spontaneously leave this state (for want of the right particle to absorb or to emit). It cannot jump into, or reach, any of its H-pure states... which therefore prove *unreachable*. (3)

When a H-mixed state includes at least one *reachable* H-pure state, a paral phase may actually occur. More accurately, it will definitely take place, sooner or later. Given enough time, it is bound to happen. The system is then said to be in a *triggering condition* (which is but a particular case of a paralling condition).

We now gather that "insisting on splitting a wave function" translates theoretically into: "putting a system in a triggering condition". The degree of insistence (i.e. the intensity of the paralling condition) can be worked out from the appropriate amplitudes - or else, intensities - of overlap.

This is a key point, which gives a clear understanding of what the *paral phase* (or 'wavefunction collapse') is all about - and, on top of this, of how widespread it is.

I end this Section on two additional points:

- i) When a paralling condition is not a triggering one, the system is said to be *thwarted*. Conversely, it is said to be *unthwarted* whenever subject to a triggering condition.
- ii) The splitting of the wave function I am writing about refers to the loss of the *mutual interfering ability* of the quantum waves within a *bare* (4) wave-function. It is not directly related to any overt spatial splitting, which may just bespeak a N-mixed (*yet not a H-mixed*) state, regarding the position operator (which is a N-operator).

I.4. THE RESOLVE

Let us go back to the as yet unanswered question of Section 4: *What happens if we insist on splitting the wavefunction?* When we do so, nature is not given much leeway. Its only choice is to forgo the wavy motion, which would inevitably lead to the unwanted - and strictly forbidden - splitting.

As we know from Section 3, this means that the system suddenly switches on to a paral phase. Obviously, this paral phase has a very specific part to play. And this accounts for its very

peculiar features.

In a nutshell, *paral phases aim at safeguarding quantumhood despite the onset of triggering conditions*. They successfully achieve this by appropriately jolting any unthwarted system into a new, or 'final', state ; such that these conditions no longer exist.

Indeed, this final state is *always* a reachable pure state of the 'initial' Hamiltonian (viz. the Hamiltonian of the system *before* the collapse), whereby the triggering condition is destroyed. This is arrived at *without incurring any violation of quantumhood*. This aply saves the day, notwithstanding the above-mentioned contradiction.

Most strikingly, the collapse breaks away from the principle of least action. During a collapse, the wavy movement vanishes. And so does accordingly the wavefunction. For this reason, the standard theory becomes hopelessly irrelevant. It can give no detailed account of the evolution of the system (this is the case, for example, for any quantum jump - which to this day has consistently eluded mathematical description).

Once the paralling has performed its main task, the wavy motion resumes (we recall that this task consists in picking or "choosing" a reachable H-pure state out of the former H-mixed state). The system (or whatever it has evolved into) is now found to start afresh in its new or final state, which materialises once the paral phase is over.

Mother nature is remarkably consistent: it endows the paral phase with precisely the right features needed to overcome the contradiction made explicit by the triggering conditions. This is further evidenced by the following key traits of the collapse. Here they are.

Firstly, a paral phase always results in a transition from an initial H-mixed state into one of its reachable H-pure states. This is absolutely crucial, and suffers no exception. The pure H-status of the final state is the only way to ensure that the initial triggering condition has been removed.

Secondly, it contains something of a surprise, since a collapse seemingly displays an element of chance, whereby one or another of the reachable H-pure states is selected. One cannot predict which one will actually be chosen. The theory churns out the mere probabilities of these optional events. It definitely cannot go any further.

To sum up, paral phases allow evolutions which share at least two common features:

- i) The initial state is H-mixed, and includes one or more *reachable* H-pure states (this defines a *triggering condition*).
- ii) The final state is always one of these reachable states (I shall dub it the *paral product* or the *paral outcome*).

A paral phase "jumps" the system from its initial *mixed* state into the final *pure* state (both these H-states refer to the *initial* Hamiltonian). Indeed, the final state is nothing short of a brand new system. It possesses a new Hamiltonian, say, H'. Now, the H'-status may differ from the H-status. Hence the final state may turn out to be H'-mixed! This may thus trigger yet another collapse - and lead for instance to some atomic cascading.

We may now grasp, along these lines, that *all* quantum jumps or transitions are due to parallings (whether they be radioactive decays, inelastic collisions or scatterings - and the like). Paral phases are quite widespread! They actually befall wherever an individual physical event displays *particle-like* (instead of wave-like) properties. This is a simple rule of the thumb, which makes them fairly easy to spot.

How about the thwarted systems - for which no reachable H-pure state is available? For such systems, no collapse can arise, *unless* an external influence turns their paralling condition into a triggering one. As long as they remain isolated, they hold on to their initial H-mixed state. They consequently have a typical nonvanishing 'energy width' (and they typically oscillate).

In the next Section we shall see how this framework applies to measurement processes. But beforehand, let I summarise my views. This is best done by means of the *Paralling Postulate*, which supersedes the current Measurement or Projection Postulate. It goes as follows:

The Paralling Postulate

1. A physical system is in a paralling condition iff it is in a H-mixed (viz., a H-superposed) state. A paralling condition becomes a triggering condition whenever this H-mixed state includes at least one reachable H-pure state.
2. For want of a triggering condition, no paralling or paral phase - or else, no collapse - can ever happen. Then the system necessarily evolves in keeping with the principle of least action. It accordingly displays wave-like features.
3. In the event of a paral phase, the quantum waves momentarily vanish (whereby the system displays particle-like properties).
4. A paral phase destroys the initial wavefunction, to beget a new one. The new wavefunction (or state vector) is the final state of the system. We may call it the **paral outcome**, or the **paral product**.
5. A paral outcome is always:
 - a) a pure (or eigen) state of the Hamiltonian of the initial system; and, to be more accurate :
 - b) any of the *reachable* H-pure states included in the initial H-mixed state.
6. The initial time of a paralling, and the selection of a paral product, are given by probability laws. These laws can be derived from the *amplitudes of overlap* (often yet inappropriately called the transition amplitudes) which link the initial H-mixed state to the apposite H-eigenstates.

The theoretical derivation of these probability laws (*point 6. above*) is a customary procedure, which is routinely used in the study of unstable systems.

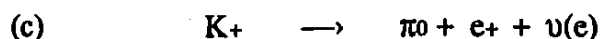
I now carry on to suggest how the foregoing analysis applies to a wide spectrum of quantum events. I shall do so by investigating two fairly dissimilar ones. A rough account of them will be more that enough, I believe, to support my claim conclusively (as I intend and hope to show).

I.5. TWO ILLUSTRATIONS

The first case in point is a free kaon, say, of the kind denoted K^+ . We recall that a kaon is an elementary particle belonging to the hadron family (which means that it is made up of quarks). It is known from experience that an isolated kaon decays spontaneously. It does so according to a few possible modes of decay, or 'channels'. The corresponding average lifespans are also known to a high accuracy.

The main channels are:

(a)	K^+	$\longrightarrow$	$\mu^+ + \nu(\mu)$
(b)	K^+	$\longrightarrow$	$\pi^+ + \pi^0$



where $\{\mu^+, \nu(\mu), \pi^+, \text{etc.}\}$ symbolise specific elementary particles.

Each of the above processes has a definite probability of occurrence, along with a specific time-probability. For example, channels (a) and (b) are the most likely ones. They roughly appear in 63% and 21% of the cases respectively.

These data are in forthright agreement with my general picture of a collapse. This is easy to show. *For one*, the sheer unstability of a kaon entails that it is in a H-mixed state. *For two*, each channel of decay is plainly one of its reachable H-pure states. (We take note in passing that each of these possible *paral products* are made up of a few - and not just one - elementary particles.)

One additional point: any decay transition shoves the system out of its initial H-mixed (viz. H-superposed) state, into a H-pure state. In so doing, it breaks away from the wavy movement, as we found out in Section 3. We recognise here the two characteristic features of the paral phases identified at the end of the previous Section (Section I.4.).

This ensures that a decay reaction is prompted by a paral phase (which is in its turn set off due to the existing triggering condition linked to the *mixed H-status* of the free kaon.) Indeed, we can readily work out the exact expression of the (*H-mixed*) free kaon state from the experimental statistical data. This again is standard theoretical practice.

Our second example is a conventional measurement or observation process. Let us consider a system on which we shall perform, say, a position measurement. For simplicity's sake, we assume that this system is originally in a H-pure state. It may for instance be a free electron.

To carry the observation out, we need a suitable measurement set-up, which typically goes as follows. The electron is sent out from an electron gun, passes on through a two-slit plaque, and eventually hits a scintillation screen - which then flashes. The plaque is an analyser, whereas the screen is a detector. They altogether form a conventional measurement apparatus.

The first stage of the observation process occurs as the electron flies through the slits. The latter does so by spreading into a mixed state of the position operator, according to the following reaction:

$$(a) \quad |p\rangle\langle p|e\rangle \longrightarrow |1\rangle\langle 1|e\rangle + |2\rangle\langle 2|e\rangle$$

where $|1\rangle$ and $|2\rangle$ denote the two eigenstates of the position operator, corresponding to the electron crossing the plaque through the "first" and the "second" slit respectively. (We use the conventional Dirac bracket notation, whereby $|p\rangle\langle p|e\rangle$ represents the incoming electron expressed in terms of the position observable, while $|1\rangle\langle 1|e\rangle + |2\rangle\langle 2|e\rangle$ means that the outgoing electron is a superposition of the pure states $|1\rangle$ and $|2\rangle$; $\langle 1|e\rangle$ and $\langle 2|e\rangle$ are the matching amplitudes of overlap.)

This evolution falls short of putting the system into a proper triggering condition, since its end-state is not, in fact, H-mixed. (Since position is a N-observable, it is only N-mixed; and definitely *not* H-mixed.)

This first stage of the observation can thus be overlooked, bearing in mind that the electron flies across the analyser unscathed. No paralling occurs: all what the analyser does is to add some extra spatial spreadedness to the incoming electron wavefunction. (It goes without saying that this ultimately modifies the observation upshot - but the details of this are none of our concern here.)

is during this very stage that a collapse comes off. We have yet to understand why. We have to grasp how it is that a detector detects at all. *What makes it so special?* Or, going back to our example: *why does a scintillation screen flash when an electron strikes it?*

The answer is that a detector contains a host of thwarted systems. This means, as we know, that a large number of its atoms or molecules are unstable but *cannot* proceed on to a paral phase - unless, precisely, they can absorb the incoming electron.

The pith of the matter lies in "thwartedness". It is totally unrelated whatsoever to the macroscopic nature of the detecting device, let alone of the measuring apparatus. (If so, the distinction between the *quantum* microworld and the allegedly truly *classical* macroworld becomes spurious.) This, of course, is in stark opposition to the current conventional view.

Let us first consider one of the thwarted systems on the detector's surface. To avoid unnecessary complication, I assume that this system, say, x , has two discreet energy levels and only that. I can write it down, in the conventional bracket notation, as:

$$(b) \quad |H\rangle\langle H/x| = |E1\rangle\langle E1/x| + |E2\rangle\langle E2/x|$$

where $|E1\rangle$ and $|E2\rangle$ represent the two H -eigenstates. (Equation (b) reads as follows: *The unstable system $|x\rangle$ is in the H -state $|H\rangle\langle H/x|$, which is - as we know - mixed, that is to say, superposed. It is a mathematical linear superposition of the H -pure states $|E1\rangle$ and $|E2\rangle$, with the respective coefficients $\langle E1/x|$ and $\langle E2/x|$, which are the amplitudes of overlap.)*

As the electron approaches, it becomes increasingly coupled to this system, so that the two of them eventually form an overall system. Let $|xe\rangle$ denote this new system, which becomes $|H'\rangle\langle H'/xe|$ when expanded as a H -state (it belongs to the proper tensor-product Hilbert space). Its Hamiltonian, H' , is somehow 'akin' to the former Hamiltonian of $|x\rangle$, since the two systems differ fairly slightly (Again, I implicitly consider the relevant Hilbert spaces, where this 'kinship' receives a proper mathematical translation.)

Therefore we still have two energy levels for the new compound system, so that I can write:

$$(c) \quad |H'\rangle\langle H'/xe| = |E\rangle\langle E/x| + |E^*\rangle\langle E^*/xe|$$

where $|E\rangle$ and $|E^*\rangle$ are the eigenvectors of the new Hamiltonian (they can be taken as the *ground* and *excited* levels respectively).

The key point is that the above H -mixed state is no longer thwarted. The very possibility of absorbing the incoming electron - brought about by the coupling of the two sub-systems into a single new one - has turned the paralling condition into a triggering one. The hitherto impossible evolution (away from the initial paralling condition) now becomes a possibility - and is bound to happen sooner or later.

When this so-called 'quantum jump' happens, the actual absorption of the electron then flashes the detecting screen, owing to a macroscopic amplification. The absorption reaction can be depicted as follows:

$$(d) \quad |H'\rangle\langle H'/xe| \rightarrow |E^*\rangle\langle E^*/x|$$

where $|E^*\rangle\langle E^*/x|$ describes the final system $|x\rangle$ in a pure state of the initial Hamiltonian corresponding to the eigenstate $|E^*\rangle$.

This analysis extends to the whole screen. We readily generalise it by taking into account all the unstable systems to which the incoming electron becomes coupled. (We make use of the appropriate Hilbert vector space.)

This is enough to show how to settle the issue of the measurement, as interpreted from my perspective. I skipped the full mathematical details, since they are not necessary to make my point.

Incidentally, this line of reasoning leads to the **Equivalence Principle**, which states that *whatever the measurement carried out on a microsystem, it always boils down to provoking the quantum jump of an appropriate system towards an eigenstate of its Hamiltonian.*

Let us, to sum up, consider a measurement bearing explicitly upon an N-observable (e.g. a position or a spin measurement). This 'N-measurement' is rendered such by means of the analyser (which creates the proper N-mixed state). But the actual collapse, or paralling, of the incoming 'observed system' is triggered by the detector. How is it so?

Here is the answer. Basically, the detector is made up of thwarted unstable systems. The key point is that they become unthwarted when coupled to the observed system. (5) The detecting device does precisely this: *it uses the incoming system to create triggering conditions for some of its erstwhile thwarted systems.*

Thus when the paralling is performed, it duly involves the incoming system, which becomes a sub-system of the new unthwarted system. The latter reaches a H-pure final state by means of the paral phase. This clearly entails that what, if anything, is actually performed is an *energy* measurement (on this new unthwarted system...)

The outcome is at once amplified by the detector into becoming macroscopically manifest and thus qualifies, in agreement with the Equivalence Principle, as a "measurement result".

Interestingly enough, we now gather why the electron seems to be point-like upon observation. This arises from its being absorbed by a tiny detector's unstable system (which was originally thwarted, as we know). Only *one* out of the whole screen - which has countless of them - is concerned! (6)

The absorption by a unique system on the detector's surface brings the electron into a N-pure state (relative, here, to the position operator). This is why this event comes out as the genuine result of a position measurement. Likewise, this is how the electron suddenly becomes a localised hence "real" particle. (7)

All of the above substantiates my claims that:

- i) A measurement is but a means to draw the observed system into creating triggering conditions (thanks to the detector's *thwarted* instability).
- ii) A measurement result is no evidence that a point-like particle exists at all, however fleetingly.

I.6. CONCLUDING REMARKS

I hope that the foregoing account of a standard observation process, however sketchy, succeeded in showing how my interpretation removes much of the well-publicised weirdness of the sub-atomic world. Within this framework, it is no longer mandatory to divide the world into a quantum part and a classical part.

If I am right, we definitely can do without this dubious (quantum / classical) dichotomy; and that takes away a slew of nagging conceptual problems. Furthermore, we may eventually realise that a so-called elementary particle is just a bunch of mutually interfering, and *parallable*, waves. (I'd therefore rather call it a *wavicle*.) It is no longer so odd and ghostly!

waves. (I'd therefore rather call it a *wavicle*.) It is no longer so odd and ghostly!

Waves are said to be *parallable* when they are prone to paral phases, whereby they momentarily vanish. This key feature of quantum waves makes a huge difference with plain or 'naïve' matter waves. It explains why they have been so consistently misunderstood ever since their discovery. It also provides a straightforward and consistent insight into the true meaning of the wave-particle duality.

Let I now conclude on a few remarks:

- a) *Both mixed and pure states are full-fledged physical entities.* They do exist on an equal footing. It is groundless to oppose them as a set of (ghostly) potentialities vs. a unique and definite actuality.
- b) The central role of the observer is 'debunked', since the reality being observed is no longer created. The only feat achieved by the observer is to prompt a (previously 'thwarted') paral phase, which actively and explicitly involves the system being observed.
- c) A paral phase is unlike usual matter. It behaves very differently, in a blatant nonmaterial way. Here are three of its original and distinctly unphysical features:
 - i) It is intrinsically *non-computational*. Hence no equation - whether nonlinear or otherwise - can ever encapsulate it. (This trait can possibly be linked to the Gödelian undecidability) (8).
 - ii) It brings about a *nondeterministic new element of reality*, whereby the actual selection or 'choice' of a specific paral outcome is made.
 - iii) It is *a-relativistic*, with regard both to special and general relativity. In particular, a paral phase is non-covariant, (9) and does not contribute to gravitation.
- d) The probabilistic time-law which in my view holds for any collapse nevertheless does not show, say, for measurements or unelastic scatterings. This is due to the fact that such events are exceedingly short-lived, and above all, that they relate to fast-changing systems.
- e) My analysis strongly suggests that *gravitation originates in the quantum waves*. There are two ways to look at this. Either we reckon that these waves, being extended physical waves, accordingly stash extended matter-energy which ultimately caters for the gravity field's potential energy. (*Some early calculations actually point in that direction.*) (10) Or else, we make out that these waves locally twist or 'warp' space-time, as seen from any other incoming quantum waves. (11)
- f) The perspective that gravitation may stem from quantum waves provides a new insight into the very early universe. According to the standard cosmological model of the big bang theory, the awesomely hot and dense universe of the beginning played host to a frenzy of high-energy collisions. As a result its particles - or rather, 'wavicles' - were prey to ever-recurring triggering conditions. These wavicles would thus ceaselessly hop, as it were, from a paral phase to the next. The overall picture is that our early universe was home to a large-scale *primordial paralling*. (12)
- g) My understanding of quantum reality has a number of implications, which it may be interesting to explore. For instance:
 - i) The aforesaid *primordial paralling* ought to rid cosmology of the troublesome and worrying necessity, established by R. Penrose and S. Hawking, of a primeval singularity. (This mind-boggling singularity corresponds to the initial state of our universe, when it was shrunk or squeezed into a single point.)
 - ii) The inherent 'stretchedness' of elementary particles (in the absence of a collapse) may eventually rid physics of the unwanted infinite quantities

- particles are treated like points of zero size.)
- iii) The averaging-out of *all* the quantum waves coming from the *whole* universe present - however dimly - in any small volume of space, may lead to the notion of *intrinsic* zero acceleration. It may explain why nonuniform motion seems to be absolute, whereas uniform motion is relative (or else: accelerations are absolute whereas velocities are relative - which is very odd indeed!). It may give a clue towards understanding Mach's Principle, which acknowledges that inertial forces are somehow related to the far-off galaxies of our universe.

Now we move on to *Part Two*, where I shall introduce a bold and seemingly odd hypothesis. Namely, I shall argue that mind (*or rather, some kind of elemental consciousness*) may actually be embedded in matter. And that it is, however, normally dormant, or latent, in it.

Quite a bit unusual and baffling, isn't it? But this is certainly not good enough a reason to dismiss it high-handedly. It could nevertheless be true, by some uncanny trick and quirk of nature...

(1) *Iff* means, according to a now standard convention: *if and only if*.

(2) For instance, no one ever came across half photons or bits of electrons, hanging around in isolation. There is not such an impossibility in the macro-world - and this is arguably what makes the sub-atomic world so special and different.

(3) Conservation laws and quantumhood obviously require that a leap from a ground state to an excited one be concomitant with the absorption, say, of a photon with the appropriate Bohr frequency.

(4) I define a *bare* wavefunction as corresponding to a single *unsupralled* elementary particle. (*Supralness* refers to quantum *nonseparability*, or *nonlocality*. It is introduced in *Part Two* thereafter.)

(5) In my example of a position measurement, the sub-system being observed is the electron; whilst the new unthwarted systems are like the one I denoted $|xe\rangle$. They comprise the incoming electron, and any of the (previously thwarted) unstable microsystems of the detector to which it becomes increasingly coupled.

(6) Had the incoming electron been partially absorbed by several of these unstable systems, it would therefore have been split *against* the quantisation constraint. Quantumhood emphatically precludes this from happening.

(7) A "real" particle, as opposed to the mere set of potentialities allegedly contained in the N-mixed state prior to the paral phase ...

(8) I developed such an idea in either of the following two papers: "Où sont passés les énoncés indécis de la physique théorique?", in *La Jaune et la Rouge* (5 rue Descartes, F-75005 Paris), N° 419, Nov. 1986; and "Théorie physique et incomplétude au sens de Gödel", publ. by IREM-Paris-Nord, leaflet N° 67.

(9) This has been substantiated by Aharonov and Albert, in *Physical Review D* 21, 3316 (1980); 24, 359 (1981).

(10) It is worth mentioning, in that respect, an intriguing semi-classical exercise. Here it is. Let us consider two elementary particles. The first one - henceforth denoted (O, m) - is a regular quantum particle, taken for simplicity's sake to be a Gaussian wavepacket centred in O . Its mass, m , is assumed to be spread out according to the local density of presence given by the wavepacket. The second particle is a classical point-like one of mass m' , located in O' . The exercise consists in calculating the gravity potential energy corresponding exactly to the second particles (O', m') , as immersed in the wavepacket-induced mass density of (O, m) . The upshot is that the find a potential energy of the Newton law of gravitation! (*Hints for finding the solution; a) given the symmetry of the problem, we choose a set of spherical coordinates centred in O ; b) we use Gauss' formula transforming a volume integral into a closed surface integral ...*)

(11) "Othemess" with respect to quantum waves means that there is no possible mutual interference.

(12) If so, gravitation was then drastically weakened by all the quantum waves 'wiped-out' by this paralling. This may well have fuelled an 'inflation' era of accelerated expansion, regardless of any alleged negative gravitation. Needless to say we yet have, in order to work that out thoroughly, to determine what is the average timespan of a paral phase.

PART TWO:

TOWARDS SOLVING THE MIND-BODY PROBLEM

II.1. A NEW PERSPECTIVE ON THE MIND-BODY PROBLEM

From now on I shall present a new approach to the longstanding - yet still unvanquished - mind-body problem. This approach (which leads to the *im-im model*) will be summarised hereafter. It rests on some partially new concepts. If valid, it will have far-reaching consequences in areas as diverse as medicine, personal development and technology.

For clarity's sake, new concepts require new words: existing words are not geared to cater properly for them (at best, they can be confusing). This is why neologisms are in order in many speculative endeavours - be it in philosophy, in science or in technology. In a way they are part of the price to be paid for innovation!

Accordingly, I have coined a few new words. I shall introduce them right away to help the reader:

- I surmise, as we shall soon see, that there is more to matter than meets the eye. Namely, matter contains both a material part and a *psychic* part. Hence it ought to be called *psycho-matter* rather than mere matter. Indeed, I shall often call it *psychomatter*.
- The psychic content of psychomatter is usually hidden, for it is inert or *latent* (and this is exactly why it fails to meet the eye!). It can be 'sparked' out of its state of latency to become *active*; but only under some peculiar circumstances. I christen them the *paralling conditions*.
- On becoming active, the psychic part interferes with the material part of psychomatter. This brings about a genuine *mind-matter interaction*, which I call the *paralling* or the *paral phase* (as in *Part One* - we shall find out why).
- We know from physics that matter - or rather, psychomatter - is made up of elementary particles. The psychic components of various particles can interweave, or blend, into forming broader entities. I name *supral link* such a collective blending of the psychic parts (likewise, *supralness* refers to the fact of being suprally connected).

That's about all ! With psychomatter, the paralling or paral phase - duly triggered by paralling conditions - and the supral link, we are fully equipped to cope with the mind-body puzzle. At least this is what I think and want to show. Perhaps it sounds a bit complicated at first - but really it is not so. It is just a matter of getting used to it (and to my new-coined words...).

In fact, we came across most of these neologisms in *Part One*. We also recall from *Part One* that a paralling condition has to be a triggering condition to be effective. But I shall overlook this technical detail in the present *Part Two*, since it is much less concerned with the physical theory.

II.2. A BOLD ASSUMPTION

But really, what is awareness? What is consciousness? Broadly speaking, there are three ways to look at it. *Either* it is a seemingly weird - yet in fact not so special - property of matter (or rather, of some purely material processes). *Or* it is a preternatural phenomenon, alien and unrelated to our material world. *Or else* - and this is my assumption - it is an 'earthly' yet nonmaterial occurrence, which somehow lurks within matter.

In the last case, our universe is not wholly material. Besides matter, it is endowed with a nonmaterial content which leads, precisely, to the possibility of conscious beings. As I already wrote, I call it its *psychic* content; whence matter becomes *psychomatter* instead of mere matter.

However, the world seems overwhelmingly bereft of consciousness. As far as we know, trees, stones and water are inanimate. To account for that, I surmise that the psychic part of psychomatter is generally *latent*. If so, it then usually remains a hidden virtuality - and goes unnoticed. (*This is why we wontedly think that it does not exist at all...*)

Yet the very existence of the living beings of the animal kingdom - including ourselves - adamantly supports the claim that this hidden 'psychic' can at times leave its state of lethargy - given the right (and presumably very peculiar) circumstances. Again, I call these circumstances the *paralling conditions*.

A comparison will clarify this idea, which really is very simple. Awareness in matter - or rather: *psychic in psychomatter* - is fairly similar to water in a sponge. A sponge may seem externally dry, and yet be soaked with water. Its water content will then show only upon squeezing it.

Likewise, the conscious or psychic content of psychomatter would dwell in matter unheeded, till it becomes 'squeezed' into full-blown existence - by means of a suitable paralling condition.

In a nutshell, the *im-im* idea deems consciousness as both immaterial and immanent. What does this mean? Put simply, its being *immaterial* means that it is not a mere side-effect of some material processes. (*Although it is clearly related to such processes, there is more to it than that. It is not just a by-product of them, it partly stands on its own.*)

Its being *immanent* means that it belongs to our world, just like any tangible object. It is but one of its contents. It is neither transcendental nor 'otherworldly'.

But there is a hitch. How can we reconcile this view with the glaring and obvious fact that none of our everyday objects seems to be aware? I shall come to that in a short while.

Our assumption can be summarised as follows: *consciousness stems from a normally latent content of our world, which is immaterial and yet, is embedded in matter*. It is therefore pervasive and ubiquitous, being ever 'hooked' to matter. It is immaterial in the plain sense that it does not comply with the laws of matter (hence we cannot define its weight, its energy - and so forth).

I call the above assumption the *im-im hypothesis*, since it envisions consciousness as being an *im-material* and *im-manent* (as opposed to a material and transcendental) content of our universe. From this starting point, I want to build the *im-im model*, which aims at solving the mind-body problem.

II.3. COMING TO GRIPS WITH THE CONSCIOUS BRAIN

The brain is the organ of consciousness: this is borne out by the weight of evidence, beyond any shadow of doubt. Neuroscientists strive hard to understand why it is so. But in spite of their strenuous and fruitful efforts, the key to this tantalising puzzle remains elusive to this day - notwithstanding a few rash statements to the contrary.

There is little doubt nowadays that conscious mental processes depend on specific brain processes. (It should be emphasised however that *not all* brain or neural processes do contribute directly to our conscious life - a far cry from it.)

Within the *im-im* framework, we can readily interpret this as an unambiguous token that a normal living brain implements wide-scale *paralling conditions* - obviously through some of its neural processes.

Now, this may be an interesting insight, but it falls short of settling the issue at stake. I yet have to explain some fundamental data, such as:

- (a) We can hear, see, taste and feel; we can move ourselves about in a purposeful way;
- (b) We experience our conscious self as a whole, as a holistic oneness.

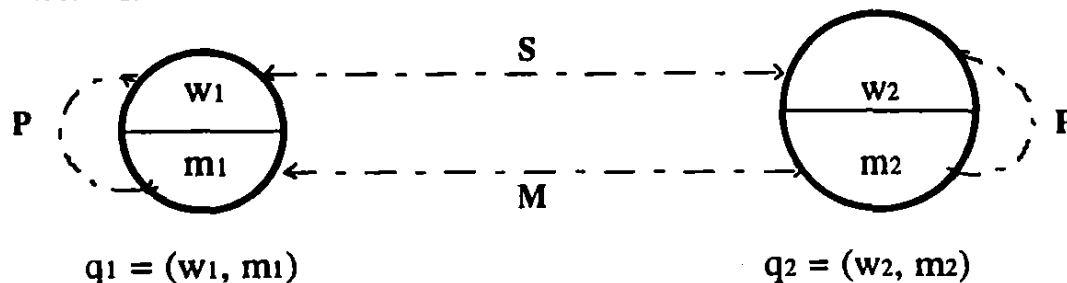
The first set of data, (a), shows that the psychic and the material parts of psychomatter can be made to interact (within our brain for example). This plainly happens *only* when the psychic content relinquishes its state of latency, and is therefore active. In other words, it occurs under a proper *paralling condition*. I therefore call this interaction the *paralling*, or the *paral phase*.

The second data, (b), underscores the fact that different psychic parts can somehow be coherently assembled or interwoven into forming unified macro-psychic entities. I dub this 'mingling' interaction the *supral link* or the *supral bond*.

Put together, these three elements define the *im-im model* (they are, for the record: *the paralling condition, the paral phase and the supral link*). (1') With all this, I believe that we possess all the chief ingredients needed to sort the mind-body problem out.

Indeed, a simple drawing will help us to visualise the aforesaid interactions. Matter - hence *psychomatter* - is made up of elementary particles. For simplicity's sake, I can depict one of these particles as a tiny bead. Let us denote it *q*. Since it is bi-dimensional, I can write it down as $q = (w, m)$, where *w* and *m* are respectively its psychic and its material components, or parts (*m as matter, w as ... wit*).

Now I use this to represent two of these particles, say q_1 and q_2 , along with their possible interactions:



We successively have:

M : material interaction (it binds m_1 and m_2)

P : paral phase, or paralling (it binds w_1 and m_1 , or else w_2 and m_2)

S : supral bond, or supral link (it binds w_1 and w_2)

So far I indulged in sheer speculation. I entertained myself with pure constructs of the mind. But I am dealing with a concrete and factual issue: I must sooner or later measure my ideas and conjectures up against the hard facts of reality. Otherwise my approach will be misguided, or empty at best. It will remain useless and groundless.

The first step in appraising the relevance of the *im-im model* is to find out whether its three basic elements have any likely counterparts in the physical world. And here is the good news: quantum physics, which deals with the sub-atomic world, provides us with a likely candidate for both the paral and the supral interactions.

We recall that the paral interaction (or phase) is an interaction between the psychic and the material parts of any elementary particle. As such, it is at the core of the mind-matter interaction, at its most elemental level.

During such a paralling or a paral phase, the psychic component becomes active, and readily interacts with the material part. Thus a paralling, owing to its 'psychic legacy', a paralling is a quantum event endowed with highly idiosyncratic features. And these are just what I need to spot it.

What are these features? Most strikingly, an *active* psychic component jerks or jolts the otherwise smooth evolution of the material part. I moreover surmise that it possesses a very dim element of free will, which is more appropriately a degree of self-determinacy.

This 'degree' is exceedingly low or weak for an individual particle; it picks up weight or momentum - so to speak - only when this active psychic is suprally swollen, or extended, to a certain bulk.

I draw from this that a paralling has the following characteristics:

- (a) It displays an element of indeterminism, which mirrors its partial self-determinacy;
- (b) It breaches the prevalent wave-like evolution law (which marks out the material component of an elementary particle).

This brings me to a straightforward conclusion. If the *im-im model* proves right, then *the paral phase is the 'wave-packet collapse' of quantum mechanics*. I am given no other choice - and this one perfectly fits the bill.

Let us now turn our attention to the supral interaction. We remember that it bears exclusively on the psychic content of psychomatter. More accurately, it blends or welds together formerly autonomous psychic parts (belonging to various elementary particles) into new psychic wholes. I infer from this that the supral bond manifests itself:

- i) only when the psychic parts involved become active (when the psychic components are hidden, whatever relates to them is also hidden);
- ii) by combining (or *correlating*) the events triggered by these active and 'supralled' psychic parts.

This leads me to conclude at once that *supralness is identical to quantum 'nonseparability'*. (2') (3')

What can I say, *last but not least*, about the paralling conditions? A paralling condition tends, as we know from the above, to elicit a paralling - i.e. a wavepacket collapse -; which implies that a quantum measurement process is an instance of paralling condition.

Indeed, as I contended in Part One and elsewhere (4'), a paralling condition occurs whenever a microsystem is in a *mixed state* of its energy operator (viz. in a superposed state of its Hamiltonian).

The conventional (Copenhagen) interpretation of quantum mechanics is adamant that a paral phase can only be prompted by a quantum measurement, or observation. My allegation that the *paralling* (and in fact: the *triggering*) conditions are more general than the mere measurement processes is clearly at odds with it.

Fortunately my view can be established directly and firmly, by demonstrating that there do exist some 'collapses' that are not linked to any standard observation (which *ever* involves a *macroscopic* instrument).

This is the case for the so-called 'spontaneous quantum jump': these are definitely brought about by a paralling, and not through a measurement process (otherwise, they just wouldn't be spontaneous!).

One instance of such a jump is provided by the decay of an unstable microsystem. It obviously happens regardless of any measurement process (this is why this very phenomenon - which includes radioactive decay - can reliably be used for datation, whether in archeology or in paleontology).

Now my challenge is to prove that such a decay, independant as it is from any measurement, involves a paral phase. How can I do so? Easy enough, as we shall see. The first step is to point out that such a decay breaches the least action principle (we already touched upon this in *Part One*). (5')

But precisely, the least action (or wavelike) movement definitely precludes any transition from the initial (*undecayed*) to the final (*decayed*) state of the unstable system. The second step is then to recall (again from *Part One*) that there is no alternative to the least action motion, other than the paralling. Quantum physics just leaves no other choice: It knows of the wavelike motion and paralling only (this a duly battle-tested fact).

Whenever - in a given quantum process or evolution - the least action motion can be shown to be breached, we can readily infer that at least one paral phase took place between the initial and final states. *And this suffices to prove that a paral phase comes off at some stage during a decay (without it, this evolution would be stark impossible).*

Indeed, the decay transition, or 'jump', is a paral phase. The resulting decayed system is thus a paral outcome (as defined in *Part One*).

Hence wherever one of the two evolution laws above is violated, it means that the other has been enforced somewhere along the road. This is so *whether or not any measurement has been performed....*

Now it is timely that I sum up the main *im-im* ideas, in three basic points:

- A. Matter is actually **psychomatter**. Its psychic content is predominantly latent, or dormant, and does not become active unless a **paralling condition** is put into effect.
- B. A **paralling**, or **paral phase**, may arise under a paralling condition. If so, the psychic content of psychomatter suddenly becomes active, and interferes with its material part. (To put it differently, the psychic and physical parts of psychomatter are then made to interact; *and this in essence is a mind-body interaction.*)
- C. The psychic components of various elementary particles can mingle or gather into forming an overall psychic entity. This possibility, exemplified by our 'macro-psychic' minds, stems from the **supral link**, also named the **supral bond**.

Interestingly enough, it turns out that supralness is exactly what we need to solve the neuroscientists' **binding problem**. This problem refers to an apparent paradox, brought

about by the glaring discrepancy which opposes our comprehensive sensorial perception of the world on the one hand, and the underlying fragmented brain processes on the other hand.

For instance, our visual cortex routinely brings to our mind a unified and dependable image of our whereabouts, although the supporting neural processes involved are conspicuously spread out (and split up) in the cortex. How this can be achieved has remained something of a watertight mystery.

More generally, no one has the faintest idea as to how the subjective oneness of the self can be arrived at, given the fragmentation and the dispersion of the neurobiological processes implemented in the brain. Again, *it seems that supralness is just the right answer to this puzzle!*

II.5. ASSESSING THE TRUTH

I am apparently reasonably lucky: I found likely candidates for my paral and supral interactions. (6') So far so good. But can I go any further, with a view to check or 'falsify' my ideas?

The main battlegrounds on which these ideas can ever be investigated are physics and the neurosciences. I shall only hint at two possible tests, within the scope of the neurosciences. I set physics aside, for it is not the concern in this *Part Two*.

The first test rests on the inference that *our mental memory is supral in essence*. (This is a forthright consequence of the *im-im* framework, which will not be substantiated here.) It means that our 'declarative' or 'explicit' memory - as the neuroscientists call it (7') - is encoded or engrammed in some specific *supral circuits* within our brain. (8')

This statement about mental memory can in principle be tested, even though it is far more easily said than done. It is worth noting that it entails that our 'explicit' memory is both immaterial and nonlocal. Encouragingly, these two features are consistent with the current scientific knowledge. (As a matter of fact, scientists have failed to identify any 'molecule of memory'.)

Another possible test hinges on the existence of neurobiological *paralgens*. What is that again? *Paralgens* are the structures in charge of carrying out, in the living brain, wide-scale paralling - or rather, as we know from Part One : triggering - conditions. They are presumably what makes the brain so special - and so amazing.

The question is: where in the brain are these paralgens? Do they exist at all? (If not, then the *im-im model* must be discarded altogether, for it is groundless.) In fact, we have to look for them where alcohol and drugs meddle in the brain, when they 'reshape' our subjective experience of life. This 'reshaping' is a clue that the normal workings of our paralgens have been fiddled about, so to speak.

This unambiguously points at some specific synapses in the brain. More precisely, it points at some receptors of acetylcholine (9') - and also of serotonin, amongst many other possibilities - in the cortex. (Incidentally, they play a key role when we are suddenly woken up, in connection with the so-called reticular formation of our central nervous system. This is yet another clue!)

If the paralgens exist at all, they should be sought after in this direction at least (that is: somewhere along the neurobiological pathways of mood-altering substances in the brain cortex). On that basis, we can readily imagine a few tests (the details of which cannot be considered here).

Let I conclude. According to the *im-im model*, consciousness is produced by **supralled paral**. In other words, our conscious mental life is somehow a by-product of the suprally

combined paral phases which occur in our living brain (I could even say: consciousness is supralled paral). This 'supralled' paral is yielded by some specific neural processes; they actively involve a whole array of paralgens ...

Finally, we are led to gather that *our brain is the organ of consciousness because it can routinely produce some supralled paral*, in a continuous flow and on a wide enough a scale.

II.6. A NEW CHALLENGE: ARTIFICIAL AWARENESS

One of the drawbacks of my present formulation of the *im-im* thesis is that it is too far apart from the standard 'neuroscientific' approaches. One of my first tasks ahead will certainly be to bridge this linguistic and conceptual gap, so as to foster some degree of 'cross-fertilisation' - this being the very fuel of scientific advances and breakthroughs, as we know from history.

The full validation of the *im-im model* (if any) will eventually come from the production, along its lines, of artificial consciousness. This can in principle be achieved by :

- i) devising *artificial paralgens*, mimicking the natural ones; and :
- ii) putting them to work jointly, according to an overall architecture designed to create large-scale paral with the proper supral span (*this architecture will typically reproduce the 'massive parallel' processing of the brain*)

If I am right, this exciting prospect of artificial consciousness is what looms ahead of us. Once we know what consciousness is made from, how it can be produced from matter, we can plausibly dream of creating genuine thinking machines. If that dream is ever to come true, it will open up a daunting era of sweeping changes. That will mean a lot for mankind - well beyond our wildest speculations.

Consciousness will at last enter the exo-biological era. At long last freed from the shackles of biology, it will be geared up to conquer erstwhile barren and hostile surroundings, in all walks of our universe. It will become far more widespread than it is to this day. For sure, this awe-inspiring perspective is hard to imagine, yet it may well shape the forthcoming third millennium.

(1') This model has been presented in the French quarterly magazine *3° Millénaire* N° 28, Summer 1993 (B.P. 40, F-75661 Paris Cedex 14) under the title: *Les Trois Piliers du Cerveau Conscient*. See also, in English : *Towards Solving the Mind-Body Problem*, in the *ANPA WEST Journal*, Vol. 5, No 1 (Winter 1995).

(2') Supralness means: "the quality of being suprally linked".

(3') Quantum 'nonseparability' (also called 'nonlocality') is akin to the renowned E.P.R. paradox, named after Einstein, Podolsky and Rosen. An example of nonseparability is provided by the pairs of 'twin' photons, which always yield correlated values of their polarisation upon measurement - even though they are flying wide apart.

(4') See for example my two articles published in the magazine *3° Millénaire* (B.P. 40, F-75661 Paris Cedex 15), N° 28 (1993); and N° 31 & 32 (1994), entitled: *L'Onde, le Canular Quantique et l'Esprit*. For a brief and recent article in English, see for instance in the November 1994 issue of the British-based *International Journal of Alternative and Complementary Medicine (JACM)*.

(5') Incidentally, we recall that this fact is further evidenced by the very collapse or breakdown of the physical theory: no detailed theoretical account of the decay can be put forward. Would it faithfully comply with the least action principle, a full description of this event would be possible and straightforward.

(6') It is no wonder, as I stressed in *Part One*, that both the 'collapse' and 'nonseparability' cannot make much sense within the current (and purely materialistic) framework of conventional physics....

(7') This memory deals exclusively with our *conscious* recalls (i.e. the ones we are aware of - and thus, can talk about).

(8') These *supral circuits* bind together a whole host of elementary particles, in many different ways. Their very shape and nature - which depend on the particles involved - allow them to store huge amounts of information *immaterially*.

(9') Acetylcholine and serotonin are two of the 50-odd neurotransmitters that have been discovered thus far. *Neurotransmitters* are the chemical messengers that neurons (or nerve cells) use to talk to one another.

Discrete Space-time: an exploration.

S.A.Wouthuysen, Amsterdam.

Introduction.

The mathematical model for space-time, as it is currently in use, viz. a fourdimensional metric continuum, is highly satisfactory, so much so that it hardly ever is experienced as 'merely' a *model*. Historically it originated as a formalisation of relations between events at the human scale. And successes at the human scale persistently keep feeding the illusion that this formalisation, at least in its essentials, is in no need of revision. This illusion is furthermore nourished by the usefulness of this model for the description of events at scales far larger than the human scale, up to even the largest cosmological dimensions. And at smaller scales, down to atomic dimensions, success does not seem to halt. Nevertheless here some doubts may be raised as to the physical significance of 'very small' intervals of space and time, inasmuch as these play the role of wavelengths resp. periods of wave phenomena. Waves with wavelength and period close to zero are at the origin of the infamous divergencies occurring in quantum field theory. Although these can be dealt with, for renormalizable theories, by the so-called renormalisation procedure, opinions are not unanimous as to whether the concept of continuity of space-time can leave the scene unscathed. These circumstances, together with the fact that a mathematical concept as *continuity*, which involves infinitesimal intervals, in principle eludes experimental verification, form the *raison d'être* for this adventure: a search for an alternative model for space-time avoiding the concept of continuity, i.e. a discrete model for space-time.

As space-time can only acquire a meaning by being used as a basis for the description of physical phenomena, spinor waves will be used as stand-in, as a representative physical phenomenon at the most primitive level, with an allusion to matter waves of free leptons or quarks, and to the basic notion of geodesic motion of (free) particles in relativity.

An exceptional space-time lattice.

As conventional space-time concepts seem adequate down to very small scales, at least till dimensions of elementary particles (10^{-13} cm), curvature is neglected to begin with, and replacement of Minkowski space-time by a discrete model is aimed for. Furthermore, the discrete model more specifically is assumed to be a fourdimensional (periodic) lattice. Such a (simple) lattice singles out a frame of reference in which the lattice points have four integer coordinates, and all points with integer coordinates are lattice points. The *reciprocal* lattice represents three dimensional net spaces. It is also a simple lattice, but comparison between the lattice and its reciprocal can only be made by virtue of the existence of a metric tensor; the latter finds its function here in the frame of discrete periodic pointsets: it allows representing a pair of reciprocal lattices in a common space. A natural requirement on the lattice then is that its reciprocal is part of the original lattice, i.e. that the reciprocal lattice does not introduce new points, the original discreteness is not broken.

From the point of view of the lattice, it is furthermore natural to require *permutation* symmetry of the metric, i.e. symmetry against permutation of the primitive generating vectors of the lattice. In this connection it is interesting to remember that such a permutation symmetric metric is only possible for metrics of two general types: definite metrics, and metrics with one deviating sign. As the Minkowski metric finds itself in the second category, the requirement of permutation symmetry - symmetry group S_4 - is allowed.

These requirements are met by an infinity of lattices; each one contains its reciprocal a number of times, the "multiplicity", and the smallest possible value of this multiplicity turns out to be three. In this exceptional case, which from now on is adopted as basis for further considerations, the reciprocal lattice is generated by four *null*vectors b_L^λ , whereas the generators of the original lattice, a_x^K , are space-like.

Let $\mathcal{L}(a)$ be the lattice, generated by four fourvectors a_x^K . It contains three copies $\mathcal{L}(b_1)$, $\mathcal{L}(b_2)$, $\mathcal{L}(b_3)$, generated by the set of four fourvectors b_L^λ , reciprocal to the a -set. The three sublattices together exhaust the original a -lattice; they are arranged in cyclic order along any coordinate line of $\mathcal{L}(a)$.

Spinors and spinor waves.

In every point of $\mathcal{L}(a)$ the prevailing symmetry is S_4 , the permutation group of four elements. In every point exists a direction invariant against S_4 , viz. the direction (1111). The group S_4 can be faithfully mapped on the subgroup of the three dimensional rotation group that leaves a cube invariant (the cube sports its four permuting diagonals as tangible illustration of this equivalence...). This latter fact has as important consequence that S_4 allows a two-valued representation in two complex dimensions, a *spinor* representation. This means that such a two component spinor has an objective meaning in every lattice point, it constitutes for this local group S_4 a "geometric object".

As is wellknown such a $SU(2)$ spinor allows generalisation, in two ways, to a Lorentz spinor. In what follows these will be called u-spinors and v-spinors respectively. Any two-component object in any of the lattice points permits these generalisations. Thus one can envisage two kinds of Lorentz spinor fields on any lattice, be it $\mathcal{L}(a)$ or $\mathcal{L}(bj)$ ($j=1..3$). The generalisations to Lorentz spinors become important because of the possibility to map u-spinors on v-spinors (and vice versa) with help of a Lorentz fourvector. Thus if a fourvector $V_x(PQ)$ can be assigned to an ordered pair of lattice points P and Q, a u-spinor $u(P)$ can give rise to a v-spinor in Q by the mapping

$$v(Q) = V_x(PQ) \sigma^x u(P)$$

where σ^x is a set of 2×2 matrices ($\sigma^0 = 1$, σ^k the Pauli matrices).

A similar mapping is

$$u(Q) = V_x(PQ) \sigma'^x v(P)$$

where the quadruple of matrices σ'^x is: $\sigma'^0 = -1$, $\sigma'^k = \sigma^k$. The obvious choice for the vector V_x is the lattice vector from P to Q. These mappings permit a concept of "propagation" if in addition be defined on the lattice a "topology", designating for each point its "neighbours". The choice of topology will be restricted by requiring S_4 invariance, and the proposed neighbours of a lattice point P are the four points Q with $PQ = a^M$, and as fifth the S_4 -invariant neighbour Q_0 with $PQ_0 = \sum_M a^M$. If P is in the sublattice $\mathcal{L}(j)$, all five points Q are in $\mathcal{L}(j+1)$. Please note that this concept of "neighbour" is one-sided, i.e. non-reciprocal. It will be used to describe the *directed* influence of a spinor in P on spinors in $Q_0 \dots Q_4$.

A u-spinor field on $\mathcal{L}(j)$ will, by virtue of the aforementioned mappings, induce v-spinors on $\mathcal{L}(j+1)$, and a given point Q on $\mathcal{L}(j+1)$ will receive influences from five points on $\mathcal{L}(j)$. The "shielding requirement" that no influence will reach $\mathcal{L}(j+1)$ translates into a condition between the five u-spinors in $\mathcal{L}(j)$ contributing to the same v-spinor in $\mathcal{L}(j+1)$. This condition plays the role of an equation of motion for the u-spinor field on $\mathcal{L}(j)$.

Plane wave solutions are now to be found, corresponding to momentum p_χ , and this leads to a dispersion law, i.e. a condition on p_χ . The two components of the spinor amplitude satisfy two homogeneous linear equations, which leads to a *complex* determinant condition, a requirement to be satisfied by the (real) momentum fourvector p_χ . Thus the dispersion law in general defines a twodimensional manifold, but this turns out to be degenerate in some cases.

In the vicinity of $p_\chi=0$ (which is a solution by virtue of the special choice of topology and mapping) one finds four null lines in momentum space, $p_\chi = \lambda b_{\mu\chi}$, where b_μ^χ are the (null) generators of the sublattice in question. Thus only four lines of null momentum rigorously satisfy the dispersion law in the vicinity of the origin. However, sufficiently close to the origin, i.e. for long wavelengths and small frequencies, plane wave solutions exist for *slightly different equations of motion*, corresponding to a slightly different lattice. The small change of lattice corresponds to a small translation (appropriate for the p_χ considered) of the sublattice $\mathcal{L}(b, j+1)$ with respect to $\mathcal{L}(b, j)$, a change of lattice which is similar to what is known, at the atomic or molecular scale, as crystal polarisation. For these plane waves the momentum is *anywhere* on the lightcone, and not only in the four lattice directions.

This circumstance enables a formulation for long wavelengths using only one lattice and a momentum-dependent embedding continuum: in stead of considering differently polarised lattices in a fixed embedding continuum, the lattices are identified with each other, and the embedding continuum, a construction a posteriori, has to be adapted, by a "ripple", to each passing wave. A universal continuum accomodating all spinor waves of small momentum does not strictly exist.

The principle of shielding thus makes possible the description of *three varieties* of spinor waves, that obey, in the long wavelength limit, Weyl's equation. This could indicate them as model for the three types of neutrino field found in nature.

Work in progress, in collaboration with M.Hazewinkel (Amsterdam) who

discovered new exact solutions of the dispersion condition for the equation of shielding, is a systematic study of these solutions under the supplementary condition $p_0=0$, i.e. of static solutions, waves that survive all lattice generations. These are called "persistent" ($p_0=0$), to be distinguished from the solution $p_x=0$, which is "ubiquitous" ($p_{1,2,3}=0$) besides being persistent. Some of the static solutions (and solutions with neighbouring momentum) may be suitable as models for quark waves. The shielding equations, without introducing terms designed to represent "interactions", have solutions that are nearly static ($p_0 \ll 1$) in two regions of (spatial) momentum space: near $p_k=0$, and around momenta the triple of which is equivalent to zero. The neighbourhood of this triple momentum zero is however different from that of single momentum zero. These two types of plane waves are candidate models for neutrinos and quarks respectively.

These suggestions hinge on solving the problem of the imposition of quantum mechanical (anti-)commutation rules for the plane wave amplitudes, which would make possible the formulation of (multi) particle states. The fact that persistent wave momenta essentially form a three dimensional space might be helpful in this connection.

Conclusion.

Although the present approach to space-time structure is only initiated in two preceding papers mentioned in the references, and is preliminary in character, a conclusion, just as preliminary, may still be permitted.

The assumption of a discrete space-time micro structure apparently presents potentialities in the domain of particle physics: the exceptional lattice structure could well be the origin of family relationships between particles, i.e. between elementary excitations of the vacuum. In this connection the excitation population of the neutrino degrees of freedom may play a formative role.

In a sense these aspects of space-time structure would form an extension of the role played by the curvature structure of space-time in the large: material processes on the small scale would be governed similarly by the micro structure of space-time.

References.

Two notes on the above considerations have appeared to date:

A remarkable space-time lattice and its spinor waves (I)

(Academiae Analecta, Proc.Royal Academy of Belgium, 55(1993)1-16)

Spinor waves in a space-time lattice (II)

(International J. Theor. Physics, vol.33(2),247-259, 1994)

This note is an elaboration of a short communication at the ANPA meeting 1994 at Cambridge (UK).

Status report as of July '95.

M. Hazewinkel has completed the inventory of static plane wave solutions, i.e. plane wave solutions with $p_0=0$. Besides the point $p_k=0$, the limit of infinite wavelength, static solutions exist on a complicated curvilinear network in momentum space, separated from the origin by a finite gap. The network is restricted roughly to a spherical shell of p between $\sqrt{2}$ and $2\sqrt{3}$ in units $2\pi/3$. It contains at its inner limit twelve points the threefold momentum of which is, in the periodic momentum space, equivalent to $p_k=0$. Solutions in the vicinity of any one of these twelve points with $p_0 \neq 0$ exist and are removed in two of the four possible null directions - the pair being inequivalent under S_4 - and will yield upon momentum tripling an equivalent momentum near zero. This behaviour is characteristic for quarks: a single quark cannot be observed, whereas three of them have an accessible total momentum. Thus the model contains 12×2 candidates for quark states, each having an effective momentum in one of the four sublattice null-directions. As it turns out each "quark" state and each "anti-quark" state can be realised in three ways, and it is tempting to take this fact as a possible interpretation of the color parameter in quark physics. Symmetry between color states would be, in this perspective, an aspect of the overall S_4 symmetry of the lattice. These considerations, though suggestive, lack an ingredient to allow the desired quark interpretation: the possibility to compose plane waves, as is done in quantum field theory, to yield composite states carrying the sum of the fourmomenta of the composing waves. The restriction to the very close vicinity of the static waves, i.e. to a three dimensional momentum space, offers the opportunity to impose a structure similar to that of quantum field theory by requiring the amplitudes to obey anticommutation relations local in spatial momentum space. In this way states of three "quarks" can be conceived, which have a total fourmomentum close to zero.

A note about the static spinor waves on the space-time lattice will be presented - together with M. Hazewinkel - to International Journal of Theoretical Physics.

Recapitulating it can be stated that the proposed discrete model for space-time is the result of general a priori symmetry requirements. These requirements lead to a threefold covering of space-time, the possible origin of the existence of three families of leptons and quarks. Furthermore the momenta of (nearly) static plane waves - which are the ingredients of "persistent" solutions of the equations of motion in each of the sublattices - are restricted to two regions in momentum space: the vicinity of the origin, and a region around $2\pi/3$ for each of the three momentum components. The region around the origin of momentum space will correspond to lepton waves, and quark waves are to be modelled by waves with momenta in some of the other regions. There are twelve of these latter regions available for waves in each sublattice, each centered around a momentum the triple of which is equivalent to zero. Deviations from this central momentum are possible in two of the four null directions. The upshot is that these plane waves are suitable, kinematically to model in each sublattice the states of two quarks, with an extra degeneracy of three: a given quark wave allows three separate model waves, a feature which presents a natural interpretation of the color degree of freedom.

The twofold structure of the set of "nearly static" solutions to the proposed equations of motion - nearly static on the scale of the Planck frequency - is suggestive as a model for the lepton-hadron dichotomy found in nature.

A feature worth mentioning is the way correspondence with the usual concepts is established. This is especially relevant for the usual space-time symmetries: how can ordinary relativistic free field equations follow from a scheme with S_4 symmetry? The proposed answer is that this is only required for "physically relevant" momenta, extremely small as compared to the Planck momentum. It is only waves of these momenta that are of concern.

Clearly the arguments put forward are by far not sufficiently convincing to advocate a complete restructuring of the basic principles of physics. But they might motivate and induce further enquiries in the direction described, to find more implications of discreteness in space and time.

Appendix: Some problems.

There is a multitude of problems suggested by this approach to discrete space-time. To mention a few:

1. How are the space-time points ("CAPs") generated? Do they arise because of the "existence" of "quarks" in the persistent (near-static) modes?
2. What was the world like *before* the four dimensional ordering of the CAPs took place? Is the ordering to be thought of as a cooperative phenomenon, like a phase transition?
3. Is long range order promoted by "actually existing" neutrino excitations?
4. What could be a reason for using only the twelve (innermost) triple-momentum-zero states in the description of "quarks", while those further afield seem not to be relevant (they do not lead to the color degree of freedom)? Could there be a relation with the cosmological tendency toward long wavelengths?
5. The fact that in conventional physics phenomena are (nearly) invariant against time reversal, while in the discrete space-time discussed above the basic propagation mechanism is flagrantly opposing this symmetry, should be related to the marginal character (in momentum space) of physical phenomena, these being restricted to very small energies and momenta. This point is in dear need of clarification (which need it shares with many other points).
6. First priority should be given to a study, in this context, of electromagnetism, also in connection with fractional quark charges.

ABSTRACT

Commencing with the hypothesis that the internal gravitational energy of most sub-atomic particles is related to the minimum energy $\hbar/T_0$ (T_0 = age of the universe), it is predicted that the ratios between the masses of baryons and that of the proton (M_p) should, when cubed, yield a set of integers or straightforward fractions. Baryons of accurately determined masses are used to confirm this prediction. Analysis of such fractions leads to the finding that the ratio between the actual radius of the proton and its Compton Radius is exactly four and that the internal gravitational energy of the proton is equivalent to three quanta of energy. Further analysis suggests that the resulting expression relates to a proton in a frame of reference at the periphery of the universe.

Similar analysis using the mass of the electron M_e leads to the finding:

$$M_p/M_e = (3/2)^{1/3} \cdot \sqrt{137}/\alpha \quad (\text{correct to three parts in } 10^5), \text{ and}$$

$$T_0 = 18.1129 \times 10^9 \text{ years.}$$

The theory of quantised variables: its application to the masses of sub-atomic particles.

1 Introduction

The theory of quantised variables was developed in three earlier papers presented to ANPA (ref 1, 2 &3). This paper relies upon some of the findings.

It was argued in paper one that many variables are quantised and possess both maximum and minimum values. It was proposed, for instance, that energy has a minimum (quantum) value of $\hbar/T_0$. (T_0 = age of universe).

It was shown in paper two that the quotient (q) of two quantised variables (l and m) may itself exhibit quantisation at the point where $q = l_{\min}/m_{\min}$, and that such quantisation is often of the form q , $q/2$, $q/3$, ... q/n . It was also proposed there that circumstances may exist in which $e^2 = \hbar.c$ - not $\alpha.\hbar.c$ (where e is the electronic charge and α is the Fine Structure Constant).

It was argued in paper three that the many reported observations of quantisation of galactic red-shifts can be analysed to show that the Solar System is in a region of the universe where gravitational potential (relative to the periphery of the universe) is $c^2(1/2 - 1/N)$, where $N = 67 \pm 2$.

These findings are used in conjunction with the emerging theory of quantised variables to examine and, if possible, explain the relationships between the masses of various sub-atomic particles.

Information on sub-atomic particles (including that quoted in this paper) is collected by the Particle Data Group and is published by the American Physical Society (ref 4). Such particles are often grouped under various heads: leptons (including electrons and other particles that have half-integral spin and do not take part in 'strong' interactions); mesons (particles that are characterised by possessing integral spin numbers); and baryons (heavy particles, including protons and neutrons, that possess half- integral spin).

2 The Hypothesis

The hypothesis on which this paper is based is that the internal (or 'self') gravitational energies of many sub-atomic particles (baryons in particular) are related to the minimum energy $\hbar/T_0$. Such a hypothesis is not new, and was first proposed in 1952 by Whitrow (ref 5). However, the arguments that result from such a hypothesis differ from those offered by Whitrow.

3 The application of the hypothesis to protons and other baryons.

The internal gravitational energy E_p of the proton is given by the expression:

$$E_p = A_p \times G.M_p^2 / R_p,$$

where M_p is the mass of the proton, G is the gravitational constant, R_p is the radius of the proton, and A_p is an integer or simple fraction. The value of A_p depends on the physical nature of the proton; for example, the value would be $3/5$ for a homogeneous sphere but $1/2$ for a thin spherical shell.

According to the hypothesis, the energy E_p can be related to the minimum energy $\hbar/T_0$. Thus:

$$A_p \cdot G.M_p^2 / R_p = B_p \cdot C \cdot \hbar/T_0, \quad (1)$$

where B_p and C are two further constants.

The constant B_p is particle-specific and relates to the number of quanta possessed by the internal gravitational energy of the proton and, thus, might be expected to be unity or a higher integer. (However, there is a possibility that B_p might turn out to be fractional should one or more energy quanta be required for the simultaneous formation of several particles).

The constant C is a scaling factor and may have any value. It may be needed to take account of factors such as the possibility that the relationship described by equation (1) may obtain in a frame of reference other than that from which it is observed. It is assumed, therefore, that C is not 'particle-specific' but remains constant for all of a family of particles (eg for all baryons).

In order to proceed further, it is now explored whether the R_p term in (1) might be expressed in terms of the mass M_p . For example, the Compton Radius of the proton, R_{pc} , is defined by the relationship

$$\hbar = M_p \cdot c \cdot R_{pc}. \quad (2)$$

Unfortunately, it cannot be assumed that the true radius of the proton is equal to its Compton Radius. However, (2) can be rearranged to give:

$$\hbar/2 = 1/2 \times M_p \cdot (R_{pc})^2 \times c/R_{pc}$$

which describes a rotating proton-like particle of moment of inertia $1/2.M_p.(R_{pc})^2$ and angular momentum $\hbar/2$, and which has an equatorial speed of c . Such a speed is the quotient of a distance and a time and, in appropriate circumstances, could be expected (according to the emerging theory of quantised variables) to demonstrate quantisation of the form $c/2, c/3, \dots, c/n$. If the equatorial speed of the particle turns out to be c/n , the moment of inertia of the particle will have to be enlarged by a factor of 'n' in order to preserve the angular momentum at its quantised value of $\hbar/2$.

$$\text{Thus, } \hbar/2 = 1/2 \times n \times M_p.(R_p c)^2 \times c/n.R_p c = n/2 M_p.R_p c.c/n$$

If the particle has an angular momentum of $J.\hbar/2$, (where J is an integer)

$$J.\hbar/2 = J.n/2 M_p.R_p c.c/n$$

If M_p remains unchanged and R_p is substituted for $J.n.R_p c$

$$J.\hbar/2 = 1/2. R_p.M_p.c/n$$

$$= 1/2 R_p^2.M_p.c/R_p.n$$

which describes a particle of angular momentum $J.\hbar/2$, moment of inertia $1/2.R_p^2.M_p$, and angular velocity $c/R_p.n$. In other words,

$$R_p = J.n.R_p c = D_p.R_p c, \quad (3)$$

where D_p is an integer and is divisible by J. Thus, quantisation of equatorial speed, combined with quantised increases in angular momentum, may cause the radius of a particle such as a proton to exceed the Compton Radius by a factor that is an integer. Such an assumption is now made.

Equations (1) and (3) lead to the equation:

$$A_p.M_p^3 = B_p.C.D_p.\hbar^2/G.c.To \quad (4)$$

In accordance with the initial hypothesis, a set of similar expressions can be written for other baryons. In the general case, let a baryon be denoted by 'x'. Equation (4) then becomes

$$A_x.M_x^3 = B_x.C.D_x.\hbar^2/G.c.To \quad (5)$$

Dividing (5) by (4) yields

$$(M_x/M_p)^3 = B_x.D_x/B_p.D_p, \quad (6)$$

on the assumption that for all baryons $A_p = A_x$ and C is constant.

It was argued earlier that B_x , D_x , B_p , and D_p are integers or straightforward fractions, which leads to

Prediction 1: that values of $(M_x/M_p)^3$ should be a set of not-too-complicated fractions.

Further to this, equation (3) gives

Prediction 2: that the constant D_x should be divisible by the spin number J_x .

Prediction 1 is now put to the test. Some baryons have masses that have been measured with low accuracy, but other baryon masses have been determined with considerable accuracy, and it is these that have been used in compiling Table 1.

This table uses data analysed by the Particle Data Group, who point out that all quoted errors are 'Gaussian' in nature - ie that an error δx means that the range $x \pm \delta x$ is intended to be a 68.3% confidence interval about the central value x . This interpretation of error consequently applies to all tables given in this paper.

Table 1 The relationship between the masses of baryons (with accurately determined masses) and that of the proton.

Particle	Mass (MeV)	$(M_x/M_p)^3$	Fraction (F)	Calculated Mass ($3\sqrt{F} \times M_p$)
p	938.27231 $\pm$ 0.00028			
Λ 1232	1232 $\pm$ 2	2.26	2 1/4	1229.5
Λ	1115.6 $\pm$ 0.05	1.68	1 2/3	1112.5
Λ 1405	1407 $\pm$ 4	3.35	3 1/3	1401.6
Σ^+	1189.37 $\pm$ 0.07	2.036	2.0	1182.2
Σ^0	1192.55 $\pm$ 0.1	2.052	2.0	
Σ^-	1197.43 $\pm$ 0.06	2.078	2.0	
Σ 1385	1382.8 $\pm$ 0.4	3.19	3 1/4	1389.8
	1383.7 $\pm$ 1.0	3.19	3 1/4	
	1387.2 $\pm$ 0.5	3.23	3 1/4	
Ξ^0	1314.9 $\pm$ 0.6	2.752	2 3/4	1314.6
Ξ^-	1321.9 $\pm$ 0.13	2.796	2 3/4	
Ξ 1530	1531.8 $\pm$ 0.3	4.351	4 1/3	1529.7
	1535.0 $\pm$ 0.6	4.379	4 1/3	
Ξ 1820	1823 $\pm$ 5.0	7.33	7 1/3	1822.9
Ξ 2030	2025 $\pm$ 5.0	10.03	10	2021.5
Ω^-	1672.43 $\pm$ 0.32	5.66	5 2/3	1672.8
Λ^+_c	2284.9 $\pm$ 0.6	14.39	14 1/3	2279.2

As can be seen from this table, substituting baryon masses into the expression $(M_x/M_p)^3$ yields numbers that closely match a set of straightforward fractions and integers, thus supporting Prediction 1.

Such matching is not always exact. For example, some baryons occur in groups known as multiplets, each particle possessing a similar mass but differing in other ways (eg charge). The masses of particles within such groups, although similar, are not identical. In such cases the calculated fraction or integer given in Table 1 appears to have a small off-set. In other cases the match is close but does not quite accord with the claimed accuracy of particle mass measurement. (Note: each measured mass has been derived by the Particle Data Group by averaging several sets of experimental results; referring to such sets shows that many calculated masses as given in Table 1, which apparently do not match the quoted accuracies of mass measurement, do in fact match the findings of several experimentalists).

Perhaps there is some form of 'fine-structure' effect that can account for such small discrepancies, for example small distortions in the constant 'A'. Whatever the cause, the closeness of the match between the calculated and measured baryon masses is striking and, in many cases, is well within the claimed accuracy of measurement. It is considered unlikely that the matching shown in Table 1 is the product of mere chance and, hence, that further consideration of the hypothesis that underpins this paper is justified.

It is noted that the particles listed in Table 1 exhibit a range of parities, spins, isospins, and strangeness. Such factors do not appear, therefore, to affect the quantisation described above, but might, of course, account in some way for the small discrepancies already noted.

It is also noted that the denominator of each fraction given in Table 1 is either a three or a four.

4 An investigation into the constants 'B' and 'D'.

In order to take the investigation further, it is necessary to determine (if possible) the value of the constants in equation (6).

The constant D_p is the ratio between the true radius of the proton and its Compton Radius. The actual and Compton radii for the proton and neutron are given in Table 2 (ref 6).

Table 2 Experimental Radii and 'Particle Compton Radii'

Particle	Experimental rms radius (fm)	Particle Compton radius (fm)	Constant 'D'
Proton	0.82 +/- 0.02	0.21	4.0
Neutron	0.82 +/- 0.02	0.21	4.0

As the number four occurs several times in Table 1 as a fraction denominator, it seems reasonable to conclude that the constant $D_p = 4.0$.

As the other frequently appearing denominator is three, it seems equally reasonable to conclude that $B_p = 3.0$, and that the internal gravitational energy of the proton is the equivalent of three quanta of energy, ie $3.\hbar/T_0$.

Thus equation (5) can be rewritten

$$A_p. M_p^3 = 12. C. \hbar^2/G.c.T_0 \quad (7)$$

5 The Relationship between the $B_x.D_x$ product and the Spin Number J_x .

As is shown readily by an examination of the particle tables of the Particle Data Group, baryons occur in several different series according to qualities such as strangeness, charm or beauty. Each series contains baryons of differing masses (M_x) and spin numbers (J_x). Although many masses have not been determined with great accuracy, most are sufficiently accurate to permit values for $B_x.D_x$ to be proposed and to be tested in accordance with Prediction 2 - ie that D_x (and hence the product $B_x.D_x$) should be divisible by J_x .

Table 3 Delta Resonances - non-strange baryons

Likely Mass (MeV)	Mass Range	Spin $J_x(\hbar/2)$	$(M_x/M_p)^3$	Fraction F	Calculated Mass ($3\sqrt{F} \times M_p$)	$B_x.D_x$. ($F \times 12$)
1232	+ -2	3	2.26	2 1/4	1229.5	27 ($3^2 \times 3$)
1600	1550 - 1700	3	4.96	5.0	1604	60 (3×20)
1620	1615 - 1675	1	5.20	5 1/4	1630	63
1700	1670 - 1770	3	5.95	6.0	1705	72 ($3^2 \times 8$)
1900	1850 - 1950	1	8.30	8 1/4	1896	99
1905	1870 - 1920	5	8.36	8 1/3	1902	100 ($5^2 \times 4$)
1910	1870 - 1920	1	8.44	8 1/2	1914	102
1920	1900 - 1970	3	8.57	8 1/2	1914	102 (3×34)
1930	1920 - 1970	5	8.70	8 3/4	1933	105 (5×21)
1950	1940 - 1960	7	8.97	8 3/4	1933	105 (7×15)
2420	2300 - 2500	11	17.15	16 1/2	2389	198 (11×18)

Note: only baryons rated by the Particle Data Group as 'three-star' or better have been included in Tables 3 and 4. The existence of such particles is in little doubt as each mass has been measured several times and with reasonable accuracy. The many baryons rated as 'two-star' or below have been ignored.

Table 4 'N' Baryons - non-strange

Likely Mass (MeV)	Mass Range	Spin Jx($\hbar/2$)	(Mx/Mp) ³	Fraction (F)	Calculated Mass ($3\sqrt{F} \times M_p$)	Bx.Dx (F x 12)
1440	1430 - 1470	1	3.61	3 2/3	1446.8	44
1520	1515 - 1530	3	4.25	4 1/4	1519.8	51 (3 x 17)
1535	1520 - 1535	1	4.35	4 1/3	1529.7	52
1650	1640 - 1680	1	5.43	5 1/2	1656	66
1675 ⁻	1670 - 1685	5	5.68	5 5/6	1689	70 (5 x 14)
1680 ⁺	1675 - 1690	5	5.74	5 5/6	1689	70
1700	1650 - 1750	3	5.95	6.0	1705	72 (3 ² x 8)
1710	1680 - 1740	1	6.09	6 1/12	1712	73
1720	1650 - 1750	3	6.25	6 1/4	1728	75 (3 x 25)
2190	2100 - 2200	7	12.71	12 1/4	2163	147 (7 ² x 3)
2220 ⁺	2180 - 2310	9	13.25	13 1/2	2234	162 (9 ² x 2)
2250 ⁻	2170 - 2310	9	13.78	13 1/2	2234	162
2600	2580 - 2700	11	21.27	21 1/12	2592	253 (11 x 23)

Although the data given in Tables 3 and 4 are insufficiently accurate to be used as confirmation of Prediction 1, they appear to support Prediction 2 in that all Bx.Dx products quoted are divisible by Jx and, strikingly, in many cases are divisible by Jx².

In some cases - see for example $\Delta 1950$ and $\Delta 2420$ - such products are not those immediately suggested by the values of the cubed mass ratios, but are similar in value. In such cases, the products have been selected to test whether Prediction 2 is compatible with the particle mass accuracies quoted. However, in most cases, the products quoted are exactly those suggested by the cubed mass ratios - see for example $\Delta 1232$ and $\Delta 1600$.

Both N and Δ baryons are classified as non-strange. Other baryons are classified differently. It is noted that many of those classified as strange do not possess Bx.Dx products that are divisible by Jx. The reason for this is not understood. However, the availability of further data may permit this observation to be used to explore the differences between strange and non-strange particles.

Three particles deserve special mention as follows:

N1720. The calculated fraction F for this particle is given in Table 4 as $6 \frac{1}{4}$. This leads to a $Bx.Dx$ product of 75 which, as is required by Prediction 2, is divisible by 3. However, on the assumption that many products are divisible by Jx^2 , it is thought likely that the true value for F is 6.0, as this value leads to a $Bx.Dx$ product of 72 which is divisible by 3^2 . Referring to the experimental results on which the quoted mass value of 1720 is based shows three readings as follows: 1717 $\pm$ 31 (Manley), 1700 $\pm$ 50 (Cutkosky) and 1710 $\pm$ 20 (Hoehler). If ' F ' = 6.0, the calculated mass for this particle becomes 1705, which is thought to be compatible with the experimental results quoted above and, therefore, to be more probable than the mass 1720 proposed by the Particle Data Group.

N2190. Although an ' F ' value of $12 \frac{3}{4}$ would seem to be indicated for this particle, the value quoted in Table 4 is $12 \frac{1}{4}$ (as this value leads to a $Bx.Dx$ product of 147 which is divisible by both 7 and 7^2). The calculated mass becomes 2163, which differs significantly from the 'measured' value of 2190. The experimental results on which the 2190 value is based are: 2127 $\pm$ 9 (Manley), 2200 $\pm$ 70 (Cutkosky), 2140 $\pm$ 12 (Hoehler), and 2140 $\pm$ 40 (Hendry). In the light of these results it is believed that 2163 may be closer to the true mass of this particle than 2190.

N2600. The $Bx.Dx$ product quoted in Table 4 for this particle is 11×23 . It is thought possible, however, that this product should be $11^2 \times 2$. Such a value leads to a calculated mass of 2554, not 2600. The appropriate experimental results are 2577 $\pm$ 50 (Hoehler) and 2700 $\pm$ 100 (Hendry). A value of 2554 would appear, therefore, to be an acceptable prediction.

6 Quark theory.

At this point some note has to be taken of the important concept that baryons (and other particles) consist of subsidiary particles known as quarks. Although the determination of quark masses is controversial, most writers seem to agree that quarks have half-integral spin and that a proton consists of three quarks plus other particles.

Such thinking appears to coincide with the finding given above that the internal gravitational energy of the proton consists of three quanta of energy - ie that the proton might consist of three subsidiary particles each possessing the basic internal gravitational energy $\hbar/T_0$.

Some quark protagonists concede that other baryons may have to possess more than three quarks. Others insist that all baryons consist of just three quarks, these providing the spin, charge and magnetic moment characteristics of the baryon concerned. The theory being expounded in this paper appears to support the former interpretation. For example $\Delta 1600$ has a $Bx.Dx$ product of 60 - ie $3 \times 4 \times 5$ - and a spin of $3\hbar/2$. Dx has to be divisible by three and, as the number of quarks would have to be odd (in order to provide an odd value of Jx), the number of quarks

present would have to be five. Similar arguments concerning other particles yield other quark numbers - eg 7 or 11.

Furthermore, the fact that many of the $B_x.D_x$ products quoted in Tables 3 and 4 are divisible by J_x^2 may mean that, in such cases, $B_x = J_x$, and that the number of quarks is exactly equal to the spin number. This makes sense if each quark contributes a half integral spin to the host baryon - a view that may, however, be incompatible with the Pauli Exclusion Principle as currently understood.

It is interesting to refer to the particles $\Delta 1930$ and $\Delta 1950$ in Table 3, the former possessing $J_x = 5$ and the latter possessing $J_x = 7$, but both possessing a $B_x.D_x$ product of 105 ($7 \times 5 \times 3$). In the former case, D_x being divisible by 5, it might be argued that 7 quarks are present in order to provide $J_x = 5$. In this case, the spins of two quarks will have to be equal and opposite in order to cancel out. In the latter case it can be argued that only 5 quarks are present, but have to provide a total spin no J_x of 7. In such a case at least one quark will have to possess a spin of greater than $\hbar/2 - 3/2\hbar$ perhaps.

It is concluded, therefore, that the theory of quantised variables may be able to contribute to our understanding of quarks but that extensions to current quark theory may be required. It is noted, in particular, that some particles may possess more than three quarks, and that some quarks may possess spins that are equal but opposite, while others may possess spins of more than $\hbar/2$.

7 An investigation into the constant C.

Equation (7) has three unknowns: A_p , C and T_o . However, some information concerning these unknowns is available. It is generally accepted, for example, that the value of T_o lies somewhere in the region $10 - 20 \times 10^9$ years, or $3.1 - 6.2 \times 10^{17}$ s. Furthermore, it is reasonable to assume that the value of A_p is not less than $1/2$ nor greater than 1.0. Hence, it is immediately obvious by straightforward arithmetic that C cannot be of value unity (and would need to be ca 200 in value), and thus that (7) may describe a process that, although observed by us, takes place in a frame of reference other than our own.

To make progress, three 'intelligent guesses' are needed:

- a) that equation (7) describes a proton at the periphery of the universe but observed by us;
- b) that the gravitational potential difference between the periphery of the universe and the Solar System is $c^2(1/2 - 2/137)$; and
- c) that the scope of the General Theory of Relativity can be expanded to include the variation of mass when viewed across a difference of gravitational potential, in a manner similar to the variation of length and time when so viewed, and in a

manner analogous to the variation of mass attributable to the Special Theory of Relativity.

Each 'intelligent guess' requires some justification. Guess (a) depends upon the fact that the internal gravitational energy of the proton is minute compared with, say, the mass energy of the proton and is only likely to be of significance when the net energy of the particle approaches zero. Such a situation obtains at the periphery of the universe where the gravitational potential (with respect to infinity - see paper one) is $-c^2$, ie the potential at the surface of a body of mass c^3T_0/G and radius $c.T_0$. In such circumstances the mass energy of a particle, $M.c^2$, is equal but opposite to its gravitational potential energy, $-M.c^2$.

Guess (b) depends upon the observation - see paper three - that galactic red-shifts are quantised, the subsequent finding that such quantisation is predicted by the theory of quantised variables and can be accounted for by a quantisation of gravitational potential throughout the universe, and the calculation that the Solar System is at a potential difference with respect to the periphery of the universe of $c^2(1/2 - 1/N)$ where $N = 67 \pm 2$. Guess (b), therefore, is that $N = 137/2$.

Guess (c) rests on the fact that the frequency of radiation is modified when such radiation passes across a difference of gravitational potential, and the deduction that a mass (converted into a pulse of radiation and then viewed across a similar potential difference) would appear to an observer to be similarly modified.

The consequence of guesses (a), (b), and (c) is that a proton at the periphery of the universe viewed from the Solar System would appear to be less massive than a local proton by a factor of $\sqrt{1 - 2\Delta\phi/c^2}$ or, as the gravitational potential difference $\Delta\phi$ between these two locations is $c^2(1/2 - 2/137)$, a factor of $2/\sqrt{137}$. Under the terms of these guesses, therefore, the constant C of equation (7) is $(\sqrt{137}/2)^3$.

Equation (7) thus becomes

$$A_p.M_p^3 = 12/8. (\sqrt{137})^3 \times \hbar^2/G.c.T_0 = 3/2 (\sqrt{137})^3 \times \hbar^2/G.c.T_0 \quad (8)$$

The validity of this equation will be tested in the light of the arguments that follow concerning the mass of the electron.

8 The mass of the electron.

As was argued in paper two, the charge of the electron is recognised as the minimum quantum of charge and, by equating minimum energies, should comply with the following expression:

$$e^2/c.T_0 = \hbar/T_0, \quad (9)$$

$$\text{or } e^2 = \hbar \cdot c \quad (10)$$

where e is the electronic charge, $c \cdot T_0$ is the radius of the universe, and $\hbar/T_0$ is the minimum quantum of energy.

But equation (10) conflicts with the definition (11) of the Fine Structure Constant α , where $\alpha = 1/137.036$.

$$e^2 = \hbar \cdot c \times \alpha \quad (11)$$

It was proposed by Eddington (ref 7) that there are 137 degrees of freedom that relate to the attraction between two electronic charges. Such a proposal might resolve the difference between (10) and (11), were it not for the inconvenient fact that $1/\alpha$ is not an exact integer. However, an alternative explanation is that there is a set of circumstances in which equation (10) is valid. Without speculating here on the nature of such circumstances, it is proposed that the basic hypothesis of this paper should be tested against an electron as defined by equation (10).

It is commonly assumed that the mass of an electron arises solely from its charge and is of the form $e^2/Re \cdot c^2$ (where Re is the appropriate radius of the electron). If e^2 is to be increased according to (10) by a factor of $1/\alpha$, the mass of the electron should increase in proportion.

Thus an analogue of equation (4) can be written for the electron:

$$Ae \cdot (Me/\alpha)^3 = Be \cdot C \cdot De \times \hbar^2/G \cdot c \cdot To$$

As electric charge distributes itself over the surface of a sphere, it seems reasonable to guess that Ae should relate to a thin spherical shell and should, therefore, have the value $1/2$. As the electron is a basic particle, it seems reasonable to guess that $Be = 1$, ie that the internal gravitational energy of the electron is equal to one quantum of energy. It also seems reasonable to guess that the radius should equal the Compton Radius - the minimum radius that would permit the such an electron to possess the required quantum of angular momentum. Finally, the scaling factor 'C' is assumed to be taken into account by the factor $1/(137.036)^3$, or α^3 .

$$\text{Thus } Me^3 = 2 \cdot \alpha^3 \cdot \hbar^2/G \cdot c \cdot To \quad (12)$$

9 The ratio between the mass of the proton and that of the electron.

The validity of equations (8) and (12) is hard to test individually due to lack of precision in the known value of T_0 . However, (12) can be taken in conjunction with (8) to calculate the ratio M_p/M_e . Provided that $Ae = Ap$, the result is Prediction 3.

$$M_p/M_e = (3/2)^{1/3} \cdot \sqrt{(137)/\alpha} = 1836.082 \quad (13)$$

The mass ratio M_p/M_e has been measured precisely and is equal to 1836.15. Hence the calculated ratio has an error as compared with the measured ratio of ca three parts in 100,000.

Although small, such an error is greater than can be attributed to inaccuracies in the measurement of the proton and electron masses. Several explanations for this might be considered. For example, the proton is itself part of a multiplet that includes the neutron. As with other multiplets, this may be the cause of a small offset.

Nevertheless, the extreme closeness between the measured and predicted mass ratio M_p/M_e gives some confidence that the theory expounded in this paper has value. This theory can be expanded by use of Table 1 to yield relationships between the masses of all baryons and that of the electron. For example and at random:

$$M_{\Xi(2030)}/M_e = (15)^{1/3} \times \sqrt{(137)}/\alpha$$

10 The masses of mesons.

As in Table 1, Table 5 shows the results of calculating the cubed ratios between the masses of some mesons (particularly those that are accurately known) and that of the proton.

Table 5

Name of particle	Mass (Mx) MeV	Spin	(Mx/Mp) ³	Fraction (F)	Calculated mass (3√F.Mp)
π^+	139.57 +/- .0007	0	1/303.88	1/304	139.54
π^0	134.97 +/- .0038	0	1/336.03	1/336	139.96
η	548.4 +/- 0.6	0	.19966	1/5	548.7
$\rho(770)$	769 +/- 3	1	.55088	5/9	771.3
$\omega(783)$	782.6 +/- 0.2	1	.58025	4/7	778.6
$\eta(958)$	957.57 +/- 0.25	0	1.02056	17/16	957.4
$s(975)$	975 +/- 4	0	1.12207	9/8	975.8
$\delta(980)$	983 +/- 2	0	1.14990	8/7	980.91
$\phi(1020)$	1019.61 +/- 0.07	1	1.28323	9/7	1020.25
$h1.1170$	1170 +/- 20	1	2.039	2.0	1182
$b1.1232$	1232 +/- 10	1	2.28	2 1/4	1229
$\kappa(892)$	892.8 +/- 0.4	1	.8586	6/7	891.26
κ^+	493.667 +/- 0.015	0	.14565	4/27	496.47
κ^0	497.67 +/- 0.13	0	.14922	4/27	496.47

The accuracy with which straightforward fractions appear to determine the masses of mesons (in terms of the proton mass) is, once again, surprising. However, the fractions in question appear to be less ordered than those for baryons (Table 1) and the meaning of the cubed mass ratios is correspondingly more difficult to determine. Furthermore, there seems to be little obvious correlation between $B \times D$ products and spin numbers. Nevertheless, information in Table 5 taken together with equation (13) enables meson masses to be calculated in terms of the electron mass. For example and again at random:

$$M_{\eta}/M_e = (3/10)^{1/3} \times \sqrt{137}/\alpha.$$

11 The age of the universe.

The considerable accuracy of the results yielded by equation (13) suggests that equation (12) might reasonably be used, as Prediction 4, to calculate the age of the universe T_0 .

Rewriting (12) gives:

$$T_0 = 2 \alpha^3 \times \hbar^2 / G.c.M_e^3$$

Using current values for the constants concerned gives $T_0 = 18.1129 \times 10^9$ years - a result that falls within the established limits of 10 - 20 billion years and agrees with modern thinking that values in excess of 15 billion years are more probable than others. It should be pointed out, however, that this calculation of T_0 depends heavily upon the assumption that $A_e = 1/2$. This constant is geometry dependent and, for example, should the electron turn out to be a homogeneous sphere, not a hollow shell, T_0 would reduce to ca 15×10^9 years.

12 Summary

The arguments given in this paper are exploratory. The findings have, therefore, be judged in this light.

It is hoped, nevertheless, that the accuracy of the predictions quoted is sufficient justification for bringing this paper to the attention of ANPA. In particular, the proposal that the age of the most massive body that exists - the universe - might be calculable from the mass of one of the least massive sub-atomic particles - the electron - is considered to be both intriguing and challenging, and as such to merit further consideration.

Geoffrey Constable

23 August 1994

- Ref 1 'The maximum and minimum values of physical variables' ANPA 13
Ref 2 'An investigation into the maximum and minimum values of electrical variables' ANPA 14
Ref 3 'The quantisation of gravitational potential and its consequences upon galactic redshifts' ANPA 15
Ref 4 Physical Review D Part 2 Review of particle properties 1 June 1992
Ref 5 Whitrow Letters to Nature - 18 February 1950
Ref 6 'The Enigmatic Electron' MacGregor Kluwer Academic Publishers
Ref 7 'The Expanding Universe' Eddington - Cambridge Science Classics

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**FUNDAMENTAL UNITS,
UNIFICATION
and the
AGE OF THE UNIVERSE**

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**THE STARSON CORPORATION
404 N.W. 68th Avenue
Suite 417
Plantation, Florida U.S.A. 33317
(305) 791-5606**

ABSTRACT

A dimensional analysis is presented based upon the four Planck natural units of time, length, mass and temperature using $\hbar$, c , G_N and k (Boltzmann's constant). These Planck units are used to define the minimum and maximum units of time, length, mass, temperature, velocity, acceleration, force, energy, frequency and momentum. The quotient of the dimensionally derived Max/Mins of the Planck units is postulated to equal the age of the universe in chronons ($t_p = 1$ chronon). The charge of the electron (e_c) along with phase-locked gravity waves are explained as forming the shell of an electron so that its temperature (min. temperature; T_θ) may be determined. This results in an equation that the age of the universe may be calculated from ($t_0 = 15.72594177$ billion years). The equations show that the mass of the universe is increasing with time and from this the "time-to-closure" of the universe is calculated. This "closure" calculation results in a unification between the electromagnetic and gravitational forces with temperature and explains Dirac's Large Number Hypothesis.

THE PLANCK NATURAL UNITS

The four Planck natural units may be derived by dimensional analysis

G.Hunter, B.Wadlinger¹. They are as follows:

$$\text{min Planck Time} \rightarrow t_p = \sqrt{(\hbar G_N / c^5)} = 5.390561369 \times 10^{-44} \text{ sec} \quad (1)$$

$$\text{min Planck Length} \rightarrow l_p = \sqrt{(\hbar G_N / c^3)} = 1.616049643 \times 10^{-35} \text{ m} \quad (2)$$

$$\text{max Planck Mass} \rightarrow M_{pk} = \sqrt{(\hbar c / G_N)} = 2.176712694 \times 10^{-8} k_g \quad (3)$$

$$\text{max Planck Temperature} \rightarrow T_x = \sqrt{(\hbar c^5 / k^2 G_N)} = 1.416962973 \times 10^{32} \text{ }^\circ\text{K} \quad (4)$$

Where: $\hbar$ = Planck's constant over 2π ; $\hbar/2\pi$, G_N = Gravitational constant, k = Boltzmann's Constant, c = the speed of light.

NOTE: " $\hbar$ " is used in these definitions of Planck's units instead of " h " because " $\hbar$ " represents the minimum change in angular momentum.

The Planck Temperature can also be thought of as:

$$\begin{aligned} T_x &= \text{Newton} \cdot \text{Meters} / k \\ &= M_{pk} \cdot l_p^2 / t_p^2 \cdot k \\ &= 1.416962973 \times 10^{32} \text{ }^\circ\text{Kelvin} \end{aligned} \quad (5)$$

These values are suggested to describe the initial conditions of the "Big Bang", a Planck mass with radius l_p that remains in this state for t_p seconds or one chronon. T_x represents the maximum temperature possible in the universe today, whereas T_{BB} (the temperature of the Big Bang) will be calculated later. These conditions allow us to calculate the Schwarzschild Radius (R_s) and we find that the Universe starts in a black hole condition with a diameter of R_s .

$$\begin{aligned} R_s &= 2G_N \cdot M_{pk} / c^2 \\ &= 3.232099286 \times 10^{-35} \text{ meters} = 2 \cdot l_p \end{aligned} \quad (6)$$

TEMPERATURE OF THE ELECTRON

The Temperature of the Electron is derived from a model involving a gravity shell that contains the Electron Inertial Mass. The Gravity shell radiates gravitational energy (distinction between gravitational and inertial mass invalidates the equivalence principle of Relativity) and is one Planck length (l_p) in radius with a Mass of $2.364364741 \times 10^{-69} \text{ kg}$ (see Mass and Chart). The Gravity Shell is formed when a Gravity Wave with a frequency of $1/4t_p$ phase-locks on itself.

Figure 1: A wave-length of $4l_p$ that constitutes gravity (anti-gravity wave is 180° out of phase with gravity wave).

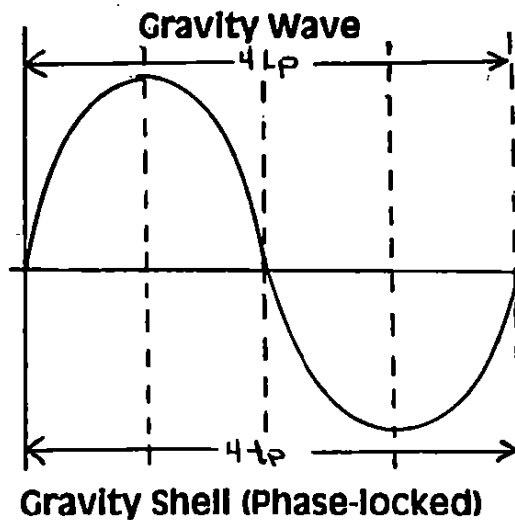
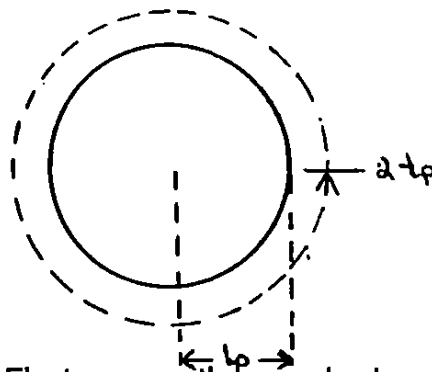


Figure 2: A gravity wave that is phase-locked upon itself forming the sphere of an electron.



Mass of Shell
 $2.364364741 \times 10^{-69} \text{ kg}$

The inertial Mass of the Electron greatly overshadows its Gravitational Mass, and the Energy of the charge of the Electron (minimum charge e_0) causes the Gravity Shell enclosing the Electron to radiate its gravitational energy in the form of thermal

energy. This energy (the Mass of the Gravity Shell radiated in the form of heat energy) is the lowest Temperature possible (T_e) and is therefore an increment of thermal energy.

The Temperature of the Electron is expressed by the following equation:

$$T_e = G_s \cdot c \cdot e_c^2 \quad (7)$$

Where: e_c = the charge of the electron

$$= 1.6021773349 \times 10^{-19} \text{ Coulombs}$$

" G_s " represents the dimensions of the Gravity Shell, it consists of two integers (2x1) but dimensionally needs some explanation.

$$G_s = (2t_p(s)^3 / l_p(m)^3) \cdot (l_p \cdot 1 \text{ mite/electron radius (m)} \cdot \text{electron mass (kg)})$$

$(2t_p(s)^3 / l_p(m)^3)$ is the volume equivalence of the Gravity Shell of the Electron (see Gravity Shell). The "2" is a integer showing the time units corresponding to the length units of the volume of the electron.

Whereas:

$(l_p \cdot 1 \text{ mite/electron radius (m)} \cdot \text{electron mass (kg)})$ is the correspondence of the radius of the electron in Planck length units (integer=1) to the overall radius of the electron in any units, and the number of mass units of the Gravity Shell (integer=1 mite) to the overall mass of the electron in any units. If the overall radius were larger than a Planck length this integer would be larger as in the case of the Proton where this integer would be 462 relative to the overall Proton radius•mass as shown in a subsequent piece of work.

Therefore:

$$G_s = 2 \text{ numerically}$$

and

$$\begin{aligned} G_s &= (s^3/m^3) \cdot (1/m \cdot kg) \\ &= s^3/m^4 \cdot kg \end{aligned} \quad \text{*(8)}$$

Since dimensionally:

$$e_c^2 \rightarrow kg \cdot m^3/s^2 \quad (9)$$

Then the temperature of the electron is equal to:

$$\begin{aligned} T_e &= G_s \cdot c \cdot e_c^2 \\ &= (s^3/m^4 \cdot kg) \cdot (m/s) \cdot (kg \cdot m^3/s^2) = ^\circ\text{Kelvin} \text{ (units cancel)} \end{aligned}$$

This works out in Kelvin since it is the actual increment of the scale denoting the minimum amount of atomic movement, defining a unit of $^\circ\text{Kelvin}$.

$$\text{Therefore numerically, } T_e = 2 \cdot c \cdot e_c^2 = 1.539117819 \times 10^{-29} \text{ } ^\circ\text{Kelvin} \quad (10)$$

Temperature is normally thought of as an averaging of molecular energy with respect to the gas laws, but here I extend that definition to that of a single particle which is how the universe starts out. In the case of a single electron (T_e), it is the amount of energy radiated by just the shell of the electron (minimum atomic energy, no external influence). The definition of temperature clearly needs to be redefined to accurately measure the temperature of a boulder, for example: a boulder lying in the sun would have different temperatures at various locations on its faces. The actual temperature would be a combination of the individual particle temperatures each

(universally the absolute reference of the background radiation).

The minimum temperature defined here (T_e) is the temperature of minimum atomic motion (not zero). This is caused by the charge of the electron propagating through the gravity shell of the electron to generate just the amount of energy of the gravity shell itself (E_N).

All matter can be described as particles with specific locations in space, each with their own contributing temperatures. Boltzmann's Constant (k) will be later shown to be decreasing with time. In order not to confuse this new extended definition of temperature with that of conventional practice, I propose that this be called Unstructured Energy. In addition, another paper I am preparing will show that energy actually has three classifications (not two), and that they should be defined as particle temperatures (Unstructured Energy), energy with mass (Bound Energy) and energy traveling at the speed of light or Photons (Structured Energy). Further, in that paper I will propose experiments that will prove that Bound Energy is actually equal to Structured Energy divided by Unstructured Energy and that this is the Ultimate Unification.

When we now take the minimum temperature (T_e) and multiply by Boltzmann's Constant (k ; Joules/°Kelvin) we do in fact get the Joules of a gravity shell (E_{GS}).

Gravity Shell Energy (from Thermal or Unstructured Energy)

$$\begin{aligned} E_{GS} &= E_N = G_s \cdot c \cdot e_c^2 \cdot k \\ &= 2.124985056 \times 10^{-52} \text{ Joules} \end{aligned} \tag{11}$$

This comprises the minimum unit of energy (E_N ; see chart).

NOTE: $4\pi\epsilon_0$ (permittivity of free space) is not necessary due to e_c^2 being converted to a temperature (only one particle involved).

Gravity Shell Energy (from Mass)

$$\begin{aligned} E_{GS} = E_N = mc^2 &= 2.364364741 \times 10^{-69} \text{ kg} \\ &= 2.124985055 \times 10^{-52} \text{ Joules} \end{aligned} \quad (12)$$

Where: $m = 1 \text{ mite}$ (see Equation #31 or Chart)

Gravity Shell Energy (from Force)

$$\begin{aligned} F_{GS} = ma &= 1 \text{ mite} \cdot 1 \text{ carrot} \text{ (see Equation \#26 or Chart)} \\ &= 1.42828392 \times 10^{-78} \text{ kg} \cdot \text{m/s}^2 \end{aligned} \quad (13)$$

$$E_{GS} = E_N = F_{GS} \cdot R_0 = 2.124985055 \times 10^{-52} \text{ Joules} \quad (14)$$

Where: R_0 is the radius of the Universe (see Radius or Chart)

Gravity Shell Energy (from Frequency)

Photons travel along Gravity Waves so that when a Gravity Wave phase-locks upon itself we must multiply " $\hbar$ " by the lowest frequency.

Therefore:

$$\begin{aligned} E_{GS} = E_N &= \hbar \cdot u \\ &= 2.124985055 \times 10^{-52} \text{ Joules} \end{aligned} \quad (15)$$

Where: $u = 2.01502004 \times 10^{-18} \text{ Hz}$ (see Chart)

Gravity Shell Energy (from Time)

The Gravity Shell (suggested to be the electron neutrino) is getting lighter in

mass with time:

Therefore:

$$\begin{aligned} E_{GS} &= E_N = M_{pk} \cdot c^2 / t_{ch} \\ &= 2.124985056 \times 10^{-52} \text{ Joules} \end{aligned} \quad (16)$$

Where: t_{ch} is the Age of the Universe in chronons (see Equation #19 or Chart).

There are 5 measured values used and 5 simultaneous equations generated for the Energy of the Gravity Shell, a full dimensional analysis will be given in a subsequent paper.

In a work that is being prepared by the author, it is suggested that all events are connected by time lines and that these time lines are comprised of connected time increments or chronons where 1 chronon = $t_p = 5.390561369 \times 10^{-44}$ sec. starting at the Big Bang. The universe is linked together through these time lines and held together by gravity waves.

The Age of the Universe in chronons would be a dimensionless number in conventional units (seconds), but not when measured in chronons.

$$\text{Universe Age (Chronons)} \quad t_{ch} = t_o / t_p = 9.206332069 \times 10^{60} \text{ chronons} \quad (17)$$

Where t_o equals the Age of the Universe in seconds (derived by the following to be 4.9627298×10^{17} sec)

Referring to the charts where subscript $_N$ denotes Minimum and subscript $_x$ denotes Maximum, unless already defined by another symbol, it can be established that the Max divided by the associated Min equals the Age of the Universe (t_{ch} in chronons) in all cases except Force and Momentum. The Minimum Force and

Momentum are calculated from the lightest mass (1 mite; suggested to be an electron neutrino) moving at extremely slow speeds (1 tortoise; see velocity) so that the Max/Min becomes the maximum possible number of divisions of force and momentum in the universe today ($8.475655015 \times 10^{121}$). The square root of this number is indeed the Age of the Universe in chronons (refer to chart) and therefore also corresponds to the other quotients and can be thought of as a type of infinity indicator. When "c" is used in the equations instead of 1 tortoise, the age of the universe is found (t_{ch}) instead of (t_{ch}^2). I suppose the maximum number of divisions possible should be calculated at the time of closure as this works out to $2.940248635 \times 10^{123}$ and would be a better indicator of infinity. It will be interesting to discover whether the Combinational Hierarchy of Noyes/McGoveran² can generate this number, as the work has been useful in corresponding with the rest of this paper.

The charts refer to FDRR's which are defined to be the absolute "Fundamental Dynamic Relationship Ratios". The maximums and minimums calculated are the limits of the universe today, but as will be shown by the following $k, t_o, R_o, M_N, T_x, V_N, A_N, E_N, F_N, u_N, P_N$, vary with time whereas $\hbar, c, G_N, t_p, I_p, M_{pk}, T_e, A_x, E_{pk}, F_x, u_x, P_x, e_c, T_e$ remain constant.

Time $t_p = t_p = 1$ chronon $t_x = t_o$ t_p (chronons)	$\text{DIM } t_p = \sqrt{(\hbar G_N / c^3)}$ $= 5.390561369 \times 10^{-44} \text{ sec}$ $\text{FDRR } t_p = l_p / c$	$*\text{DIM } t_o = \hbar / k \cdot (G_N \cdot c \cdot e_c^2) \cdot \text{Kelvin}$ $= 4.9627298 \times 10^{17} \text{ sec}$ $\text{FDRR } t_o = \hbar / E_N$ $t_o = 15.72594177$ billion years	$t_{ch} = t_o / t_p = 9.206332069 \times 10^{60}$ chronons
Length $l_p = l_p$ $l_x = l_o$	$\text{DIM } l_p = \sqrt{(\hbar G_N / c^3)}$ $= 1.616049643 \times 10^{-35} \text{ m}$ $\text{FDRR } l_p = c \cdot t_p$	$*\text{DIM } R_o = \hbar / k \cdot G_N \cdot e_c^2$ $= 1.487788965 \times 10^{26} \text{ m}$ $\text{FDRR } R_o = c \cdot t_o$	$R_o / l_p = t_{ch}$
Mass (Particle) $M_p = \text{mite}$ $M_x = M_o$	$\text{DIM } M_N = \hbar / c^2 \cdot t_o = 1 \text{ mite}$ $= 2.364364741 \times 10^{-69} \text{ kg}$ $\text{FDRR } M_N = (1 \text{ carrot} \cdot l_p^2) / G_N$	$\text{DIM } M_{pk} = \sqrt{(\hbar c / G_N)}$ $= 2.176712694 \times 10^{-8} \text{ kg}$ $\text{FDRR } M_{pk} = 1 \text{ mite} \cdot t_o / t_p$	$M_{pk} / M_N = t_{ch}$
Temperature $T_p = T_o$ $T_o = \text{temp. electron}$ T_x	$*\text{DIM } T_o = G_N \cdot c \cdot e_c^2$ $= 1.539117819 \times 10^{-29} \text{ }^\circ\text{Kelvin}$ $\text{FDRR } T_o = 2 \cdot c \cdot e_c^2$	$\text{DIM } T_x = \sqrt{(\hbar c^3 / k^2 G_N)}$ $= 1.416962973 \times 10^{32} \text{ }^\circ\text{K}$ $\text{FDRR } T_x = \hbar / k \cdot t_p$ or $T_x = M_{pk} \cdot l_p^2 / k \cdot t_p^2$	$T_x / T_o = t_{ch}$
Velocity $v_p = 1$ tortoise $v_x = c$	$\text{DIM } v_N = \sqrt{(\hbar G_N / c^3)} / t_o$ $= 3.256372416 \times 10^{-33} \text{ m/s}$ $\text{FDRR } v_N = l_p / t_o = 1 \text{ tortoise}$	$\text{DIM } c = 2.99792458 \times 10^8 \text{ m/s}$ $\text{FDRR } c = 299792458 \text{ m/s}$ $*\text{See Eqn. 8}$ $G = 2 \text{ numerically}$ $= \text{s}^3 / \text{m}^4 \cdot \text{kg dimensionally}$	$c / v_N = t_{ch}$

VARIABLE	MINIMUM VALUE	MAXIMUM VALUE	MAX/MIN
Acceleration $A_x = 1$ carrot A_x	$\text{DIM } A_x = G_x \cdot c^3 \cdot t_o / G_x \cdot 1/c^2 t_o^2$ $= c/t_o$ $= 6.040878107 \times 10^{-10} \text{ m/s}^2$ FDRR $A_x = c/t_o = 1$ carrot	$\text{DIM } A_x = c/t_p$ $= 5.561432984 \times 10^{31} \text{ m/s}^2$ FDRR same	$A_x/A_x = t_o/t_p = t_{ch}$
Energy E_x E_x E_x	$\text{*DIM } E_x = G_x \cdot c \cdot e_c^2 \cdot k$ $= 2.124985056 \times 10^{-52} \text{ Joules}$ FDRR $E_x = \mu u$ or $E_x = 1 \text{ mite} \cdot c^2$	$\text{DIM } E_{pk} = \sqrt{(Kc^3/G_x)}$ $= 1.956331806 \times 10^9 \text{ Joules}$ FDRR $E_{pk} = M_{pk} \cdot c^2$	$E_{pk}/E_x = t_o/t_p = t_{ch}$
Force F_x F_x F_x	$\text{DIM } F_x = K/c \cdot t_o^2$ $= 1.42828392 \times 10^{-78} \text{ Kgm/s}^2$ FDRR $F_x = 1 \text{ mite} \times 1 \text{ carrot}$	$\text{DIM } F_x = c^4/G_x$ $= 1.210564177 \times 10^{44} \text{ Kgm/s}^2$ FDRR $F_x = M_{pk} \cdot A_x$	$\sqrt{(F_x/F_x)} = t_o/t_p = t_{ch}$
Frequency u_x u_x	$\text{DIM } u_x = 1/t_o$ $= 2.01502004 \times 10^{-18} \text{ Hz}$ FDRR same	$\text{DIM } u_x = 1/\sqrt{(KG_x/c^3)}$ $= 1.855094361 \times 10^{43} \text{ Hz}$ FDRR $u_x = 1/t_p$	$u_x/u_x = t_{ch}$
Momentum P_x P_x	$\text{DIM } P_x = M \cdot \sqrt{(M \cdot G_x/c^3)} / (c^2 \cdot t_o^2)$ $= 7.699252125 \times 10^{-122} \text{ kg} \cdot \text{m/s}$ FDRR $P_x = 1 \text{ mite} \times 1 \text{ tortoise}$	$\text{DIM } P_x = \sqrt{(Kc/G_x)} \cdot c$ $= 6.525620489 \text{ kg} \cdot \text{m/s}$ FDRR $P_x = M_{pk} \cdot c$	$\sqrt{(P_x/P_x)} = t_o/t_p = t_{ch}$

AGE OF THE UNIVERSE

The Age of the Universe is the ratio of the Maximum Temperature T_x divided by the Temperature of the electron T_e (min. temperature).

$$T_x = \sqrt{(\hbar c^5/k^2 G_N)} = 1.416962973 \times 10^{32} \text{ }^\circ\text{Kelvin} \quad (18)$$

$$T_e = 1.539117819 \times 10^{-29} \text{ }^\circ\text{Kelvin}$$

$$t_{ch} = T_x/T_e = 9.206332066 \times 10^{60} \text{ chronons} \quad (19)$$

Therefore the Age of the Universe (seconds) using measured values only equals:

$$t_o = \frac{\sqrt{(\hbar c^5/k^2 G_N)} \cdot \sqrt{(\hbar G_N/c^5)}}{G_s \cdot c \cdot e_c^2} \quad (20)$$

$$= 4.9627298 \times 10^{17} \text{ sec or } 15.72594177 \text{ billion years}$$

this closely corresponds to measured values, and can be further reduced to:

$$t_o = \hbar/k \cdot G_s \cdot c \cdot e_c^2 \text{ sec} \quad (21)$$

-or in FDRR units:

$$t_o = t_p T_x/T_e = \text{seconds} \quad (22)$$

NOTE: That T_e is in units of $^\circ\text{Kelvin}$ from equation 10 so that the Kelvin units cancel leaving time units (seconds).

One can see from the above equations that Boltzmann's constant (k) must be decreasing proportionately with the increase in the Age of the Universe by one part per 10^{10} per year.

$$\begin{aligned} k &= \hbar/G_s \cdot c \cdot e_c^2 \cdot t_o \\ &= 1.380651325 \times 10^{-23} \text{ Joules/Kelvin} \end{aligned} \quad (23)$$

One can think of the universe as an expanding cooling gas where "k" yields the joules/°Kelvin of the expanding gas. Therefore, the amount of energy necessary to cause a given temperature or Unstructured Energy is decreasing.

RADIUS OF THE UNIVERSE

The Radius of the Universe would be the speed of light times the Age of the Universe ($c \cdot t_0$) which yields a result that also shows its relationship to temperature:

$$R_0 = c \cdot t_0 \text{ where: } t_0 = t_p \cdot T_x / T_\theta \quad (24)$$

$$\text{since as already shown } T_\theta = G_s \cdot c \cdot e_c^2$$

$$\text{then: } R_0 = T_x \cdot t_p / G_s e_c^2$$

$$\text{and since } H/k = T_x \cdot t_p$$

$$\text{then: } R_0 = H / (k \cdot G_s e_c^2) = 1.487788965 \times 10^{26} \text{ meters}$$

This corresponds very accurately with astronomically measured values.

In units:

$$R_0 = \frac{\text{kg} \cdot \text{m}^2 \cdot ^\circ\text{K}}{\text{s} \cdot (\text{kg} \cdot \text{m}^2 / \text{s}^2) \cdot (\text{s}^3 / \text{m}^4 \cdot \text{kg}) \cdot (\text{kg} \cdot \text{m}^3 / \text{s}^2) \cdot ^\circ\text{K}} = \text{length (meters)} \quad (25)$$

$R_0 = H / (k \cdot 2e_c^2)$ is an elegant and fascinating result since "c" is expressed only in terms of "H".

VELOCITY

There are no zeros or infinities in the Universe, just Maximums and Minimums, so it follows that there is a Minimum Velocity. The minimum velocity describes the minimum expansion related to the reference frame determined by the background radiation of 2.735°K (absolute reference). This Velocity ($V_N = 1$ tortoise named by

J. Prentice, University of Toronto) would denote the Velocity of the origin of the Big Bang, namely the minimum length (l_p) divided by the Maximum Time.

$$V_N = l_p / t_o = 3.256372416 \times 10^{-53} \text{ m/s or 1 tortoise}$$

Thus, the classical definitions of potential and kinetic energy lose their meanings since all energy is in motion.

ACCELERATION

The Minimum Acceleration ($A_N = 1$ carrot named by author) is the Acceleration achieved by taking the Maximum Time (t_o) to reach the fundamental Velocity (c).

$$A_N = c / t_o = 6.040878107 \times 10^{-10} \text{ m/s}^2 \text{ or 1 carrot} \quad (26)$$

This Acceleration could also be thought as the Acceleration due to Gravity experienced by a body at the periphery of the Universe.

$$A_N = G_N c^3 t_o / G_N \cdot 1 / c^2 t_o^2 \quad (\text{G. Constable}^3) \quad (27)$$

which reduces to $A_N = c / t_o$

FREQUENCY

Solving for Frequency in FDRR units:

$$u = T \cdot k / \hbar \quad (28)$$

Using FDRR units

$$k / \hbar = 1 / T_x \cdot t_p \quad (29)$$

$$\text{Therefore: Frequency } u = T / T_x \cdot t_p \quad (30)$$

This equation makes a lot of sense since this means frequency is equal to the ratio of the Temperature to the Maximum Temperature divided by the Planck time.

MASS

The Minimum Mass or Gravity Shell ($M_N=1$ mite named by J. Prentice) is calculated from

$$\begin{aligned} M_N &= H/c^2 \cdot t_0 = 1 \text{ mite} \\ &= 2.364364741 \times 10^{-69} \text{ kg} \end{aligned} \quad (31)$$

$$\text{Since: } G_N = m^3/\text{Kg/s}^2 \quad (32)$$

Therefore the Minimum Mass may also be found from

$$\begin{aligned} M_N &= \frac{1 \text{ carrot} \cdot l_p^2}{G_N} = \frac{m/s^2 \cdot m^2}{m^3/\text{Kg/s}^2} \\ &= 2.364364742 \times 10^{-69} \text{ Kg or 1 mite} \end{aligned} \quad (33)$$

The maximum overall mass or mass of the universe may be calculated from the Age of the Universe in chronons (t_{ch})x the Planck Mass (M_{pk}).

$$M_{UNIV} = M_{pk} \cdot t_0/t_p \quad (34)$$

$$= M_{pk}^2 / 1 \text{ mite} \quad (35)$$

$$= c^3 \cdot t_0 / G_N \quad (36)$$

$$= 2.003953988 \times 10^{53} \text{ kg}$$

However this would mean that the universe was still in a black hole condition which can be shown by calculating the Schwarzschild Radius (R_s).

$$R_s = 2G_N \cdot M_{UNIV} / c^2 \quad (37)$$

$$= 2.975577931 \times 10^{26} \text{ m}$$

$$R_0 = c \cdot t_0 \quad (38)$$

$$= 1.487788965 \times 10^{26}$$

Therefore: R_s = Diameter of Universe

Since the universe is expanding not contracting as it would be by being inside its own Schwarzschild Radius (R_s), then the actual mass of the universe must be less than this amount shown in equation 34.

To find the true mass of the universe one must take into account the background radiation of the universe (T_{BR}). Since the Background Radiation could be converted to an energy which would take the place of mass until the cooling results in thermal equilibrium at closure.

Therefore:

$$\begin{aligned} M_{UNIV} &= M_{pk} \cdot (T_x / (T_{BR} / T_{BRcl})) / T_e \\ &= 7.327071253 \times 10^{52} \text{ kg} \end{aligned} \quad (39)$$

Where: $T_{BR} = 2.735$ °Kelvin

$T_{BRcl} = 1$ °Kelvin = Closure Background Radiation as will be shown later.

This is 23% of Einstein's calculation of $TT \cdot R_0 \cdot c^2 / 2G_N$ or 3.147804×10^{53} kg and is closer to the observed mass.

The Schwarzschild Radius (R_s) would then be:

$$\begin{aligned} R_s &= 2G_N M_{UNIV} / c^2 \\ &= 1.08796268 \times 10^{26} \text{ meters} \end{aligned} \quad (40)$$

and

$$R_0 = 1.487788965 \times 10^{26} \text{ meters}$$

Therefore, 73.5% ($2R_0/R_s$) of the universe would lie outside the event horizon and the universe would be in a state of expansion.

The Dirac Large Number Hypothesis^{7,8} produces two clusters of dimensionless numbers, one grouped around unity (1) and the other grouped around the electromagnetic force divided by the gravitational force ($2.269238811 \times 10^{39}$).

As already explained the Gravity Shell is comprised of gravitational energy (see Gravity Shell and equations 33 and 16) and is getting lighter with time. The electron on the other hand is constructed almost entirely of electromagnetic energy (see Gravity Shell). Since the c^2 's cancel, the ratio of their masses would be the ratio of their energies (R_m).

$$\begin{aligned} R_m &= m_e / 1 \text{ mite} \\ &= 3.852785315 \times 10^{38} \end{aligned} \quad (41)$$

The ratio of the electromagnetic force to the gravitational force between an electron and a proton (R_E) equals

$$\begin{aligned} R_E &= e_c^2 / 4\pi\epsilon_0 \cdot G_N \cdot m_p \cdot m_e \\ &= 2.269238811 \times 10^{39} \end{aligned} \quad (42)$$

Since the "mite" is getting less massive with time there will come a time when $R_m = R_E$. This time is the point of closure of the universe.

The value of the mite at closure may therefore be calculated as:

$$\begin{aligned} \text{mite}_{cl} &= 4\pi\epsilon_0 \cdot G_N \cdot m_p \cdot m_e^2 / e_c^2 \\ &= 4.014293123 \times 10^{-70} \text{ kg} \end{aligned} \quad (43)$$

and then:

$$R_E = m_e / \text{mite}_{cl} \quad (44)$$

This explains the cluster of numbers around R_E in the Large Number

Hypothesis.

Since "k" has been shown to be decreasing with time its value at closure may also be calculated.

$$k_{cl} = \frac{4TT\epsilon_0 \cdot G_N \cdot m_p \cdot m_e^2 \cdot c}{G_s \cdot e_c^4} \quad (45)$$

$$= 2TT\epsilon_0 \cdot G_N \cdot m_p \cdot m_e^2 \cdot c / e_c^4 \quad (46)$$

$$= 2.344113421 \times 10^{-24} \text{ Joules/}^\circ\text{Kelvin}$$

NOTE: At closure, the same ratio of the electromagnetic to the gravitational force hold true for the electron mass energy when divided by its thermal energy ($T_e \cdot k_{cl}$ see equation 11) therefore ($R_E = m_e c^2 / T_e \cdot k_{cl}$) and temperature is connected with gravity and the electromagnetic force. This ratio (R_E) reveals that electrons would be in thermal equilibrium at the closure point of the universe, allowing them to start clumping back together once again to form the conditions that lead to another Big Bang, thus indicating an oscillating universe.

The temperature of the Big Bang may now be calculated:

$$T_{BB} = \sqrt{(k c^5 / k_{cl}^2 \cdot G_N)} \quad (47)$$

$$= 8.345721626 \times 10^{32} \text{ }^\circ\text{Kelvin}$$

The universe closes at Thermo Equilibrium and this explains the grouping of numbers around unity in the Dirac Large Number Hypothesis.

Energy due to Thermal Radiation of Big Bang at closure equals:

$$E_T = T_{BB} \cdot k_{cl} \quad (48)$$

$$= 1.956331806 \times 10^9 \text{ Joules}$$

Energy due to mass of Big Bang equals:

$$E_m = M_{pk} \cdot c^2 \quad (49)$$

$$= 1.956331806 \times 10^9 \text{ Joules}$$

$$E_T/E_m = 1 = \text{unity} = \text{Thermal Equilibrium} \quad (50)$$

The age of the universe at closure equals:

$$t_{ocl} = \sqrt{1/k_{cl} \cdot G_s \cdot c \cdot e_c^2} \text{ (sec)} \quad (51)$$

$$= 92.62368513 \text{ billion years}$$

Therefore time to closure equals:

$$t_{cl} = t_{ocl} - t_o \quad (52)$$

$$= 76.89774336 \text{ billion years}$$

The background radiation of the Big Bang would be decreasing as time increases and must get to 1°Kelvin at closure for the universe to be at thermal equilibrium and for the Radius (R_o) to once again be inside the event horizon (R_s). The mass of the universe at closure could be calculated as shown in equation 34 since $T_{BRcl} = 1^\circ\text{Kelvin}$ (Eqn. 34 = Eqn. 39).

$$M_{UNIV} = M_{pk} \cdot t_{ocl}/t_p = M_{pk} (T_{BB}/(T_{BRcl}/T_{BRcl}))/T_e \quad (53)$$

$$M_{UNIVcl} = M_{pk} \cdot t_{ocl}/t_p \quad (54)$$

$$= 1.180301988 \times 10^{54} \text{ kg}$$

and

$$t_{chcl} = \sqrt{(M_{UNIVcl}/1 \text{ mite}_{cl})} \quad (55)$$

$$= 5.422405955 \times 10^{61} \text{ chronons}$$

$$= 92.62368513 \text{ billion years}$$

The background radiation at closure can be used to calculate the background energy (E_{BR1}).

$$E_{BR1} = T_{BRcl} \cdot k_{cl} \quad (56)$$

$$= 2.344113421 \times 10^{-24} \text{ Joules}$$

$$E_{BR2} = k_{cl} = 2.344113421 \times 10^{-24} \text{ Joules} \quad (57)$$

$$E_{BR1}/E_{BR2} = 1 = \text{Thermal Equilibrium} \quad (58)$$

We are now able to calculate the Electromagnetic Force (E_f):

$$E_f = e_c^2 = \frac{4TT\epsilon_o \cdot G_N \cdot m_p \cdot m_e^2 \cdot c^2}{T_e \cdot k_{cl}} \quad (59)$$

$$= 2.566972213 \times 10^{-38}$$

Similarly the Gravitational Force (G_f) may be calculated:

$$G_f = 4TT\epsilon_o \cdot G_N \cdot m_p \cdot m_e = \frac{e_c^2 \cdot T_e \cdot k_{cl}}{m_e \cdot c^2} \quad (60)$$

$$= 1.131204085 \times 10^{-77}$$

These equations, since they are taken at the point of Gravitational Closure of the universe form a unification of the Electromagnetic Force with gravity and temperature.

The Schwarzschild Radius may now be calculated (R_s)

$$R_s = 2G_N \cdot M_{UNIVcl} / c^2 \quad (61)$$

$$= 1.752575442 \times 10^{27} \text{ m}$$

$$R_o = c \cdot t_{ocl} \quad (62)$$

$$= 8.762877204 \times 10^{26} \text{ m}$$

R_s is now equal to $2R_o$ (diameter) again so the universe is once again in a black hole condition and may begin to contract towards another Big Bang.

The Unstructured Energy of the Big Bang may be found by calculating Boltzmann's Constant (k) at the Planck time (t_p) and multiplying by the Temperature of the Big Bang (T_{BB}).

$$k_{BB} = \frac{h}{T_e \cdot t_p} = 1.271073457 \times 10^{38} \quad (63)$$

$$E_{UBB} = T_{BB} \cdot k_{BB} = 1.060802524 \times 10^{71} \text{ Joules} \quad (64)$$

This Energy accounts exactly for the Energy (Bound Energy) of the Mass of the Universe at point of closure.

$$M_{UNIVcl} \cdot c^2 = 1.060802524 \times 10^{71} \text{ Joules} \quad (65)$$

The Universe is apparently changing the Unstructured Energy or Energy used to cause temperature into Bound Energy, thus slowing the rate of expansion through the increase in inertial mass.

Quasars have been detected at distances corresponding to a time in the universe when Boltzmann's Constant (k) was three to five times its present value, helping to explain the massive amount of energy the Quasars give off.

The equations that produce (t_o) can be further reduced to show that the Age of the Universe in seconds (t_o) is equal to the minimum change in Angular Momentum of the electron divided by the Energy of its shell.

$$t_o = \frac{h}{E_N} = 4.9627298 \times 10^{17} \text{ sec} \quad (66)$$

Where: E_N is the energy of the mite or gravity shell of the electron

$$(E_N = k \cdot G_s \cdot c \cdot e_c^2 \text{ or } 1 \text{ mite} \times c^2).$$

Therefore, every electron in the Universe is in effect an atomic clock yielding the Universe's Age.

Furthermore, when the Energy of the electron shell is taken at closure and t_{ocl} is multiplied by "c", divided by the Electron Compton Wavelength, one gets the ratio of the Electromagnetic to the Gravitational Force of Equation #42, offering additional explanation of the group of larger numbers of the Dirac Large Number Hypothesis.

$$t_{ocl} = \frac{h}{E_{Ncl}} \quad (67)$$

Where: $E_{Ncl} = 3.607866735 \times 10^{-53}$ Joules

$$R_E = \frac{E_f}{G_f} = \frac{h}{E_{Ncl}} \times \frac{c}{\lambda_e} = 2.26938811 \times 10^{39} \quad (68)$$

The universe is postulated to be an oscillating universe that is encapsulated by a 5th dimensional universe which is in turn encapsulated by a 6th dimensional universe on up to the combinational hierarchy² limit of 256 dimensions. The universe starts and eventually closes in a black hole condition, but is not presently in this state. The mite is not light enough and the maximum temperature not high enough to unify the electromagnetic with the gravitational force until point of closure. A detailed analysis of black holes, time lines and gravity waves will be addressed in another paper.

CONCLUSIONS

1. All measured values in the Universe have Minimums and Maximums, some of which, such as the Minimum Acceleration ($A_N = 6.040878107 \times 10^{-10} \text{m/s}^2$) are not far from the resolution of current gravity wave accelerometers.
2. The Age of the Universe is 15.72594177 billion years and should begin to be confirmed by the Hubble Telescope and other such measuring apparatus.
3. Boltzmann's Constant (k) is decreasing by 1 part per 10^{10} per year and should be able to be measured as such.
4. This work indicates that there are phase-locked gravity waves that surround the perimeter of particles, and that there is a phase-locked antigravity wave that surrounds antiparticles. Therefore, antiparticles should be shown to fall up (Discrete Antigravity; Noyes/Starson)^{4,5} and this should be confirmed by experiments underway at CERN which are involved in the measurement of the Mass of antiprotons and antihydrogen.
5. The Radius of the Universe ($R_0 = \hbar/k \cdot 2 \cdot e_c^2$) is equal to $1.487788965 \times 10^{26}$ meters.
6. The present mass of the universe is $7.327071253 \times 10^{52} \text{kg}$.
7. The mass of the universe at closure is $1.180301988 \times 10^{54} \text{kg}$.
8. The universe is an oscillating universe that will begin to close again in 76.8977434 billion years.
9. The latter part of this work represents a unification of the electromagnetic and gravitational force with temperature.

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HOLIC PRINCIPLE

THE COHERENCE OF THE UNIVERSE

FIRST PHYSICS DATA CONNECTIONS. UNIFICATION OF FORCES

FRANCIS SANCHEZ*

Orsay University 14 Villa d'Este Apt 907. 75013 Paris (F)

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Abstract: a "quantisation of everything" that quantifies the "Everything itself" (this Universal Quantum is called 'Hol') and also quantifies Mathematics: "only whole number exists and all that exists is whole number". The Holic Principle defines the Discrete Inevitable Holistic Universe by postulating that the functional differentiation between Duration, Extension, Mass,... is provided by the exponent to which the number representing the Physical Quantity is raised: T^2 ; L^3 ; M^5 . The simplest equations are then $T^2 = L^3$, giving the Kepler law and the critical Galaxy Recession, while by symmetry a new physical quantity must be introduced. This is the 'Comatter' M' , such that $M^5 = M'^7$. The generalised simplest equations give the Unification of Forces, including a Geometric Vital Force. The equation $T^2=L^3$ is interpreted as a "complexity conservation", leading to the rationalisation of π , giving in turn a proposal to the rationalisation of the Electromagnetic Coupling α , which is shown to be a Central Parameter both in the data correlations and in the Unification of Forces. That implies complete failure of Standard Theory, and thereby debunks Standard Thinking. The connection with Eddington's Theory suggests the basis to the three Leptonic Pairs and predicts the masses of the three Neutrinos and the X Boson, we propose to call 'Eddon' (700 GeV).

INDEX TERMS: History of Science, Unification, Discrete Physics, Antimatter, Cosmology, Quantum Relativity, Symmetry, Forces, Information, Holography, Particles, Systemics, Biology, Art, Psychobiology.

1. THE HOLIC PRINCIPLE: THE DISCRETE INEVITABLE HOLISTIC UNIVERSE

The functional differentiation between Duration, Extension, Mass,... is provided by the exponent to which the whole number representing the Physical Quantity is raised:

$$(DURATION)^2, \quad (LENGTH)^3, \quad (MASS)^5$$

in a non-linear diophantine equation. The characteristic exponents: 2,3,5 are the three smallest coprime numbers. The power 1 is reserved for ordinary quantum numbers. In order to establish a coherence in the Universe, it is assumed to be ruled by an Ultimate Diophantine Equation whose solution entails several sub-equations corresponding to Elementary Particles. They give an appearance of local connectivity which actually masks a profound non-local connectivity.

The solutions of sub-equations are related to numerical singularities and the rationalisation of π , as proved in the present study. They are basic invariants, which justifies in principle the identity of particles of the same label, as well as the Cosmological Principle (overall homogeneity of the Universe), but rules out both the Anthropic Principle and Indeterminism as there is not any possibility of a different Universe. The Holic Principle defines the Discrete Inevitable Holistic Universe: the Holic Universe. The Ultimate Equation corresponds itself to one Entity which one cannot consider as an ordinary particle, baptised 'Hol', the Universal Quantum, which sweeps and regenerates the permanence of the Universe.

2. THE HOL CONCEPT

The Hol concept may be supported independently of the Holic Principle auto-coherence: this "*Universal Quantum*" is *aesthetic, historical, logical, necessary, enlightening and predictive*.

The two last centuries are characterised by an history of successive *quantisations*: whole numbers appeared firstly in Chemistry and Genetics, then came Atoms (*which appeared as foolish to the great majority during the 19th Century*). But this was a collective *logical fault* since in a structural unification spirit, it is sufficient that one thing is quantified, to deduce that everything has to be quantified too, while the reverse is not true: one cannot deduce the universality of continuity from a continuum example since the misnamed 'real' numbers contain the whole numbers. Later, *of course*, came more quantisations: the electromagnetic interaction quantisation (Photon), and *the quantisation of Electricity itself* !

So, any discrete « theory of everything » that does not quantify everything (including the « Everything » itself) is not logically consistent: the Hol concept is a necessity. This is the Universal Quantum. Mathematics itself needs quantisation: the exclusive use of whole numbers is inevitable. The Hol concept explains, connects many things and makes predictions. Some of these are:

- 1/ A base for the identity of identically labelled particles (an obvious idea)
- 2/ A base for justifying the relativity of local time by contrast with absolute cosmological Holic time: the movement creates a variation in the local frequency of an object.
- 3/ The mass is defined from the start: a Hol recurrence frequency.
- 4/ A base for *the quantum event: the Time-Space origin of the Hol sweep*.
- 5/ The sweep being necessary quasi-cyclic, the Cosmos is finite, Time-Space curved, *and flickering* (see the following figure).
- 6/ *Antimatter is an anti-synchronistic recreation of matter* (a new concept)
- 7/ The Big-Bang is a particular pulse of the universe, corresponding to the resolution of a part of the Supreme Equation giving rise to the appearance of Space-Matter, viewed as an extension of the diophantine analysis domain to 3rd and 5th powers.

More generally , *the Holic Principle makes sense of the Universe*, postulating that it is looking for a diophantine Great Solution, of *aesthetical nature*. As greater and greater limit integers are tried, this corresponds to the Arrow of Time, and produces the Galaxy Recession. Also Life makes sense: the evident *human correlated artistic and research spirit* is the concretisation of this Holic Program. This is the answer to the Einstein question: why is the Universe understandable?

This Art-Science identification means there is no future for ugly science. In particular the present status of Theoretical Physics is very unsatisfactory (and correctly rejected by many). On the other hand, the results obtained by *Experimental Physics have overwhelming value*: in particular Particle Physics Data permit such a wonderful thing as the Great Correlation involving 65 decimal places of measured fundamental Quantities, leading directly to the Forces Unification (see below).

An open problem is the existence of *the Supreme Solution*. It will be a goal of future theory. In this case we could predict the future of the Universe. The more aesthetical idea is there is One Solution, meaning a new start of the Universe, with *exact repetition of all the events*. The Laplace vision of perfect Determinism was in this Holic spirit. It was rejected and

even severely mocked for religious (*not logical*) reasons. This means that the concept of Liberty is illusion. The Artist has only one way; towards Beauty. That is the result of vital programming. As there can be only one history, *prediction or retrodiction* are not excluded.

The ideas involved by the Holic Principle are so simple. No doubt an historical research will find a lot of precursors (we discovered the Pythagorean philosophy after the Meeting). In particular the Zeno Paradoxes asking the basic question of the very nature of the movement are solved. *Movement is a discrete reconstruction process*. The mastering of this process would permit in principle Quasi-Instantaneous Travel. The very fact that Antimatter can be made is a strong indication that this may be possible.

In this Study we use an artistic approach: starting from a blank page (a negation of *all* received ideas) we proceed by a simultaneous attack from many different points of view, as a painter does by beginning with several apparently disconnected patches. The connections are then looked for, found and related to other theoretical approaches: Eddington's, ANPA's, Systema's, Superstring's, Pythagoras and Musical Harmonic ratios, Noyes bit-string's... *At first sight, this Study may appear incoherent to a conventional reader. It is in fact a coming back to the Experimental Method of Physics (see the Discussion). The aim of this sketch is to initiate a collective work towards the Achievement of Natural Philosophy.*

The technical difference to the Standard approach is the following. The latter supposes a varying Electrical Charge with reducing scale, due to action of Virtual Particles, in an Euclidian Local Geometry. Here the Electrical Charge is 1 (but with commutations): *the flickering Geometry is Quantified in a variable manner as one explores short scales, in connection with rational approximations for π , as will be proven below*. The Particles are the cracks, or transitions, of these rational geometries, becoming stronger as one approaches the Cell limit of Space ("Topon").

3. CHRONORELATIVITY

In order to explain the most complex concepts, we start from the *simplest* idea: the equation of Pythagoras:

$$T^2 = T_1^2 + T_2^2$$

Notice that Pope⁽¹⁾ intuitively replaces the metrics by a pure « Chronorelativity » (we coin a new term, to mark the transition towards the following Fully Quantified Relativity).

This equation includes the obvious degenerate case: $T_1=0$; $T_2=\pm T$.

If T is the Absolute Cosmic Time (sequence of whole numbers from Time One at what may be called a First step, *before* the Big-Bang), then $T_1=0$ appears as the *null proper time* of the Hol and $T_2=\pm T$ represents a spherical wave with the two possible directions of motion (divergence and convergence) which quantifies a « potential space » (up to a Reference Superspeed, a Singular Ratio to be ultimately discovered in a 'pre-Big Bang Physics').

To each solution T_1, T_2 of the above equation there corresponds a « potential De Broglie particle wave » with a quite precise speed, inferior to the reference superspeed (an operational

definition for Virtual Matter). The Big-Bang is the transition Virtuality-Reality: *an underlying Numerical Collision i.e. a very special property of whole numbers, a "numerical singularity".*

The case where $T_1 = 2^N$ is degenerate, because it corresponds to N values for T. *But the symmetric minimal modification:*

$$T^2 + 1 = T_1^2 + T_2^2$$

suppresses this degeneracy and defines a single non-trivial solution if $2^N - 1$ and $2^N + 1$ are prime numbers, as can be checked by elementary arithmetics. The trivial solution $T = T_2$ and $T_1 = 1$, must relate to the Black Hole. So, *about half of the Matter of the Universe is Black Holes*. In fact huge zones of the Universe seem empty. They may simply correspond to Super Black Holes whose initial formation makes the so far unexplained observed filament structure of galaxy clusters.

One observes, for the Proton and the Planck characteristic times (their ratio is the *inverse* of the corresponding mass ratio), the well-known coincidence:

$$\left(\frac{T_p}{T_{Pl}} \right)^2 \approx 2^{127} \approx 2^{2^{2^{2^{2-1-1}}-1}} - 1$$

where $2^{127} - 1$ is prime. 127 is itself of the Mersenne form $2^N - 1$ and so for 7 and then 3. These particular prime numbers⁽²⁾ form the basics of the Combinatorial Hierarchy⁽³⁾. *But $128+1$ is divisible by 43, which is roughly the square root of 1837. Here is the germ of the proton-electron couple, removing a basic defect of present C.Hierarchy, with its electron-proton asymmetry, since a value near 1837 is not at once evident.*

Chronorelativity answers the Kilmister's question in the 1992 ANPA Meeting: « what is the minimal hypothesis for constructing a discrete approximation to classical Space and Time » (it is in fact Space and Matter, since the simplest model for Time is *obviously* the counting, and *counting back*, of natural integers).

Remark: this coincidence involves the square of the mass ratio. Following the Holic Principle, it is written down as a duration ratio. This implies a rigid connection between mass and duration, which is guaranteed by the Hol Sweeping Concept (and implying a Universal Ratio, to be identified later with h/c^2). So, ultimately, the Universe has only *one* dimension: quantified time, but with two opposite directions that are counting and counting back. *The Time Reversals are not apparent because of the time characteristic exponent 2: 2 is the single even prime number, corresponding to the 2 time directions.*

The above coincidence suggests that the proton is connected with 127 particles, in accordance with the natural idea that the exotic particles are *necessary* for the existence of the principal ones. There are not 127 known Particles, which may open a « Missing Particles Quest ». These 127 Truly Elementary Particles will be called the 127 Nodons (they are intuitively thought of as nodes of successive Hol sweeps). They do not necessarily correspond to what are thought now to be Elementary Particles, but the number 127 is an overall invariant. Most probably they are merely the 127 first Prime Numbers; this is supported by the identification of the Quarks u and d with the Nodons 5 and 2×3 , as shown below, indicating that the Quark d is composite, as made of the combination of the two Nodons 2 and 3.

One observes that by adding 1 to the Time Equation looks like the change of metrics of space-time when one goes from Special to General Relativity: thus it is logical to relate it to the appearance of Matter. *This supports the Relativity-Quantum harmonisation introduced by Chronorelativity.*

But, in order to have both space and singular particles (the two artistic faces of the above Diophantine Singularity), the extra 1 factor must commute with the values $Q = 1; 0$ and -1 : *it is the electrical charge whose commutations command time reversals.*

Note. Feynman⁽⁴⁾ did not *seriously* consider Wheeler's idea of a *single* electron because of the apparent asymmetry between matter and antimatter populations. *The charge commutations establish this symmetry*: what we call 'Matter' is in fact a Matter-Antimatter flickering.

So, the definition of the Electrical Charge Q is merely the expression of discrete character of Reversible Time (whose unit is called 'Chronon'):

$$Q = \Delta T = \pm 1$$

But a duration must act through its square (Holic Principle), giving rise to the *irreversibility*:

$$Q^2 = (\Delta T)^2 = 1$$

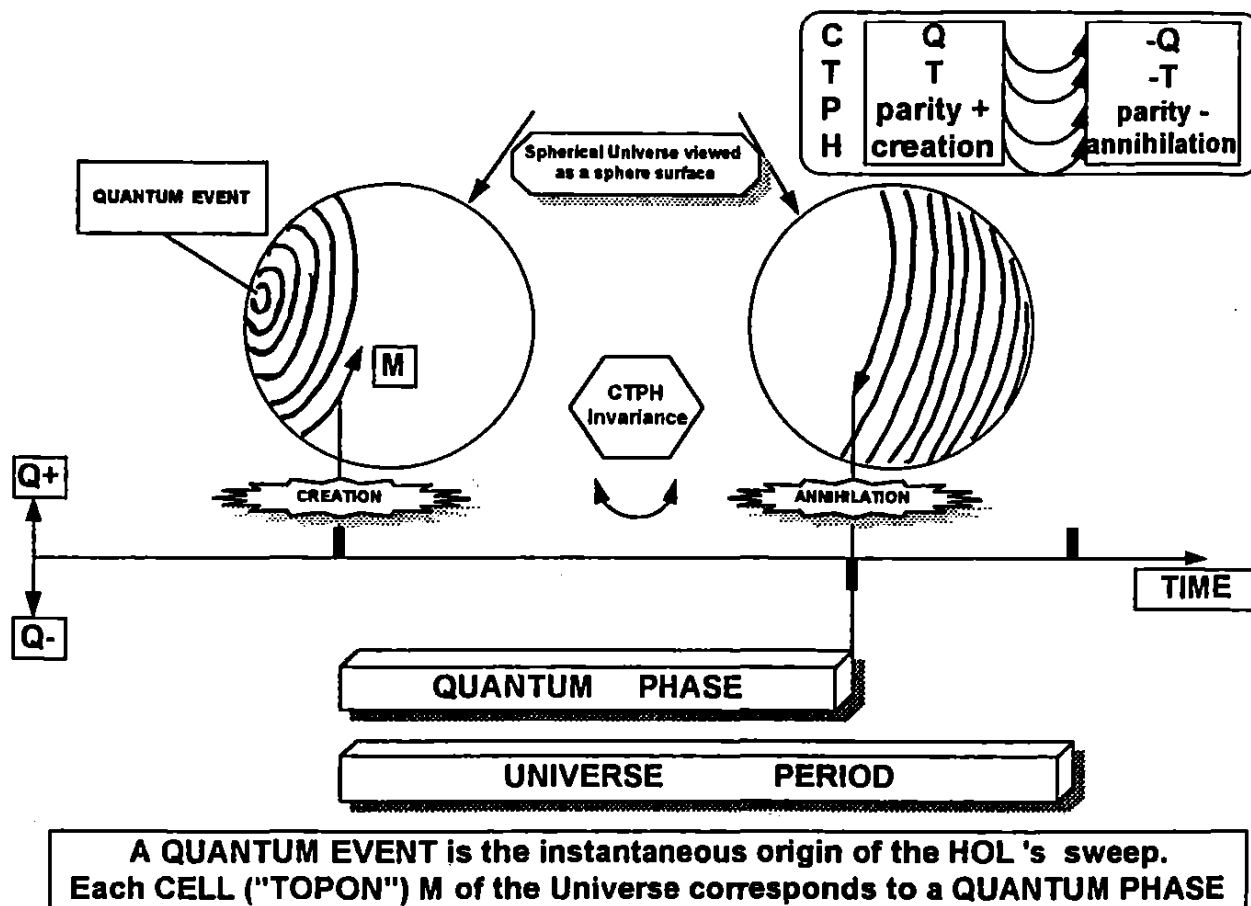
That *explains* why an Electrodynamics Quantum Event (irreversible) is tied to the *square* of an Electric Charge, and more generally, why Quantum Physics makes use of a *probability amplitude*, which acts through its squared modulus, eliminating the Quantum Phase, see below. The Holic Principle implies that it is a *temporal* term, clarifying the interpretation of Quantum Mechanics. In particular *there is no future for chance in Science*. For instance Deakin's analysis of Schrödinger's Equation during this Meeting, where a squared and a cubic term arise, is at once interpreted: the first is a temporal ratio, the second a spatial one.

4. THE QUANTUM PHASE AND CTPH INVARIANCE

The Quantum Phase, (this basic Quantity which remains undefined by current Physics) *naturally* follows from the concept of the *Hol Sweep*, which must in succession generate and destroy the Universe in the two opposite revolving ways (« Parities ») from an *Instantaneous Time-Space Centre Cell* which is the location of a Quantum Event, so every other Cell M of the potential Space to be reconstructed is characterised by a *Temporal Sequence* entailing the Quantum Phase. (See the figure and the glossary).

The apparent independence of two successive Quantum Events is a consequence of the apparently arbitrary distribution of Quantum Phases. The *Standard Gauge Invariance* appears, but general relativity and quantum-electrodynamics are only approximations of Holic Principle, since the Quantum Phase must be itself rational. Nodes of Hol's successive sweeps are the Truly Elementary Particles ('Nodons'). *Indeterminism is not only an unnecessary complication, but the very negation of Cosmic Coherence.*

Remark: the Heisenberg Inequalities do not establish chance. They are merely the expression of 'wave-matter complementarity', which demonstrates the holistic character of the World.



A QUANTUM EVENT CONTAINS ALL THE INFORMATION OF THE UNIVERSE

The creation-annihilation asymmetry must be tied to galaxy recession, looked on as space cell ("Topons") creations occurring at the antipodal location of the quantum event (this justifies the reversal of the Hol sweep parity). So galaxy recession is strictly connected to the rate of Quantum Events, a constraint that should be tied to *the observed, not explained so far, critical character* of this recession. As Matter, like Space, is generated by Time, there is also a regular production of Matter; *the conservation of Matter-Energy is ruled out*. The CTP symmetry is also an approximation, as well as the individual symmetries C,P,T and H.

The geometry of Space i.e. the interconnections of Topons is dependent on all the quantum events of the Universe (not only matter). The apparent local space homogeneity is only a statistical mean. Any 'Referential' is subject to these universal determinist fluctuations. This meets and makes precise the very start of Eddington's Fundamental Theory.

The foundations of quantum physics, general relativity and Eddington theory⁽⁵⁾ are explained, connected and severely corrected by the Hol concept, in the Holic Universe, where there is no place for continuum (i.e. infinity), reductionism and chance, four definitively ugly concepts.

5. THE CONSERVATION OF INFORMATION COMPLEXITY

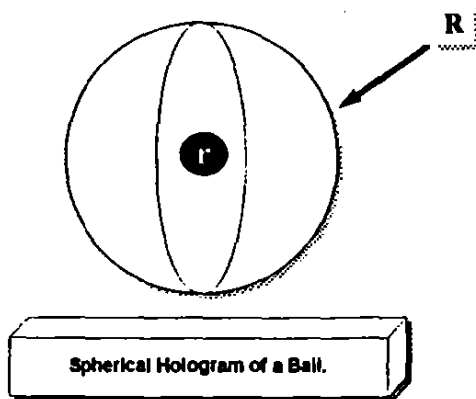
Notice: through this study, the particle masses are refereed to the electron mass, with the exception of neutrinos, for which the *inverse* ratio is considered, in order to always work with numbers greater than unity. It is also the reason why our α is the inverse standard notation. For the particle symbols and numerical values, see the Table.

The simplest way to obtain diophantine equations is to consider from the start the whole number that defines a class of systems (an isolated system is not allowed by an holistic theory, in harmony with the Pauli Exclusion Principle). This is the number of independent parameters describing this class, a number which is an absolute invariant whatever theory is considered. *This super-invariant will be called the Information Complexity Number of the System Class.* While it is often said that information cannot be defined, this complexity number can be defined in some cases, and in particular for a Hologram (the new term « holic » uses the same Greek prefix : "holos", meaning totality, as in 'holistic').

The Hologram realises a *topological information transfer*. Indeed it records, on one surface, information which relates to a volume, the unity length being the wavelength λ . So, by identifying the information complexity C , one obtains non-linear relations which *must* be tied to the Particles Singularities, and which depend on symmetry.

1. **Spherical Symmetry:** the complexity relative to the surface of the large sphere (radius R) must be equated the complexity in the volume of the little sphere (radius r) $C = 4\pi(R/\lambda)^2 = 4(\pi/3)(r/\lambda)^3$. After elimination of $3C/(4\pi)$ (*whose diophantine properties should imply a rationalisation for π , viz. section 9*), this relation, *taken in its holic form (by virtue of the Holic Principle the squared term must be a temporal ratio)*, corresponding to a hologram by its Sweeping Action⁽⁶⁾) becomes:

$$3T^2 = L^3$$



$$3(R/\lambda)^2 = (r/\lambda)^3$$

This is Kepler's law and the form of critical galactic recession.

One notices that p , the ratio between Proton and Electron masses obeys the following form, (p is so given the standardised value 1836,152729),

$$3(p^2-1/2) \approx 6^6 + 13^2 (6^3 + 1)$$

Notice a singularity for $3^3 + 4^3 + 5^3 = 6^3$. And $13^2 = (2^2 + 3^2)^2$ is the single squared number in the Y solutions of the basic Pell-Fermat Equation⁽⁷⁾: $2Y^2 - X^2 = 1$.

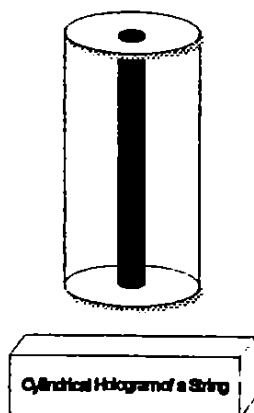
Remark: additive term are singular, and may be viewed as integration constant, the equation $T^2 = L^3/3$ being of 'integration' type).

2. Cylindrical Symmetry: the complexity conservation gives the relation:

$$(T_2/T_1)^2 = 2X$$

In this case the sweep is inside the string: this is an internal reference hologram⁽⁸⁾, where X is a common quantum number (because of exponent 1), whose diophantine solution is:

$$T_1/T_2 = 2^N ; \quad X = 2^{2N-1}.$$



☆ For $N=1$. This case defines the *Spin* of the fermions $X=2$ (standard notation $S=1/2$). The equation $T_1 = 2T_1'$ indicates that the regeneration period of the fermion is double a more fundamental period (a boson one). That leaves a dead time for the possibility of appearance of anti-synchronised re-created fermions (*Antimatter*). *The Complexity Conservation merely confirms the Holic Principle. The Spin is a mark of the Hol's sweep.*

☆ For $N=64$ (first non-trivial square-cube number) you get back to $X = 2^{127}$ as we saw in the preceding Section. This makes the fourth level of the Combinatorial Hierarchy special, and shows that this is *connected* with a Huge Spin (Hol).

6. THE PAIR HYDROGEN-NEUTRON, u and d QUARKS. THE CENTRAL ELECTROMAGNETIC COUPLING CONSTANT α

Consider more precisely spherical symmetry. If we suppress the Topological Factor 3, in order to obtain a *degenerate non-linear diophantine equation*: $A^2=B^3=C^6$ one observes: (the Hydrogen/Electron mass ratio is $H \approx p+1$ with excellent approximation)

$$(H)^2 \approx (6 \times 5^2)^3 \approx (7/2)^{12} \approx n^2$$

providing a diophantine basis for the couple Hydrogen-Neutron ($n \approx (7/2)^6$) and suggesting that the quarks u and d are respectively associated with the Whole Numbers 5 and 6, which may be associated in the framework of Superstring Theory with numbers of « Internal Dimensions » 5 or 6, and more generally with Information Complexities since these numbers naturally enter through their combination as a product. The confirmation of this hypothesis comes from the fact that the other combination $6^2 \times 5$ is extremely singular. One observes the *the 5 and 6 Quark Relations* (the second one, involving α is very near n^2):

$$\begin{aligned} p^2 &\approx (5^2 \times 6)((5^2 \times 6)^2 - 5^2) + 206.844 \\ (6^2 \times 5) \alpha^2 - 2 &\approx (5^2 \times 6)((5^2 \times 6)^2 + 6^2) - 206.8 \end{aligned}$$

The residual term 206.8 is the Muon/Electron ratio μ with a four-figure precision. By assuming it is the same in the two relations, this would give $\alpha \approx 137.0359885$.

Remark: the singularities $H \approx 150^{3/2}$ and $\alpha^2 \approx 6 \times 5^5$ here discovered have been demonstrated independently (but without connection with Quarks) by the Systema Arithmetical Theory⁽⁹⁾.

Study of the deviation of n with respect to $(7/2)^6$ leads to $n = 1838.683663$ given by:

$$n \approx (7^7 - 1) 5^4 / 6^7 \quad (10^{-9})$$

No doubt Nature uses small numbers raised to high powers. This is characteristic of Number Theory Singularities. Moreover $7/6$ is the 7th Bernoulli number, the one which is closest to unity, and 5^4 is the 7th root of the Systema Singularity⁽⁹⁾: $2^{65} \approx 3^{41} \approx 5^{28}$. This is extremely singular and significant, since one observe with the above (10^{-9}) values p ; n , the

$$\text{12th order Beating Relation} \quad (n/p)^{12} \approx 61/60 \quad (10^{-9})$$

As $12 = 5 + 7$ the ratio n/p acts also through its 7th power (organisational ratio, see below)

An examination of the numeric deviation of the coincidence $(p+1)^2 \approx 150^3$ shows that

$$n^2 \approx (150 + (\alpha)^{-1/2})^3 - (\alpha)^{1/2} \quad (10^{-8})$$

revealing that α plays a central role. This is confirmed by the following form, giving the main light Mesons⁽¹⁰⁾: $(7n + m\alpha^{-1/2})^{3/2}$, giving $\Pi^\pm$ ($n=6; m=1$) within 0.04%, Π^0 ($n=6; m=-10$) (0.08%), $K^\pm$ ($n=14; m=-3$) (0.03%) and K^0 ($n=14; m=3$), the last within experimental accuracy (0.006%). *This central role of α is totally unexpected by the Standard Theory*, for which, in the Particle Range, the Force Coupling varies with the interaction distance. In fact it must be the Quantum Geometry which varies (see the rationalisations of π in the following).

7. THE MASS EQUATION: THE CONCEPT OF COMATTER AND EDDINGTON NUMBERS: 6 ; 10 ; 136; 137

Because the mass was raised to power 5, it is logical to postulate:

$$M^5 = M'^7 \quad \text{generalising} \quad T^2 = L^3$$

M' is a new Physical quantity obviously called the 'Comatter', acting by its 7th power (an organisational quantity). Such an hypothesis is an *aesthetical necessity*. Moreover the two pairs of numbers (2;3) and (5;7) are the two simplest non-trivial solutions of the Pell-Fermat Equation:

$$2Y^2 - X^2 = \pm 1$$

The connection of this equation with the Extended Time Equation of Chronorelativity is immediately obtained by equating the two times T_1 and T_2 .

Remark: The contraction of the residual term in the holographic information for p gives half

the corrected Tau comass ($\tau_H = \tau (1+1/\mu)$), with 5 figures : $3494.0 \approx (2 \times 13^2 (6^3 + 1) / 6^3)^{7/5}$

Since the proton and the electron must be symmetric (*a non-standard hypothesis*) the equation $p^5 = p^{17}$ is, in the highest degree, singular. Consider, moreover, the seventh root of p and n ; one observes: ($H = p+1$)

$$H^{1/7} \approx (137)^{1/2}/4 \quad n^{1/7} \approx (\alpha)^{1/2}/4 \quad (10^{-5}) (2 \times 10^{-6})$$

By introducing the 'pictorial' form: $\text{Pict}(X) \equiv X^X$, one observes *the Key Relations*, whose pertinence is guaranteed by that of their characteristic deviations ($t\ddot{t}$ is toponium):

$$e^\pi \approx \text{Pict}(n^{1/7}) (1 - 1/K^2) (1 + 1/t\ddot{t}) \approx \text{Pict}(\alpha^{1/2}/4) (1 - 1/K^0) (1 + 1/(\Pi^2)^{8/3}) \quad (10^{-8}) (10^{-8})$$

So the Coupling α is tied to the resolution of $e^\pi = X^X$. This has a profound significance. Nature chooses an exponentially intermediary base between the Euler's natural one and π .

The Proton-Hydrogen symmetry is preserved since one observes:

$$e^\pi \approx H^{1/7} \wedge p^{1/7} (1 - 1/4\tau) \quad (2 \times 10^{-9})$$

$$2\pi\alpha \approx \text{Pict}(p^{1/5}) (1 + 1/\eta) (1 + 1/e^{\alpha/2}) \approx \text{Pict}(H^{1/5}) (1 - 1/\tau_H) (1 + 1/\alpha_f) \quad (10^{-8}) (10^{-8})$$

As $2\pi\alpha$ plays an eminent role in the Standard Theory, and as $p^{1/5}$ has Holic character (see further), *the strong non-linearity of Physics is evident*. Standard perturbative methods cannot be used to explain such relations. This strong non-linearity is tied to *high order Numerical Resonances*.

The appearance of 137 confirms Eddington's view^[7] and the Combinatorial Hierarchy, where the sum of the first three terms is $3 + 7 + 127 = 137$. Eddington's Theory was rejected as soon as α was measured as different from 137. However this is a *Primary Broken Symmetry* as is shown by the three 9 decimal place relations: (with the value obtained below $\alpha = 137.0358844972$)

$$\begin{aligned} (\alpha^2 - 137^2)^{1/2} &\approx \pi - 1/(2\pi\alpha) - 2/(\Pi^0 + 3/2)^2 & (10^{-9}) \\ \alpha(\alpha^2 - 137^2) &\approx \pi^2\alpha - 1 - 1/(\Pi^0 + e/2)^{23} & (10^{-9}) \\ (\alpha + \pi)^2 - 4 &\approx (137 + 10^{1/2}) (1 + 1/E) M (2 - M) & (10^{-9}) \end{aligned}$$

where E is the Characteristic Value of Force Unification ($E = U^{1/6}$) (see below) and M the Magnetic Moment of Electron. The last shows that *the asymmetry $\alpha/137$ is connected with the classic one $\pi^2/10$* . 10 is the number of components of the symmetric part of the Time-space Matrix (gravitational), while 6 corresponds to the antisymmetric part (electromagnetic), as noted by Eddington:

$$16 = 10 + 6$$

This is also the total proton Complexity Number: $16 = 5 + 5 + 6$, (two quarks $u=5$ and a quark $v=6$, producing $5^2 \times 6$, as seen above). So the rejection of Eddington's Theory was collective blindness, since his Equation would have led to Quarks.

Moreover, π shows an intrinsic Holic-type singularity :

$$\pi^2 \approx (\pi - 1)^3 (1 + 1/\mu) (1 - 1/(\Pi^0 + 1)^2) \quad (2 \cdot 10^{-8})$$

the Muon Ratio μ being itself $(\pi - 1)^7$, within 0.08%. This implies *rationalisation of algebraic forms, containing powers of π* . The powers of π appear in the even Riemann Zeta series: so $\zeta(2) = \pi^2/6$, while the odd series has no synthetic expression. But one observes $\zeta(3) \approx e^2/6$, which could show a *symmetry π/e* . This shows up in the total neutron Complexity ($6+6+5=17$):

$$4^2 + 1 \approx \pi^2 + e^2 \approx 207/12$$

(12 and 17 are solutions of the Pell-Fermat equation) and also in:

$$\alpha^{1/2} \approx (\pi/e)^{17} (1 - 1/\tau_H) \quad 10 e^8/\pi^9 \approx 1 + 1/E \quad (2 \times 10^{-8})(10^{-8})$$

That leads us to examine $e^2/6$: the Weak Mixing Angle⁽¹⁰⁾ $\sin^2 \theta_W$ is very near $e^2/6 - 1$, and also $207 - \mu$, 207 being a whole number of Noyes⁽¹¹⁾ model.

8. THE THREE LEPTONIC PAIRS AND GAUGE BOSONS

As seen above, the Quarks were *apparent* in the Eddington Formula. *It is thus natural to look for the decompositions of 16 into two small prime numbers:*

$$16 = 17 - 1 \quad ; \quad 16 = 13 + 3 \quad ; \quad 16 = 11 + 5$$

The first one is necessary, in order to get the unity, representing the electron, which is the natural unity to define Particle Mass Ratios. *The fifth power of 3 and 5 give the principal value of the Muon and the Tau.* This is in harmony with the Holic Principle, since a mass acting by its fifth power, must be itself a fifth power, in order to use the Pell-Fermat property: $5^2 \approx 7^2/2$. In particular the proton/electron ratio is near $(9/2)^5$. The pertinence of 3^5 is definitely proven by its proximity to $\tau_H/\mu^{1/2}$, within 0.008%, where $\tau_H = \tau (1 + 1/\mu)$.

It is thus natural to look for the 5th power of the other numbers: 11^5 et 13^5 give the bosons W et $2 \times Z \approx tt$ (Quarkonium 'top' recently measured at 174 GeV)⁽¹²⁾. *That leads to the prediction of a boson near 17^5 (720 GeV), a candidate for the missing X boson.* If this is confirmed, we suggest the name: 'Eddon'. It appears also as the missing term in the following relation ($E=62053.93916$):

$$1/E \approx (1/\mu - 1/\Pi^0) - (1/K^{\pm} - 1/17^5) \quad (\text{The Beatnote Relation})$$

Another arithmetical form must give the Neutrino Ratios (as their masses are known to be less than the Electron mass, these ratios are defined as Electron mass/Neutrino mass, in order to work with ratios greater than 1). By using the symmetric form $(3^{3/2^2})N^2(N^2+1)$, giving 1836 for $N=4$ and replacing 4 by 17, one obtains 565717.5 (0,90 eV) within 3% of the basic Electron-eNeutrino mass ratio obtained in the Force Unification Relation obtained below. So, the values of this form for 13 and 11 are logical candidates for the two other neutrinos (always with respect to the Electron). One obtains respectively 194×10^3 and 99.7×10^3 , corresponding to 2.63 eV and 5.13 eV. The sum of these three Neutrino masses amount to 8.67 eV. This corresponds to about $1/4$ the Critical Mass of the Universe⁽¹⁰⁾.

Remark: *the power 2/3 of the Exotic Particle Ratios are near Integer Values.* That seems to imply a 'Nodon' composition: Muon(5x7), Tau(2x5x23), (23 is the integer value of e^n), Pions(2x3x7), Kaons(2x7x7), Eta(3x5x7), Oméga(7x19), D(2x7x17), Ds: 5x7x7, ce: 2x7x23, bb: 2x2x5x5x7, tt: 2x2x5x5x7x7. The predominance of Nodon 7 is obvious (2nd level of Combinatorial Hierarchy).

9. RATIONALISATION OF π . WORLD DISCRETENESS PROVEN

We have seen above the tight connection between α and the two mathematical bases π and e . The nearest whole value is 3, which appears to be the most efficient Integer Base. The 'fractionate' charges of the Nodons 2 and 5 appears clearly in this base 3:

$$2 = 3 - 1 \qquad 5 = 3 + 2$$

The Quark d is the combination of the Nodon 2 and the 'neutral' Nodon 3. The Quark u is the Nodon 5. The Charge Sum for the Proton and Neutron are thus:

$$5+5+2 = 12 = 3 \times (3+1) \qquad 2+2+5 = 9 = 3 \times 3$$

The values 12 and 9 are of the order of $\alpha^{1/2}$ and α_F (the Strong Nuclear Coupling)⁽¹⁰⁾.

The Classical rationalisation of π , 355/113 can be written in function of $137 + 1/16$, and by replacing this quantity by α , one gets the inverse neutral Pion as residue:

$$17(\pi - 2) = (137 + 1/16)(\pi - 3) \approx \alpha(\pi - 3) + 1/\Pi^0 \qquad (10^{-9})$$

As $16 \times 137 + 1 = (2^4 + 1)(2^7 + 1)$, and $\Pi^0 \approx (2^7 + 1)^2 / (2^6 - 1)$ within the experimental limit 4×10^{-6} , this clearly connects with Chronorelativity. Also, this rationalisation can be written,

$$"\pi"/3 = (16 \times 137 - 1837) / (16 \times 136 - 1837) \qquad "\pi" = 355/113$$

The denominator shows *overwhelming singularity*: by replacing 136 by $\alpha - 1$ one gets the corrected-Tau comass ($\tau_H = \tau(1 + 1/\mu)$) with 6 figure accuracy, connecting directly with the 9 figures value of p given above by the Complexity conservation, (where π was eliminated): π returns here. The numerator gives 8 times the Muon comass with 5 figures by replacing 137 by α and 1837 by 1832 whose square is both the entire value of $1837^2 - 137^2$, the 4/3 power of $(\alpha + \alpha^{1/2} + 1)$ and $P1^2/2^{127}$.

10. THE ALPHA RATIONALISATION

As seen above α is tightly connected to π , whose rationalisation connects to Physics Data, which in turn is connected to α . So, *the rationalisations of α and π must be directly connected*. In fact, by pushing further the fractional development of π , one observes:

$$\pi \approx 3 + 1 / ((7 + 1 / (16 - 1/6 \times 7^2))) \qquad (10^{-9})$$

Half the forth term of the development, 3×7^2 is $2 \times 137 - 127$. So one can recognise the elements of the Combinatorial Hierarchy, but with the appearance of 16, obviously the Eddingtonian's one. The above development can be written:

$$(\pi - 3)(2^6 + 1)(2^9 - 1) \approx 32 \times 137 + 1 + 6 \times 53$$

Now $32 \times 137 + 1$ is very close to 32α . By making the substitution one obtains a specific approximation of π , which shows up a singular fractional development: 3 ; 7 ; 16 ; 18; 6; $\pi/21$. The corresponding relation implying π^2 and π shows up in turn a spectacular property: the discriminant is very close to a square number: $(2^{16} + 2^{11} + 43)^2$. So the coefficient of π^2 , which is 17×727 , is the natural candidate for the multiplier of 32α . By inspecting $32(\alpha - 137) \times 17 \times 727$, one finds:

$$(\alpha - 137) 2^5 (2^4 + 1) (3^6 - 2) = (2^7 + 1) (2^{15} + 1) (2^3 + 1)^{-1} (2^5 + 1)^{-1} \quad (10^{-9} \text{ for } \alpha)$$

$$\alpha = 137,03598844972 \dots$$

$(2^{15} + 1)$ is divisible by $(2^3 + 1)$ and by $(2^5 + 1)$, reproducing (as $15 = 3 \times 5$) a property that is only general to the Mersenne Form $2^N - 1$. Moreover the two ratios are 3641 and 993, of the order of the D and K Mesons ratios, whose geometrical mean is near p.

11. THE GREAT CORRELATION

A direct analysis of Physics Data produces a pure gem. The following Great Correlation, where the three first quantities (including the proton comass $p' = p^{3/7}$) connect within 10^{-9} , inside the 10^{-4} accuracy of the last one (due to the imprecision on G),

$$\underbrace{(p' + 1)}_{\text{Holic}} / \underbrace{(p' + 2)}_{\text{Eddington}} = \underbrace{p / (16/10)^{16}}_{\text{Particles}} = \underbrace{(1 + 1/Z) / M^4}_{\text{Hierarchy}} = \underbrace{(Pl/p)^2 / 2^{127}}_{\text{Hierarchy}}$$

where Z is the Intermediate Neutral Boson mass ratio (with always the Electron mass as unit) and M is the anomalous magnetic moment of the electron (with the Bohr magneton as unit). In this situation, where 30 significant decimals are involved, (and 35 more have been found in characteristic relations) one can postulate the identification, correct to (10^{-8}) of the last quantity, that is the ratio $Pl = 2,38 \underline{9505672} \times 10^{22}$. This produces a more precise value of the Gravitation Constant⁽¹⁰⁾ $G = 6.6727141 \underline{(80)} \times 10^{-11}$ (S.I). The underlining shows the decimals gained, relative to the empirical value. In atomic units, one obtains one decimal more. Moreover the corresponding ratio $Pl/\text{Electron}$ shows spectacular confirmation of the whole procedure:

$$Pl^2 / 2^{127} \approx (5^2 \times 6) ((5^2 \times 6)^2 - 11^2) - 2 \times 11^2 \quad (10^{-9})$$

A connection with the $22 = 26 - 4$ hidden dimensions of the Superstring Model⁽¹⁰⁾ is most probable.

12. THE UNIFICATION OF FORCES

The Unification of the 4 known Forces is a great challenge of current Physics. The Standard Theory is not able to include Gravitation in the realm of the three others Forces, which are themselves *only empirically* unified since this Theory introduces about 30 *non-correlated* 'free parameters'. From the Holic Form of the two Eddingtonian terms of the Grand Coincidence, *one observes that* :

$$\begin{array}{ccccccc} \emptyset^{137} \approx U \equiv (Pl/10^8)^2 \equiv (2^{21}p)^3 \approx \alpha_f^5 \approx E^6 \approx (e^{3\pi})^7 \approx \alpha_F^{30} \approx (\alpha/5)^{20} \approx (43\mu/(n-1))^{42} \approx (\alpha/10^2)^{210} \\ \downarrow \quad \quad \quad \downarrow \quad \quad \quad \downarrow \quad \quad \quad \downarrow \quad \quad \quad \downarrow \quad \quad \quad \downarrow \quad \quad \quad \downarrow \quad \quad \quad \downarrow \\ ??? \quad \quad \quad \text{Gravitation} \quad ? \text{ Weak Nucl. Elm.} \quad ? \text{ Strong Nuclear} \quad \quad \quad ??? \end{array}$$

where α_f , α_F are respectively the weak and strong nuclear coupling constants (The Standard Notation is $1/\alpha$). $\alpha_f = 573004(10)$ is the inverse square root of the Fermi coupling constant, normalised to the electron⁽¹⁰⁾. Once again, this is extremely supportive of a diophantine resolution scheme since $30=2 \times 3 \times 5$ is a necessary exponent since 2; 3; and 5 are coprime numbers. And so for $210 = 2 \times 3 \times 5 \times 7$.

The Great Correlation is so strong that the Holic Theory, (including the Comatter concept, the pertinence of the exponent 7 being obvious), emerges directly from mere analysis of Data: the whole numbers appear really as the exponents. This definitely answers the Feynman⁽⁴⁾ question; 'How can we correlate Data of such different magnitudes'.

REMARKS

1) The Systema approach⁽⁹⁾ led to study of the coincidences between powers of 2; 3 and 5. Here Nature clearly shows that these basic whole numbers are the *exponents* of Physical Ratios, in direct accordance with the Holic Principle. So the two approaches show 'Exponential Symmetry', naturally leading to the predominance of terms of the form X^X , X being a Physical Ratio. It is exactly what was encountered above for $X=\alpha^{1/2}/4 \approx n^{1/7}$, and $X=p^{1/3}$, producing respectively $X^X \approx e^\pi$ and $2\pi\alpha$. *The two approaches unite in these Key Relations.*

2) The characteristic form of the electromagnetic factor (corresponding to the 6th powered term i.e. both a temporal and a spatial ratio, implying directly the fundamental connecting constant c) $E \approx (\sinh \sqrt{\alpha})$ is not yet explained but seems fundamental. It comes up in the *Relativity of Scale*⁽¹²⁾, as a numerical singularity, namely: $\ln Pl \approx ((2\pi)^2 + \alpha^{1/2})(1 - (n+1/6)^{-2/3})^{-1}$ to (10^{-8}) . Notice that $\exp \sqrt{\alpha}$ is of the order of the Intermediary Bosons W and Z. The value τ_H given by $E\mu/(2p)=3493.932199$, or equivalently $2^{19} \equiv p(\tau_H/\mu)^2$ was proposed at the 16th ANPA Meeting. The new Data⁽¹⁰⁾ gave confirmation, but with a Muon correction: $\tau \approx \tau_H(1 + 1/\mu)^{-1}$. 3) Being to the fifth power, α_f must be an important *mass ratio* (the Electron Neutrino Ratio), consistent with the above Three Leptonic Pair Analysis. This corresponds to *e-Neutrino mass ≈ 0.89 eV*.

4) The number 10^8 should identify with the photon/baryon ratio, a 'free parameter' not explained by Standard Cosmology⁽¹⁰⁾, but measured as about 10^9 , with the observed Universe mass. So about 9/10 of the mass is hidden. The Super-Black-Holes masses and the three Neutrino masses amount only to $\frac{1}{2} + \frac{1}{4} = \frac{3}{4}$ of the Critical Mass, so *there are other sources for gravitation: probably from the not-yet detected Comatter. In this case the search for the Hidden Mass would be replaced by the Comatter Quest.*

5) *The cubic term corresponds to a Fifth Force intermediate between Gravitation and Nuclear Forces.* Gravitation, being squared, is a purely Temporal Force. It is the main factor for large structures, but with poor geometrical information (essentially spheres). The cubic one is mainly a Geometrical Force, producing complex structures. It follows that this Vital Force acts directly on Information Complexity, and cannot be directly compared with such rudimentary forces as Gravitation. *This is the reason why this Vital Force has not yet been recognised. However, its universal action is demonstrated by its obvious consequences: the living forms (exactly as one can guess the universality of the gravitation force by examining the spherical form of the Moon or the curvature of the hearth horizon).*

6) The last terms, (especially the 20th power giving α to 5 figures, and showing $\alpha/5$ with principal value 3^3 , confirming that 3 is the true efficient base), is a strong indication that α is the one true Force Unification Constant.

7) the pertinence of the 21st and 42nd order terms (the 42nd term gives μ within 10^{-6}) is *out of the smallest doubt*. There is clear evidence of a basic role of a comatter term (7th order). This imply a special organisational structure, between Electron and Nodons: the Exotic Particles receive basis and connect with a 6th interaction.

8) Notice that the U Unification Constant is very close to 3^{60} , which shows intrinsic singularities: proximity to 2^{95} and 5^{41} (in harmony with the Systema approach) and to $\emptyset^{137}$, where $\emptyset$ is the Golden Number: $\emptyset = (1 + \sqrt{5})/2$. It is not surprising that this artistic and geometric number ultimately shows up in the Unification of forces.

CONCLUSION: A NEW START FOR NATURAL PHILOSOPHY

The simplest assumption one can imagine (the Holic Principle, i.e. "a single Thing exists", is even simpler than the Parker-Rhodes assumption "something exists") initiates the ultimate synthesis between Cosmology, Relativity, Quantum Mechanics, Particle Physics, Systemics, Biology, Art and Psychobiology. Old questions and current Physics foundations are simply answered and corrected. *They can be understood by everyone*, opening a fruitful multidisciplinary discussion in the realm of Holic Natural Philosophy where the words 'Continuum', 'Infinity', 'Indeterminism' and 'Reductionism' are ruled out. *Experimental Data proves definitely* the Discreteness of Universe, through the rationalisation of π , and the Great Correlation which involves neatly *integer exponents*. The Holistic character of the Cosmos is *definitely* shown by the central role of α . Standard Physics appears as a superficial linearisation of a highly non-linear Universe, so is *definitely ruled out for answering basic questions*.

The *topological Complexity Conservation* gives the basic equations for the high order non-linear Universe. It provides clear-cut relations between particle data. A double structure of the quark d is predicted. An extrapolation of the Fundamental Equation of Eddington gives the masses of the three neutrinos and the Boson X ('Eddon'). The simplest imaginable Holic Equations show definitely the Diophantine Unification of the 4 known interactions, plus 2 more. *The exotic particles and life itself receive theoretical basis.*

The *Comatter Concept*, probably the strangest idea ever recorded (an hidden Physical Quantity, acting by its seventh power), is the missing link between Physics and Biology.

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Advice to answer the too frequently asked question: "where have you taken that?" or "are you paraphrasing Pythagoras or Eddington?". In fact the main concern is the 6th reference, since it opens the *really new technical possibility to make Architectural Holograms: it was natural to extend this to the Whole Universe...*

This is a pure Creation, *only based on experimental data and simple ideas, as every Physical Theory should do.* The following references are only useful for establishing connections with others 'points of view' or stating the questions that are *resolved* in this study. Even Eddington cannot be said to be an *initiator* since the English used to describe his Fundamental Theory is very hard to understand (a French translation is badly needed), except for his critique of the referential concept and the paramount beauty of his identity: $16 = 10 + 6$ (nobody has seen this gives both Quarks and the three Leptonic pairs family). Although the referee does not agree, the same remark applies for ANPA - (with this same kind of 'sophisticated', or misleading English I *cannot* readily understand, especially philosophical considerations), - from which I retained only the wonderful hierarchic $137 = 3 + 7 + 127$ (apparently nobody in ANPA has seen the *obvious* connection with the rationalisation of π , in conjunction with the Eddingtonian 16 in the fractional development). Also, the Systema work is very hard to follow, because of heavy formalism (this group has failed to see that $137 = 84 + 53$, where 2^{84} is so close with 3^{53} , the Hindu musical scale numerical singularity). The even more precise conjunction $2^{1054} (\approx 3^{665})$ gives $\mu^{137+1/36}$ producing μ with the 7 measured decimals, is also the 5th root (a mass acting by its 5th power) of e^{3653} , resulting in the 4 known decimals of the mean Meson D. *Such truly improbable, or 'impossible' connections - but they do exist! - are sufficient to prove definitely the highly non-linear diophantine character of everything in the Universe. This is one more proof of the irreversible failure of standard theory.*

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DISCUSSION (CAMBRIDGE 13 SEPT. 1994)

During the Lecture the question arose, "what is the Comatter?" the answer was, "no ideal" (it was then only an *aesthetic necessity*, and the connection with Systemics and Biology had not been made).

Mike Manthey: Are you really going to be religious about whole numbers ?

Answer: It is not a matter of Religion. Physics is devoted to measurable quantities, thus 'in fact' discrete. So the traditional Differential Equations are, strictly speaking, fictional idealisations. Not so for Diophantine Equations.

Mike Manthey : Diophantine, because solutions are integral ?

Answer: Not only. Also because they are beautiful. Consider Fermat's last Theorem! For $n=2$ there are solutions. There is beauty in that, the discovered relations between Physical Data show that Nature tries to find solutions for greater n , and these tries define the Particles.

Pierre Noyes: What we are doing is really within diophantine analysis, so we should be closer together. Though what we include and what we leave out is still an open question. Some diophantine relationships come in ANPA I hope to find if this is the same. I will study the text.

Answer. Thanks. It has taken me almost 3 years to analyse the data, but far much time to achieve the conviction of the validity of the HOL concept, since this idea struck me at the age of 15, as soon as I heard about the Identity of Electrons.

Emmanuel Ransford: Where is the physics?

Answer: *What is physics ? Observation, data, and simple ideas to discover numerical connections.* This work is pure physics! Compare Bode, Kepler, Dalton, Lavoisier, Mendeleev, Mandel, Balmer, Eddington, Dirac. But it is true that the Standard Attitude is to denigrate this as « numerology ». Nobody says that Eddington has predicted the Tau several decades before its detection, with the right order of mass, calling it the « heavy mesotron ». Moreover his formula $16=10+6$ appears to have a fundamental importance in the holic relations. *It is now clear that Physics cannot escape a reconsideration of Eddington Theory.*

Emmanuel Ransford: I was really impressed by Starson (but for some open questions) and by you. But it is very surprising you can get such a host of results. What is the trick ?

Answer: You must reformulate physics at the very beginning, and *study the data*. This is what we teach to our students. Only Noyes has tried this, but in a formalist manner. Here there is a detailed and time-consuming *direct analysis of data*, so success was most probable, although I confess I was surprised that so simple relations connect the 4 classic interactions, *(at this time the connection with Biology through 2 new interactions and the comass organisational concept had not been made)*. The holic relations are so improbable that I promise champagne to ANPA if the predictions are not corroborated (and also, of course, if they are confirmed)... Who else met Diophantine Analysis ?

Peter Marcer : Diophantine equations arise in the Halting Problem for Turing Machines

Pierre Noyes : The question is : what is common to such disparate points of view ? We have a common case in which we are all interested, trick, interest, question...? It is a clue to what ANPA is about.

Answer: The common point is Whole Number, but what is new is the *Aesthetical Consideration*. What can be more beautiful than the linking between the two Opposite Singularities that are Space and Matter? The trick is to establish a self-organisation between them, and what is simpler than the Pythagorean Equation and degenerate Non-Linear Diophantine Equations? Also, Information Conservation has not been used before. However this is essential to explain how an Hologram works. But who cares about holograms? In this Meeting only Peter Marcer spoke of this, (and also insisted on the importance of a self-organisation). The great majority thinks erroneously that it is a beautiful gadget, but a gadget.

Peter Marcer: Diophantine Equations are what determine the phase-locking in the auto-organisation process...

Pierre Noyes : Two sequences not in phase are mode-locked if the relative phase conveys no information

Reply: You need only one entity, the HOL.

Pierre smiled....

(?!) Post-Meeting Remark. This discussion was extremely useful. It led directly to the discovery of the 'commuting Electrical Charge', a model explaining Antimatter by the 'dephased Matter concept'.

HOLIC GLOSSARY

ANTIMATTER: Holic Theory gives a simple interpretation to antimatter. (not to be confused with Comatter. which is a completely new kind of Physical Quantity). While for ordinary matter an elementary charge oscillates between the values 1; 0; -1; 0...the antimatter's charge follows the opposite sequence -1; 0; +1; 0. This is and by the nature of it being so, represents the rhythm of the Universe.

CHRONON: atom (derived from Greek, to describe the undecomposable part) of time, identical to the Arithmetic Unit (the simplest choice in discrete Physics) and the unit of electric charge (the simplest choice for the auto-organisation parameter). This conjunction of simplest choices produces the Chronorelativity.

COMATTER: the physical quantity complementary to Matter, as Space is to Time. This new concept is imposed by aesthetic logic to make the canonical Holic equations symmetrical. The dramatic apparition of the vital force in the Unification Equation confirms that Comatter is tied to organisation properties; this new Physical Quantity is the needed missing link between Physics and Biology, opening the way to true Natural Philosophy. It may be the resolution of the so-called 'Hidden Mass' problem, restated as a 'Hidden Gravitation Sources' quest.

COMPLEXITY CONSERVATION: the conservation of the Information Complexity Number, under the change of the information support topology. It is an absolute law, applying to whatever theory is considered. It is the most important conservation law of Physics, since, in connection with the Holic Principle and the sequential reading of an Hologram, it results directly in producing the Kepler law and the critical Galactic Recession. Its generalisation in conjunction with "the Comatter concept" results directly in the Unification Forces Equation.

FLICKERING UNIVERSE: discontinuity being the rule in discrete Physics, the Universe is oscillating between creation and annihilation. This flickering is produced by the Hol sweep going forth and back (time reversals).

HOL: the quantum of the Universe which identifies with the Universe itself, with all its information, at each quantum event. In the same manner as a photon absorption is the concretisation of a non-localised electromagnetic interaction, the Hol can be considered to be the 'Universe-Particle' or, by the principle of complementarity, its propagating wave counterpart (see "Hol sweep").

HOLIC: related to the holic principle.

HOLIC PRINCIPLE: the principle defining the operational mechanism of the four main physical quantities in our model - time, space, matter and comatter - by the exponents affecting characteristic integers in the associated equations. It turns out that the simplest possible choice, i.e. the sequence 2, 3, 5, 7 of exponents, is confirmed by the consistent agreement between the predictions of the theory and the results of analysis of empirical data.

HOLISTIC: relative to a non-separable Universe.

HOL SWEEP: the creation and annihilation of the Universe that occurs in our model between two successive quantum events by the transfer of the Hol from one Topon to another Topon, producing a precise labelling of these topons (see 'quantum phase').

INFORMATION COMPLEXITY NUMBER: the number of independent parameters necessary to define a class of identical systems.

NODONS: the truly elementary particles, probably associated with the 129 first prime numbers from 2 to 727.

QUANTUM EVENT: in our model the instantaneous process (also called 'wave-packet reduction'), describing the localisation of a whole physical quantity which was initially non-localised. In the Holic Philosophy the whole information of the Universe is concentrated in each Quantum Event, the starting Topon of each Hol sweep (see the figure in the text).

QUANTUM PHASE: the rational physical quantity labelling each Topon, and the ratio between the Topon's number in the Hol sweep and the Universe Period (i. e. the total number of topons) of the Hol sweep. This is called a phase because of the quasi-periodicity of the Hol sweep.

SUPREME EQUATION: the Equation the Universe is always trying to solve. As it doesn't succeed, Chronons and Topons (with also new Matter and Comatter) are added, producing the arrow of time and Galaxy Recession.

TOPON: atom (undecomposable part) of space, i.e. the smallest physical part or cell limit of space.

BASIC PHYSICS DATA (Phys.Rev.D50 August 1994)

The relative ratios (in bold character) are mysterious pure numbers bearing messages from the Universe (the masses of Quarks and Neutrinos have not been measured). The Holic Theory is reading one, who else will help find the secrets contained in these numbers?

COUPLING CONSTANTS:

Elect.Magn.	α	137.0359895(61)	$(.45 \times 10^{-6})$	(standard notation $1/\alpha$)
Fermi	$G_F/(\hbar c)^3$	$1,16639(2) \times 10^{-5}$	$(\text{GeV}/c^2)^{-2} (20 \times 10^{-6})$	$\alpha_f = (G_F/(\hbar c)^3)^{1/2}/m_e \approx 573004(10)$
Strong	α_f	1/0.116(5)	(43×10^{-3})	(standard notation $1/\alpha_f$)

WEAK MIXING ANGLE:

$\sin^2 \theta_w$	0.2319(5)	$(2,2 \times 10^{-3})$

ELECTRON'S MAGNETIC MOMENT:

$M = 1.001159652193(10)$	μ_B	(10^{-11})

PLANCK MASS (the mass given by the three main universal constants: c ; G ; $\hbar = h/(2\pi)$)

$Pl = (\hbar c/G)^{1/2}$	$1,221047(79) \times 10^{19}$	$\text{GeV}/c^2 (65 \times 10^{-6})$	$Pl/el \approx 2.38953(15) \times 10^{19} (65 \times 10^{-6})$

MASSES OF MAIN PARTICLES

AND RELATIVE RATIOS TO ELECTRON

STABLE PARTICLES

Electron: e	$0.51099906(15) \times 10^{-3}$	$\text{GeV}/c^2 (0,30 \times 10^{-6})$	1
Proton: $p \approx H-1$	$0.93827231(28)$	$\text{GeV}/c^2 (0,30 \times 10^{-6})$	1836.152701(37) (20 x 10³)
Semi-st. Neutron: n	$0.93956563(28)$	$\text{GeV}/c^2 (0,30 \times 10^{-6})$	1838.683660(40) (22 x 10³)

GAUGE BOSONS

$W^\pm$	$80.22(26)$	$\text{GeV}/c^2 (0,32 \times 10^{-2})$	156.99(50) x 10³ (0,32 x 10⁻²)
Z	$91.187(7)$	$\text{GeV}/c^2 (77 \times 10^{-6})$	178.448(14) x 10³ (77 x 10⁻⁶)

HEAVY ELECTRONS' LEPTONS

Muon: μ	$0.105658389(34)$	$\text{GeV}/c^2 (0,32 \times 10^{-6})$	206.768265(31) (0.15 x 10⁻⁶)
Tau: τ	$1.7771(5)$	$\text{GeV}/c^2 (0,28 \times 10^{-3})$	3477.8(1.0) (0,28 10⁻³)

MAIN MESONS:

Pions	Π^0	$0.1349764(6)$	$\text{GeV}/c^2 (4,4 \times 10^{-6})$	264.1422(12) (4,7 x 10⁻⁶)
	$\Pi^\pm$	$0.13956995(35)$	$\text{GeV}/c^2 (2,5 \times 10^{-6})$	273.13152(76) (2,8 x 10⁻⁶)
Eta	η	$0.54745(19)$	$\text{GeV}/c^2 (0,34 \times 10^{-3})$	1071.33(36) (0,34 x 10⁻³)
	ρ	$0.7699(8)$	$\text{GeV}/c^2 (10^{-3})$	1506.6(16) (10⁻³)
	ω	$0.78194(12)$	$\text{GeV}/c^2 (0,15 \times 10^{-3})$	1530.22(27) (0,15 x 10⁻³)
	η'	$0.95777(14)$	$\text{GeV}/c^2 (0,15 \times 10^{-3})$	1874.31(27) (0,15 x 10⁻³)
Kaons:	$K^\pm$	$0.493677(16)$	$\text{GeV}/c^2 (32 \times 10^{-6})$	966.102(31) (32 x 10⁻⁶)
	K^0	$0.497672(31)$	$\text{GeV}/c^2 (62 \times 10^{-6})$	973.920(60) (62 x 10⁻⁶)
Charm	D^0	$1.8646(5)$	$\text{GeV}/c^2 (0,27 \times 10^{-3})$	3648.9(1.0) (0,27 x 10⁻³)
	$D^\pm$	$1.8694(4)$	$\text{GeV}/c^2 (0,21 \times 10^{-3})$	3658.3(8) (0,21 x 10⁻³)
	$D_s^\pm$	$1.9685(7)$	$\text{GeV}/c^2 (0,35 \times 10^{-3})$	3852.3(1.3) (0,35 x 10⁻³)
	$c\bar{c}$	$2.9788(19)$	$\text{GeV}/c^2 (0,63 \times 10^{-3})$	5829.3(3.7) (0,63 x 10⁻³)
	J/ψ	$3.09688(4)$	$\text{GeV}/c^2 (13 \times 10^{-6})$	6060.442(78) (13 x 10⁻⁶)
Bottom	$B^\pm$	$5.2787(20)$	$\text{GeV}/c^2 (0,38 \times 10^{-3})$	10330.2(3.9) (0,38 x 10⁻³)
	B^0	$5.2790(20)$	$\text{GeV}/c^2 (0,38 \times 10^{-3})$	10330.7(3.9) (0,38 x 10⁻³)
	B_s^0	$5.375(6)$	$\text{GeV}/c^2 (1,1 \times 10^{-3})$	10518(12) (1,1 x 10⁻³)
	$b\bar{b}$	$9.46037(21)$	$\text{GeV}/c^2 (22 \times 10^{-6})$	18513.48(41) (22 x 10⁻⁶)
Top	$t\bar{t}$ (1995)	≈ 174	GeV/c^2	$\approx 2Z$

The Alternative Natural Philosophy Association

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