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PART 1.

The Combinatorial Hierarchy and its close relations

SPACES AND MINDS

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I am going to talk about the difference between space as we perceive it and space as we formally construct it. There are all sorts of problems -huge problems- which one learns to live with in conventional physics and therefore to be happily unconscious of most of the time which we can no longer ignore when we seriously undertake a constructive or 'process' approach.

The process approach, in all the forms in which any of us has imagined it always tempts us to think of physical theory as a classificatory scheme, and this aspect is of interest to a wider range of people than just the physicists. Moreover it is this aspect which makes us realise that some most profound questions about the relation of mind to matter have to be faced. Classificatory schemes may be convenient but basically arbitrary, but we are claiming that ours enables us to deduce some results which affect what most physicists call ordinary reality.

Long after we had our first estimates of scale-constants, we were still uncertain about this difference, to which we give the all-purpose 'process' description, between our model and the familiar ones. It was only accepted gradually that we had something like a computer program to which we were proposing to give a physical interpretation, and that computer programs worked step by step. Parker-Rhodes always stood out against the process view, but he was compelled to attempt profound mathematical innovations -in particular context dependence- to save the appearance of a model in which perception took the classical form. McGoveran has context dependence too, but I don't think his rigorous constructivism would have done for Parker-Rhodes.

So our common position is that the discrete aspect of the world forces us to the process picture in order to understand it. At any rate that is the case if we take the hierarchical model as our guide, for it makes no sense to think of the constructed entities without specifying a level at which they are to be considered, or in other words a point within the construction from which everything is to be viewed. We might well say 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 observers until we have explicitly constructed it and counted the cost.

Now the word 'observer' in a context in which there is no space is puzzling to say the least. It might be better to speak of a 'perceiving mind'. That would upset everyone -physicists because the mechanical sound of 'observer' seems to offer safety, and philosophers because 'mind' smacks of old fashioned metaphysics. I want to examine the different ways within our combinatorial approach which have been followed in trying to find a basis for an objectivity which can be perceived by more than one mind, and to assess where we now stand. I shall try to do

this with reference to some mathematical points which have come up in the fairly recent past.

Program Universe was formulated. It said that there was no problem of arbitrariness in having to study one construction which had reached a particular state because there were indefinitely many more and they proceeded concurrently, with interactions which were specified in the model. In this way one got the effect of a surrounding universe. One hierarchy construction would thus in general be at a different stage from the others with which it was interacting. It didn't seem to me that one was very likely to find out any more by linking up constructions along these lines, but I could see no difficulty in doing the programming provided that one were always prepared to call on randomizers to substitute for detailed knowledge. However McGoveran says that it is not merely the case that no one has written such a program: no one could. I don't know why he says this, though he certainly wouldn't say it lightly. We have two of the Program Universe constructors here however, so they may want to protest or enlighten us. In general I always hope at these meetings to be stopped in my tracks by howls of protest, but that doesn't seem to happen much. My methodology is to present what I understand of the views which underly peoples' theories as baldly and as crudely as I can so as to elicit corrections to my crassness in order that the truth may come out.

I think that in the PU enterprise there has been the idea that since there is a multiplicity of concurrent constructions, the step to a spatially distributed universe must be quite an easy one (again forgive me, and correct me, if I parody). And again the idea has prevailed that when we have taken this step we are back in the conventional view of the place of mind in nature and in its relation to space, whereas the constructive policy had seemed to demand a new view of what the mind had to do by way of organization. I am by no means sure that there couldn't be a development of PU which would follow this path and get an equivalent of spatially distributed objects from a computing model of a network of hierarchical constructions, but I am sure it would be a long haul, and -not surprisingly- people have sought short cuts. In particular, Noyes has.

Noyes justifies his identification of a PU-type model with a spatially distributed experimental set-up by an appeal to operationalism of Bridgman's type. Bridgman wanted to say that when we speak of -for example- a length, we MEAN a prescribed sequence of operations with a long thin bit of material which is then taken as a standard. Noyes says that when we talk about the strength of an interaction what we MEAN is that we have made certain counts and formed a ratio of them. So far so good: this was the principle he introduced and which we have all followed subsequently. However he always wants to go further and say that he has thereby established a correspondence between the language of the physicist and the combinatorial approach, so that each translates into the other in an agreed way. I am unsure whether this fits in with the spirit of Bridgman because Bridgman was talking about one conceptual framework, whereas our whole problem is that we are trying to reconcile two.

However I shall not press that point because even though I were to be satisfied about it, my real dissatisfaction would lie elsewhere. My own motivation has always been to understand how

quantum objects can have their limiting or bounding character and still masquerade as having ordinary reality (albeit with some queer differences from classical objects). In terms of my title theme we want to know whether the particles are mental constructs -products of our descriptive apparatus- or parts of the real world, and I put off the philosophical answer for the moment. The technical answer to this puzzle of being a masquerade and yet not a masquerade is provided by the hierarchy construction in which it is agreed by us all that a quantum object is specified by the whole hierarchy in a particular configuration. Now if this is so, how can it be the case that in Noyes operational identification not merely are certain counts specified, but also all sorts of spatial relationships which go with a conjectural 'particle' which is associated with those counts? Later I shall describe ways in which Kilmister and I have tried to take the first steps toward a spatial picture without incurring these troubles, though so far with a much less ambitious extent of physical identification.

McGoveran's way of working is very different. I think he would agree in broad terms with me in what I have so far said about the quantum objects and the impossibility of injecting them as elementary units into a previously constructed spatial framework. He was actively exploring finiteness and constructivity in the context of physical theory with his ordering operator calculus, and a finite equivalent or rather replacement for dimensional space appears there. When he came upon the hierarchy construction he saw it as exemplifying his principles, and he was able to take over the calculations and give them a new twist. There is a paper of his called "Justifying the combinatorial hierarchy" which he gave at ANPAWest in 1991 (not so long ago) which is very helpful, and which I can show to anyone who has not seen it. He picks particularly on the double structure of the hierarchy as providing a way of interrelating an object language with a formal or descriptive language. It is the former which presents what we know of the quantum world with its multiplicity of orderings which is provided by the discriminately closed subsets, while the simpler ordering of the mapping space -normally represented by the matrices, which we use for description.

One would expect from this position that there would be some evident connexion of the mapping space with the dimensionally ordered space of conventional physics, so that one could easily see the principles of the ordering operator calculus in action. I presume that the vector algebra would provide the ordering operators. However one finds oneself brought back to the general introduction of dimensional spaces independently of and prior to the hierarchy algebra. I personally find the earlier definitions of spatial relationships an embarrassment. I think that this explanatory gap is responsible for the problems we find in following McGoveran's correction to the value of the fine-structure constant. What promises to be the brilliant and definitive coping stone to the algebraic edifice because it welds the two progressions together so satisfactorily, turns out to be shaky on the interpretation of the factors in the vital bit of combinatorics. What is missing is a surrounding web of argument within which the identifications and selections of the numbers appear. You may remember that this time last year I did my best

to fill in the reasoning and was complimented on my efforts. However I had desperately hoped to be told what a fool I was and shown the right way.

It goes without saying that whatever McGoveran is saying it is far from simple-minded realism and therefore that the action of the mind in it is something that has to be understood. He tends to respond with a rather complex methodology. Methodology is something which mostly goes on in America. I won't exactly say that when I hear the word 'methodology' I reach for my revolver, but it does have a bit that effect because try as I will I never catch myself sitting down and discussing what methodology to follow. Even if I did, I cannot believe that the decision would have the slightest effect on what people observe, or think they observe. If it were to, then that would demonstrate the dominance of mind over matter alright, and so bring it into today's ambience, but I think the connexion would be facile.

Recently Kilmister has criticised McGoveran's use of numbers from the matrix algebra and hence rather played down the importance of the double progression. In his present basis for the hierarchy, of which more later, he shows that though one needs the 2×2 , 4×4 , mapping spaces for the discriminately closed subspaces, this need can be met with a smaller space at higher levels, and therefore the matrices are not a physical necessity (I understand that a 9×9 matrix will do.) I don't think this conclusion follows necessarily, though of course it influences the argument. If a certain apparatus has to be set up to handle the level relationships it seems reasonable to suppose that it may go on being used. Also, as I have argued before, the matrix relationship is very special in the way it, and demonstrably it alone, associates each element of a vector with every one of another vector indifferently. Again I shall develop this argument later.

We know that there is always talk of the observer in quantum physics, and some of us have long argued that this intrusion needs proper explanation, including explanation at the philosophical level where its use of the concept of mind comes out into the open. WE have always been very superior about it since we conspicuously avoid those troubles. There has been an agreement among us that if we are going to talk about an observer at all then it or he must play the same part in all processes in the hierarchy construction. Another way to put this is to say that if we insist on talking about 'consciousness' then there must be a form of it in the elementary digital processes, and since they are essentially interactions I see no difficulty -let alone contradiction- in that. This view has been referred to as the principle of the participant observer: there is no reason why there should not be especially complex and structured things going on which merit talk of a human observer, but he makes no particular ontological difference as he has to do in current quantum theory to make it work.

In a protracted correspondence, Pope has pressed me to be clearer about the elementary interactions: very reasonably of course: and I have was replied that they arose because 'interactions' seemed to be as simple as you could get, and because the next step in getting any structure must surely be to concatenate them. I evidently gave the impression that the elementary units were like building blocks with some similar

character to the old atoms. To get out of this misunderstanding which I think I laid myself open to, I would remind you of what I said about the indifferent choice or 'ergodicity'. We only get the hierarchy structure if there is no significant weighting in the unknown background, and the only way the interesting things in the world can make themselves known to us are through these non-statistical weightings. From this it follows that the prescriptions of ordinary physics are a very special case, even though we are used to expecting them and so tend to see them as the norm. I guess that small deviations from ergodicity produce the ordinary non-smoothnesses in the world like tables and chairs and mountains, whereas big deviations simply cannot be incorporated as approximations at all, and appear as in outright conflict with the laws of physics. So the world built up from the special kind of elementary interactions which we have considered is a sort of crust which can break, revealing deeper realities of which we are only intermittently aware. Now I only point out that if it is possible to be sensitive to orderings other than the ergodic in building our world, then it would seem very unreasonable to refuse to speak of a 'mind' as the thing responsible for these perceptions.

Pope inveighs against the crudity of the mind/matter division which he says has bedevilled philosophy since desCartes, but I think that even the shining knights of modern philosophy who have slain these metaphysical dragons would need some word which played the same part in the language game as 'mind' for the situation I have presented to you, provided that they took seriously the logic of the arguments leading to it or to something like it. This last is a big proviso though. Kilmister and I have used the term "Classical theory-language" for the scientific-humanist kind of realism or phenomenalism, deeply permeated by Newtonian particle dynamics, which provides our world picture most of the time. This world picture is so pervasive that even quantum theory and relativity which in different ways point to different realities, are formulated so as to take the classical theory-language as the norm with corrections imposed by mathematical fiat. Within this world-picture one does not talk of minds except in the stultifying way mentioned by Pope. The world proceeds on its course, and though human observers may be said to use 'minds' to decide what observations to make, there is little to be gained by talking that way.

I have to confess that until recently I assumed that the classical theory-language was alright within its own historical boundaries however much modern physics may show the need for something deeper. I do not now think even that is true. In such a study as classical celestial mechanics we have a handful of exact solutions. But we apply these to a vastly greater range of dynamical problems by essentially imagining that we -with our bodily experience- were at the place where we have to combine the analytic bits and pieces to decide how to accelerate the spacecraft.

Why are the philosophers not professionally excited by these possibilities of resuscitating the classical philosophical categories and giving them new flesh. My answer may seem the height of arrogance but I have to give it because I can see no escape from it as a logical conclusion. They are even more deeply and unconsciously embroiled in the classical theory-language than

the physicists are, because they have relegated all the discussion of its deep problems to the merely technical; which they can happily afford to be ignorant of.

I argue that the way I have drawn 'mind' out of the museum is justified by Kilmister's present formulation of the hierarchy and the way he bases it on interaction or discrimination processes in an unknown background. I am not saying that these implications were not present in the hierarchy all along, but the original way it was understood did permit a rather loose aggregate of ways of understanding. I draw attention to one change which I find particularly significant. You may have felt when I was dispelling fears of atomism about the elementary interactions, that in spite of all that there had to be a start to the hierarchy construction and a stop, and that therefore there was some absoluteness of position. This worried me for a long time. Kilmister abandons this kind of absoluteness that a given element has, in a quite dramatic change. The situation is as McGoveran describes it in the paper I quoted earlier. One of his requirements is that "one cannot determine the level other than by the number of elements at any level". In effect, the hierarchy always looks the same from each vantage point except as far as one can make deductions from the operation now in progress. This major change has not been trumpeted much: I am trumpeting it now.

Kilmister uses the innovation cardinally in his replacement of part of McGoveran's calculation of the non-integral part of the fine-structure constant. Before quoting an example of this use I mention that it is embarrassing to have two calculations (Kilmister's fairly accurate and McGoveran's very accurate). It does not seem that they can be essentially the same since the mapping space and its combinatorics are used in McGoveran's and are replaced in Kilmister's for reasons I mentioned earlier. My own view is that Kilmister's calculation must be right since it uses only arguments which can be justified step-by-step, and which come from the theoretical base which I have been trying to describe which does not involve any recursive identifications. (That is a polite term for jumping the gun to physical interpretations which one has not provided a basis for.) On the other hand Kilmister and I have always been much less ambitious identificationwise than the PU formulators or McGoveran, and have thought it quite alright to get results which apply over a limited area while physical theory as a whole is accepted to be beyond our power to describe at this stage.

In this spirit we are content for the moment that we can take voyages through the hierarchy structure but if someone asks us if we enjoyed a particular voyage more than the previous one we have to reply that we have no mechanism to record anything about a comparison of voyages and we cannot yet give the question any meaning. Now for a theory which is supposed to be recursive this is a pretty severe limitation. We always had the vague idea that the independent mapping space would solve this problem -indeed that that was what it was there for. Because of the marvellous subtlety of the interrelations between the two progressions in the hierarchy I should be amazed if it were right to introduce memory and recursion without starting with the mapping space. Indeed I have a desperate hope that McGoveran's

calculation may provide vital keys to understanding how to develop it. (After all, the two fine-structure constants are not the same: One is of the constant in general, and the other as McGoveran stresses is essentially about the hydrogen atom.

Back to Kilmister's calculation, where he considers (I quote) "the effect of the ergodic hypothesis on the process of arriving at one of the 137 elements of the hierarchy. The first approximation to this is simply to recognize that a new element may be any of the known ones with equal probability, giving rise to the probability $1/137$ and so to use the first approximation of α which identifies the particular constant. But at each level the process has not specified whether the element is at that level or not. one needs to apply the ergodic principle against each individual level. At the first level the possibilities are 1, 2, 12 or none of these, so with a probability of $1/4$ of each. In the same way at the next level there is a probability $1/8$ of each of the 7 elements, or else of being at the next level. Similarly at the next level one has probability of $1/128$, and so the probability of not being at any of the three levels but at the fourth (forbidden) is $(1/4) \cdot 8 \cdot 128 = e$ (say). The probability of satisfying the artificial constraint is $1 - e$, and so the probability of $1/137$, which was produced by applying the constraint, should be $(1/137)(1 - e) = 1/(137.033)$. the improvement in the value of $1/\alpha$ is therefore one of order of magnitude, since the error is now only 0.002%." This quotation should be sufficient to give the character of the argument, but it is only the beginning of the story.

I have said a good deal about mind -though you may not want to use that term- but what I have said about space has been mainly negative; 'you can't do that there 'ere.' A positive construction must come from the memory aspect of the hierarchy, and as I have argued, from the interaction of the mapping space with the construction. This is a task which makes perfectly good sense from the PU point of view by the way, though I cannot agree, as I said earlier, that it was done there. I can't take it far here either, but I want to finish by mentioning two first steps which should expect to find early in the work.

The first concerns 3-dimensionality. (Hereafter 3-D). Forget notions of dimensionality which proceed from ideas of points and spaces and tell us that all possibilities for physics are open in principle but the world just happens to have landed up with the value 3. Go back to our voyages through the hierarchy and observe that there are three recursion stages. That for me is the dimension of any space we subsequently construct. The first affront this provides is that we seem to be making the dimensions wildly different or unsymmetrical. This is not really the case since we have to start somewhere and the point about symmetry is that it must not matter where you start. I am finding that more and more bits and pieces are fitting themselves together with this view. I have been putting it forward for a year or two now, and though I more and more could not see any alternative I still wondered if I was mad. I follow the converse of an argument due to Lewis Carroll to reassure me a bit. Carroll wants to prove that cats are mad and says 'you grant that dogs are not mad'. Yes 'Well, dogs wag their tails when they are pleased and growl when they are angry, but cats growl when they are pleased and wag

their tails when they are angry. So they are mad.' The relevance of this? you grant that Kilmister is not mad? Well, he has written a paper saying this about dimensions. (Space, time, discreteness, Philosophica, 1992.)

The other point about the first steps in space is something that has had me running round corners every time I saw it coming, until I was forced to confront it by Pope. In his informational account of special relativity, Pope estops himself from getting Lorentz transformations with their quadratic form from considerations of the signal velocity, and boldly assumes the quadratic form is the same as in the theorem of Pythagoras. Now there is no problem about where Pythagoras comes from for Pope. It is directly perceived as what he calls "a whole relational system". (I would call anything that could do that, and worse, a 'mind', mind, but never mind.)

Well I certainly can't do that; but in a combinatorial theory I have to face the fact that the quadratic form comes from somewhere and I want to show that it is a natural extension of my starting point and that it underlies both Lorentz and Pythagoras. The argument is extremely bald. We know very little about how we shall represent space, for reasons I have given, but we can say that however we do it we shall first have to construct a relation between two counts in two successively generated dimensions (using my way of defining 'dimension' naturally. We call such a relation a measurement. These two counts would usually be called orthogonal, as befits both Lorentz and Pythagoras, however they are separately still counts and not measurements and therefore are combined combinatorially and not geometrically. Using our old friend the ergodic principle this means we combine them by relating each element of the one to every element of the other, and this gives the quadratic form.

THE SPATIAL TRANSMISSION OF INFORMATION

21st June 1994 (DRAFT 2.4 FINAL)

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ABSTRACT

There is increasing evidence that information may be the basic stuff of the Universe. Certainly it is the means by which we perceive and communicate with our environment and as such is all that we can ever directly know. Anything else is either metaphor or speculation or religion. Physics can be viewed as the study of the relationships between the (binary) data stored on the magnetic tapes and discs of the Physics laboratories of the world. However our approach is different to that of the (pragmatic) Copenhagen Interpretation in which all questions of ontology are considered to be meaningless.

Actually this is not entirely fair. Atomism is more than just metaphor, it is an extrapolation of the everyday Universe into the world of the microscopic. However, in the light of the evidence for Quantum Theory, it is a miserable failure. To make things worse the conventional, or Copenhagen, interpretation of Quantum Theory can be stated thus: There are no (consistent) models of reality. A number of workers, in particular David Bohm, have tried to counter this by building working models that reproduce the statistical predictions of Quantum Theory. Unfortunately for reasons political and otherwise these continue to maintain a low profile.

This paper looks at aspects of the proposition that Physics should be part of Information Theory and that that is where we should be looking for ontological foundations. Unfortunately there is no coherent theory of information as yet. Shannon and Weaver's work is a theory of communication. That is relevant but it is not the same thing. Equally relevant are the laws of Thermodynamics and Relativity and Computer Science. The Combinatorial Hierarchy may provide further clues.

A particularly important property of information is the set of rules by which it propagates. These are formalised in Jessel's interpretation of Huygens' Principle, pretty well the only bit of Physics that says anything about information. With all this in mind we attempt to point the way towards a coherent theory of information and its propagation. The initial aim was a paradigm for parallel processing. In particular, in the light of recent results regarding Krons' Method of Tearing, we look for a discrete interpretation of Huygens' Principle.

1. INTRODUCTION

There is a growing school of thought that suggests that Physics - or at least much of it - must be based on Information Theory. A dissatisfaction with the ability of Physics to explain many of its own parameters - the "empirical constants" (eg, the particle masses, the coupling constants) - has led a number of workers, starting with Eddington, to derive tentative, if naive, theories to explain these numbers. Some of the most recent of these attempt to predict the masses of the elementary particles by assuming that they are solitons. All this is in direct conflict with the school of modern Physics, exemplified on the flysheet of Zukav's "Dancing Wu Li Masters" with the opening sentence "The fact is that Physics is not Mathematics".

Physics MUST obey the rules of Information Theory. By the Information Theory we mean all of

1. Mathematics, including such niceties as Goedel's Theorem,
2. Logic ie, Computer Science including Turing noncomputability,
3. General Systems Theories including those of Mesarovic, Kron and Jessel and Resconi
4. Communications Theory including for example Shannon's Law, Huygens' Principle and The Second Law of Thermodynamics.

We have used the last item as a catch all for those parts of Physics which talk only about information. Kron's General Systems Theory and Huygens' Principle imply some sort of topologically connected space-time. For those who balk at the mention of space-time at this stage let us admit that we are just being pragmatic.

2. INFORMATION TRANSMISSION

Information travels. It propagates. Whatever our viewpoint and however we define information we take this to be self evident. Of the two parts of this statement *information* is probably the hardest to define. We start from Parker-Rhodes definition "the information content of a statement is the number of yes/no questions needed to arrive at that statement". This definition nicely separates the context from the information. It makes information *relative*, dependent on the observer, and yet gives us a measure - in bits - that we can use in practice. It is a computer-science type definition and yet we can see how it might be extended to information carried by a light wave about the objects in a room. It has a strange quantum-mechanical ring to it. The cat in the box is only dead or alive relative to the knowledge of the observer. The light wave only carries information relative to the knowledge of the observer. The second part of the statement - the propagation - assumes a local space.

Information travels on (usually electromagnetic) wavefronts. It travels as bits and yet generally we cannot locate it in space. If it can travel then at a certain point in time each bit should exist at some location in space. The wavefront propagating around a room contains information about the room, the topology and the colour of the things in the room and yet we cannot locate the bits within the wave. Huygens' Principle in fact tells us that the information is smeared throughout the wavefront. There are copies of all the bits at every point on the front. A snapshot of a cross section through the wavefront is essentially a *hologram*. If a location can hold more than one bit we refer to the ordered collection of bits as a *bit-string*. We assume that such a bit-string cannot be infinite in length.

We take the view that information transmission is more important than computation. In a technical context this is fairly well recognised in that the problems of sequential computing are thought to be fairly well understood compared to the problems of networking and parallel processing. In a scientific context, however, the standard model (of physics) still treats information as a secondary phenomenon.

There are a number of physical paradigms - in particular that of Louis de Broglie (and David Bohm) - that treat information as fundamental. In an Engineering context this has been reflected in the work of Maurice Jessel and Gabriel Kron. Kron, in particular, was searching for an ontology of Engineering, in much the same way as Physicists look for fundamental structure. Both these approaches, to Physics and to Engineering, have their roots in Huygens' Principle. The most general formula which tells us about wave propagation - Jessel's formulation of Huygens' Principle - actually only talks about information. It can be considered to be a statement about conservation of information under spatial transmission. This is peculiar for a law that is normally assumed to be part of Physics. It says nothing directly about Physics. It does however constrain the laws of Physics. For instance Gauss' Law or Khirchhoff's Law can be derived from Huygens' Principle (without resorting to all those horrible little current loops). Why does information act in this manner? Because Physics is (at least causally) *local*. The maximum velocity of light (and the other forces) is c which is the the maximum velocity at which information can propagate.

Another physical paradigm that smacks of these same concepts is (Noyes' version of) the discrete physics approach of ANPA. In particular, to paraphrase Eddington, an elementary particle is considered to be (no more than) a "conceptual carrier of information between events" (collisions). Information is carried in *bits*. Noyes' paradigm says nothing about fundamental underlying reality but only that there is information transmission and that there is computation. It is an ontology of *experimental physics*. It can be considered to look at the relationships between the data on magnetic tapes in the Physics labs of the world. It also says that this is *all* we can ever know (short of interference by God). Noyes, in fact, gives two complementary definitions:

1. A particle is a conceptual carrier of conserved quantum numbers between events.
2. An event is a region over which quantum numbers are conserved.

We take the view that a wave is a conceptual carrier of information between events. This seems consistent with de Broglie's duality. It is a rather unusual view of a wave. It is however entirely consistent with Huygens' Principle being the most important description of a wave in that Huygens' Principle describes the informational evolution of a wave.

A number of interesting technical phenomena arise out of Huygens' Principle. These include Dennis Gabor's Holography, Jessel's Holophony, or 3D sound placement and wave cancellation (eg, Active Acoustic Absorbtion and the possibility of "black light") and Kron's Method of Tearing. The latter is a method of solving problems on physical systems by decomposing the system into unconnected subsystems separated by an intersection layer of dimension one less than that of the system. The subproblems can then be solved independently and recombined with the solution on the intersection layer giving an *exact* overall solution.

3. STONIER'S INFORMATION PHYSICS

In Tom Stonier's fascinating book "Information and the Internal Structure of the Universe", he has produced what amounts to a manifesto for a General Theory of Information. Tom is what I would term a naive realist. As a biologist he does not profess to be up to date with developments in modern physics or metaphysics. As a philosopher he takes a view almost diametrically opposite from ours. Tom states "Matter and energy are what we interface with physically". We take the view that information is *all* that we interface with (or at least that is all we are certain of. Furthermore we think we can build quite a big model with it.) Tom proposes a number of axioms or hypotheses which he sees as potentially laying the groundwork for a general theory of information. Some of these are

1. The addition of information to a system manifests itself by causing the system to become more organised, or reorganised. This is really a definition of information in terms of entropy. Conversely *heat* - high entropy energy - causes a system to become *less* organised. Schrodinger reformulated Boltzman's equation thus:

$$\text{Entropy } S = -k \log(I/I_0)$$

where I is a measure of information content and k is Boltzmann's constant. From this Stonier calculates that an entropy of 1 Joule per degree Kelvin is equivalent to approximately 10^{23} bits of information. A bit is indeed a very small unit. Without this conversion we would have *five* fundamental units of measurement, mass, length, time, temperature and information. From all this he discusses aspects of Prigogine's proposal that life creates a state of negative entropy.

2. Information is an implicit component of virtually every equation governing the laws of physics. As we have noted before the informational part of (many of) these equations is manifest in Huygens' Principle.

3. The information contained by a system is a function of the linkages binding simpler into more complex units. The universe is organised into a hierarchy of information levels. This is the basis of Stonier's proposed general theory of information. It is remarkably similar to Gabriel Kron's view of the Universe.

Tom states "Information exists. It does not need to be perceived [or understood] to exist... Without this insight it becomes impossible either to understand the physical universe, or to try to develop a general theory of information." Our view is diametrically opposite but with the same aim (an informational physics) in view. The universe is considered to consist of communicating observers alone. Thus from a very different starting point Stonier comes to some very similar conclusions. Tom's only reference to Christian Huygens is his observation that Huygens invented the first pendulum clock and thus initiated the modern approach to measurement.

4. APPROACHES

We intend to investigate systems with a locally connected topology, information sources and information sinks (observers). Bohr's thoughts on whether a computer can act as an observer (and hence collapse a wave function) are unknown. Information sources in terms of Physics include the initial conditions of the Universe and Heisenberg noise. (It has been noted that there are two kinds of God accordingly.) Information sources in a computer system are initial data and interactive or continuous input. A local system is defined as a system whose subsystems each have a set of subsystems (each of which is a subset of the set of all subsystems) called its neighbours, which are adjacent to it in some sense. Information can only travel directly from one subsystem to its immediate neighbours. It either travels to all the neighbours simultaneously in which case it is called a wave, or to a single neighbour in which case it could be termed a "particle". We can say the following things about the spatial transmission of information in locally connected spaces.

1. It is limited by the speed of light or propagation delays in a network.
2. It obeys Huygens' Principle as formulated by Jessel⁹ or Kron's Principle in a network.
3. Is causally unaffected by Bell's theorem (nonlocality).
4. It can be sent point to point in packets or broadcast in waves. That is, it travels over networks or through space.
5. It is constrained by the Second Law of Thermodynamics (entropy always increases with time) with possible quantum mechanical exceptions (life!) proposed by Prigogine.
6. It is constrained by Goedel's Theorem and Turing noncomputability.
7. It is constrained by the laws of logic, in particular the Combinatorial Hierarchy.
8. Information is relative to the observer (Parker-Rhodes).

Everything said so far applies to any locally connected space, that is, we are not limited to the continuum. A number of discrete spaces merit investigation - electrical networks (and by analogy other physical networks including those as diverse as economic networks), computer networks including cellular automata and parallel processor arrays, some mathematical models and computer algorithms in which information flows around a network, and Pierre Noyes' "events in the void". This paper specifically looks at how Huygens' Principle applies to the spatial transmission of information in three locally connected spaces, the continuum, electrical (analog) networks and digital networks.

Huygens' Principle should also apply to any physical model including realist theories such as those of Larson, Tedenstig, Aspden and the neo-etherists, and, of course, Bohm and Hiley. Dewey B Larson produced one of a number of realist models of the Universe designed to overcome the problems with the conventional theory that led to the Copenhagen Interpretation. He postulated a Universe continually expanding everywhere in which the resulting outward movement of matter is continually offset by an inward gravitational motion resulting in the familiar relativistic system. Imagine space as a rock surface that continually crazes everywhere. The cracks become filled with molten lava that hardens. The process repeats. New boundaries are being created continuously.

There are three major approaches to the problem of information transmission:

1. Algebraic topology (homology theory).

Information flows through space carried by fields (waves) or particles impressed upon it. Algebraic topology is an abstraction of the normal idea of space and fields. There are two dual homologies, the singular homology describes space and is the algebra of simplices and the dual de Rham cohomology describes fields in space and is the algebra of differential forms (essentially tensors). The de Rham theorem states that these two homologies are isomorphic (ie, based on the same set of axioms). The single most important device in both manifestations of homology is the **boundary operator**.

Homology theory only takes time into account by burying it in the coefficients of the algebra (as a Laplace transform) thus underemphasising the concept of *flow* of information. Nevertheless homology theory encapsulates the entire classical idea of information transmission in continuous space. It can be extended to discrete homologies. The more recent (and even more difficult) K-theory, which drops one of the Eilenberg Steenrod axioms for a homology theory, takes time into account explicitly.

2. Huygens' Principle.

Huygens' Principle (Jessels' formulation in particular) defines the mechanism of wave transmission through a medium. It is not a physical law but is purely a statement about information, yet it constrains physical laws (like Gauss' law) and has implications for conservation laws (like Kirchhoff's law). Thus it is separate to, yet can be stated in the language of, homology theory. It defines the properties of transmission of information as it passes through a series of **boundaries**.

It is based on three axioms which describe all information transmission problems in space. There is a fourth axiom introduced by Hadamard that restricts the set of differential operators allowed to define the properties of the wave in the medium, resulting in dispersionless (distortion free) transmission only.

An equivalent rule is the principle behind Kron's Method of Tearing which states that a (or at least certain classes of) problem defined on a physical system can be solved by splitting the problem up into subsystems and **boundaries**, solving the subproblems thus created, and combining the partial solutions to give an overall (exact) solution.

These paradigms can be applied recursively and then define the hierarchical information transmission and storage paradigm that Bohm refers to as the holomovement.

3. Scattering theory.

Scattering theory describes what happens when two information structures collide. It is, in one form, used widely in particle physics. In another form it was used by Bellman and others to formulate the solution of multistage optimal control problems (invariant embedding) by analogy with multistage scattering of physical waves passing through a variety of different media. Thus it applies equally well to information transmission through *algorithms* as through physical space and describes what happens at **boundaries**. In a yet slightly different form it was used by (my doctoral supervisor) Nicholson in his work "Structure of Interconnected Systems" to describe (amongst other things) information flow in Kron's Method of Tearing.

5. HUYGENS' OPERATORS AND SOLITARY WAVES

Three things can happen to information as it travels.

1. Nothing. This is good.
2. It gets lost. In digital or analog terms this may mean noisy. In analog terms it may mean the signal level has dropped (which has the same result). This is caused by **dissipation**. Dissipation of waves travelling through material media is minimised at resonant frequencies.
3. It gets distorted. This means that the information has to be undistorted at the receiving end. In digital terms this may mean decoded. In analog terms distortion usually refers to nonlinear distortion. This is caused by different levels of attenuation at different frequencies, eg second harmonic distortion, and is a form of selective dissipation.

In signal transmission terms however it usually means **dispersion**. This occurs when a signal splits up into its component parts (frequencies) because each travels at a different speed. Drop a pebble into water and high frequency ripples clearly travel away ahead of low frequency ones, yet the wave started as a pulse. The signal gets smeared. There are two cases in which this does not happen.

1. If the medium is linear and the equation of wave motion is governed by a Huygens' operator with Hadamard's axiom. In particular, Huygens' Principle, in its specialised form as given by Hadamard, only considers Huygens' Operators which have a "tailless" response. That is, if we put an impulse into a nondissipative medium the pulse will travel through the medium indefinitely without dispersion. This, remarkably, turns out to be possible only in even dimensional (continuous) space-times of dimension greater than three. That is, if we shout to someone across a large (three dimensional) space, the sound may be attenuated by dissipation and by the energy diluting effect of the expanding three dimensional spherical wavefront, but it will not be distorted by dispersion. However, watch the ripples spread out from a pebble dropped into water. The wavefront spreads and changes shape. It is *impossible* to send an arbitrary undistorted pulse through a two dimensional continuous medium.

2. If the medium is nonlinear and the wave shape is a soliton of the equation of wave motion. The *soliton*, or solitary wave, was first observed by J. Scott Russell on the Edinburgh-Glasgow canal in 1834, and reported to the British Association of Mathematics. Russell, on horseback, was observing the motion of a barge which was rapidly drawn along a narrow channel by a pair of horses. Suddenly the boat stopped, but not so the mass of water in the channel, which it had put into motion. This, a rounded heap some thirty feet long and eighteen inches high, travelled forward at around eight miles an hour, pursued by Russell until it was lost in the windings of the channel. Researchers investigating the transmission of light solitons along fibre optic cables have recently succeeded in sending undistorted pulses through (the equivalent of) 12,000 miles of glass fibre without the use of repeaters. This represents a breakthrough for the communications industry.

Conway's "Game of Life" exhibits cases of soliton like behaviour in a two dimensional digital

network or cellular automaton. For example the "glider", a small stable digital pulse, travels through the system indefinitely without distortion. This points the way towards a digital version of Huygens' Principle.

Let us be perfectly clear. There are three paradigms here for the transmission of information through space. 1. Huygens' Principle in the sense of Jessel is a tautology which applies to any operator in any space including linear, nonlinear, continuous, discrete or network. 2. Solitons occur only in nonlinear distributed media. 3. Huygens' Principle in the sense of Hadamard applies only to operators generating a tailless response. Gunther proved that these only occur in even dimensional space-times with dimension greater than three. As operators generating soliton solutions can be one dimensional and as Huygens' operators in the sense of Hadamard can be linear these are clearly two different things. However (1) applies to both (2) and (3).

During the last years of his life (he died in 1968) Gabriel Kron was working on a new project that he called the Crystal Computer. It consisted of a crystal excited by a number of mutually interfering light waves. He was very excited about this and wrote in one of his last letters "My work is more productive now than ever before and I am on the verge of a breakthrough."¹⁴ His technical writings in this area however are very difficult. It is possible that he left behind some unpublished papers in this area. Similarly Dennis Gabor spent some time investigating the possibility of a Holographic Computer which seemed to have much in common with Kron's ideas. Holography obviously involves an enormous amount of computing all done in parallel and it would clearly be beneficial to harness this power.

There is another less well known property of solitons. They can pass through each other with no effect *other than a phase change*. This phase change, being equivalent to a time delay, gives us a mechanism to produce a simple computing element based on the interference between two solitons. There seems to be much evidence that this is the basis of the system that Kron was working on immediately before his untimely death. He called his putative machine a "crystal computer" as it was to have used light pulses in a crystal lattice in much the same way as a laser. The mechanism to inject light solitons into such a crystal and get them out again is now readily available through fibre optic technology. What is required is a paradigm to generate the rules of computation and the generalised form of Huygens' Principle as described above would be a natural candidate. A final observation is the correspondence between the system we are proposing and Noyes' ontology mentioned above.

The major computer hardware companies have all got problems. They need to pull something pretty hot out of the bag soon, as the major part of their traditional market is now satisfied by the performance given by an upmarket PC. The soliton computer will give massively parallel computing at light speed, potentially cheaply.

6. JESSEL'S FORMULATION OF HUYGENS' PRINCIPLE AND KRON'S METHOD OF TEARING

Jessel's formulation of Huygens' Principle states "the perturbation that goes out (or in) through a closed surface C that contains (or excludes) a wave or field source is identical to the perturbation that can be obtained by cutting off the source and replacing it with appropriate sources distributed on the surface C . Consider the wave equation

$$OP F = S$$

where OP is a differential operator such as the Laplacian and F is a field distribution due to sources S contained within C . Jessel showed that an identical field distribution sF outside C can be given by the equations

$$OP(sF) = sS + S'$$

where the secondary sources are given by

$$S' = (OPs - sOP)F,$$

s is a scalar that takes the value 1 outside C and 0 inside C therefore sS is zero everywhere. Further $OPs - sOP$ is only nonzero on C and thus S' clearly gives the value of the secondary sources.

In a recent paper the author demonstrated that Huygens' Principle can be used to prove the validity of Kron's Method of Tearing. If a boundary value problem is physically dissected into a number of adjacent areas then each subproblem can be solved individually in terms of secondary sources on its local boundary or intersection. The values of the secondary sources are calculated from the boundary values using a matrix version of Jessel's equations. The solutions on the subsystems and the intersection are then recombined into an overall exact solution.

An analysis of the practical usefulness of Kron's method shows that it becomes less viable for large problems. This is because the advantages of tearing a system up into more and more subsystems is offset by the increasingly large intersection matrix that it becomes necessary to invert. In a recent paper the author showed that, by tearing initially into a small number of large subsystems and then tearing the subsystems into further subsystems, and so on until the level of granularity approaches the discretisation (for finite difference models) or component size of the system itself, a more efficient decomposition could be obtained suitable for use on very large systems. A direct (noniterative) solution to the hierarchical system equations was derived.

Tearing is equivalent to a reordering of the system matrix. The discretisation points are scanned into the equations subsystem by subsystem rather than arbitrarily (left to right, top to bottom). It turned out that, although the algorithm derived to solve the hierarchical set of equations was new, the reordering induced by Hierarchical Tearing was not original. It had been derived ten years earlier by Stone as the *optimal reordering* of the system equations for any indirect (iterative) method of solution of the system equations.

The author also spent some effort (much to the disgust of a referee) showing that the flow of information in this recursive hierarchical algorithm (and equivalently in the system from which it was derived) is the discrete equivalent of the *holomovement* paradigm of physics introduced by Bohm and Hiley. There is an implication here that, in some sense, the holomovement may enable an optimal flow of information through space.

7. COMPUTING

David May has recently pointed out that there is no paradigm for parallel processing equivalent to the Turing machine in the sequential world. This section introduces the concepts required to understand parallel processing and local systems then shows how Huygens' Principle can be applied to digital systems. Classical computers - Turing machines - have a single processor and a single contiguous storage unit (RAM or disk or tape or a combination thereof). They are referred to as Single Instruction Single Information systems (SISD). They can be made faster by increasing by making them smaller and/or increasing the clock speed. The combined effect of these two processes is limited by the speed of light. There are three solutions to this problem. The first involves using a single processor but allowing it to operate on multiple blocks of memory simultaneously. Machines built like this are called array processors and are referred to as Single Instruction Multiple Data (SIMD) systems. The problem with them is that they are only suitable for specialist tasks such as matrix algebra. The next category of machine is referred to as Multiple Instruction Single Data (MISD). These consist of a number of processors each of which can access the same storage unit simultaneously. Unfortunately from a technological point of view there are only two approaches to this. The first is to build multiported RAM. This is expensive and current technology is pretty well limited to dual ported RAM anyway. The second approach is to use bus contention. With more than two or three processors this causes a bottleneck on the bus drastically limiting the speed of the system. The final category of machine are the true parallel processors such as the Transputer. These have multiple processors each with local memory and connected via fast onchip input-output ports. They are referred to as Multiple Instruction Multiple Data or MIMD systems. There is NO global memory, therefore programs can have NO global variables. They are *local* in much the same way as the "real" universe.

Consider physical systems. The classical view of the universe was that it is a continuous system (continuum) on which is imposed a continuous data set (electric field, gravitation etc). We will term this Continuous System, Continuous Data (CSCD). The quantum hypothesis is that the data is actually discrete (CSDD). An electrical network, however, consists of continuous (analog) data in a discrete universe (DSCD). A digital electronic network consists of discrete (digital) data in a discrete universe (DSDD). The de Rham theorem gives an isomorphism between CSCD and DSCD. All these systems are MIMD and local in the sense that the evolution of the state at any particular point (local memory) is governed entirely by the states of its immediate neighbours. Note that we have just introduced dynamics. This implies a terminal velocity for information (speed of light). (Clearly, in a digital network it takes at least a clock cycle to communicate information to a neighbouring processor/element.) Note here that digital data implies discrete time, thus we must move from the s domain to the z domain. Continuous data can exist in either discrete or continuous time, the former often being a model of the latter.

Huygens' principle was applied to continuous systems by Huygens', Khirchoff, Fresnel, Jessel and many others. The author justified Kron's method of tearing in networks and continuous systems by appeal to HP. MIMD systems are clearly local systems and thus subject to HP. Consider digital computer systems. We have a network of finite state machines thus OP in Jessels notation must be written in terms of the z transform. It may be constant as when considering an array of transputers from the point of view of the silicon or it may

vary with position as in a heterogeneous network or when considering an array of transputers from the point of view of the software.

Consider a single processor. In Jessel's fundamental equation $OPF=S$, OP is clearly the state transition function. F must consist of the set of states (memory images) at the current time instant and the one at the previous time instant. S is the set of input data (sources). Now looking at a processor array from the point of view of the silicon OP is still the state transition function. F is the set of all current and previous memory images and S the set of all inputs. (Where inputs may consist of an initial condition or continuous inputs to the memory image.) Consider a closed boundary enclosing a connected subset of processors. HP says that the sources within the surface can be replaced by a new set on the surface. Jessel shows that the secondary sources S' in the equation

$$OP(sF) = sOPF-S' \text{ can be written } S' = [OP,s]F = OPsF-sOPF$$

where $s=1$ outside the boundary and $s=0$ inside the boundary. If we were considering a Kron type setup where the concepts of inside and outside were reversed then the sources would be likely to be around the edge of the array and $sOPF$ could well be zero. sF gives the setup in the remaining processor memories. The boundary consists of a set of processors/memories which is removed and replaced by a set of sources given by $S' = OPsF-sOPF$.

8. CELLULAR AUTOMATA

The mathematics necessary to describe a normal CISC or RISC processor and its associated static and dynamic memory complicates the above issues when looking for a paradigm of the sort suggested. The simplest processor array to which we can apply our putative theory would be the cellular automaton. The most well known example is Conway's Game of Life.

John von Neumann proved that a Turing machine could be implemented on a cellular automaton. He derived an example which required over a hundred nodes. Much simpler implementations are now known. Consider a Transputer (or other Turing machine) array on a regular Cartesian mesh. If each Transputer is replaced by a cellular automaton patch of sufficient size to represent it completely, then with suitable interfaces between the patches it can be seen that our Transputer array becomes one very large cellular automaton. (This incidently shows that anything that can be calculated on a Turing machine array could equally well be calculated on a single Turing machine given sufficient time. But that is not the point.) So if we can apply our putative theory to cellular automata then it automatically applies to local parallel processing (local communications links and no global memory). In fact in Rudy Rucker's manual to the CALab software, in the section entitled "Why cellular automata?", Rucker opens his answer with the statement "Physics is local..." Cellular automata are used to simulate many phenomena in Engineering and Physics that are almost impossible by other means (eg turbulence). Jessel's formula can be applied to patches on a cellular automaton containing primary sources (either initial conditions or input data) to give the secondary sources on the patch boundaries. Will Huygens' Principle describe the complex wave phenomena which Cellular Automata emulate? Clearly it does describe the Laplacian, Maxwell's equations etc. But how about turbulence? Or the glider guns in Life?

9. HUMAN COMPUTER INTERFACES AND GENETIC ALGORITHMS

For this section I am grateful to Dave Gee of UEL for an interesting discussion. HCI is the study of the interface between a computer and a human operator. The current fashion in HCI's is the WIMP or Window-Icon-Mouse-Pointer paradigm. However we should make it clear that we also consider a programming language or an operating system to be an HCI. The aim of HCI is to optimise information flow across this barrier. The interface can be considered to be an intersection network or Huygens' surface. As far as the computer is concerned the set of sources within the human (Heisenberg Uncertainty, decisions, goals, models) can be replaced by a set of secondary sources (mouse position, keyboard input) on the intersection. As far as the human is concerned the set of sources (eg, a database) within the computer can be replaced by a set of secondary sources on the intersection (the screen). The interface between a human and any machine (eg, a car) can be viewed in a similar manner. Indeed the interface between two human beings is not dissimilar. Our hypothesis is suggests that this is all there is.

There is a peculiar difference between living beings and computers in the communicating entities model of the universe. Living beings can reproduce. They pass genetic information, according to appropriate rules, to their offspring. Both beings and genes evolve according to the rules of natural selection (so the theory goes). There is some evidence however that other informational structures - for instance **ideas** or **software** or **products** in general - evolve in a similar way, according to the exigencies of their environment - and that this process of evolution may have a genetic structure associated with it. The piece of software called the Blind Watchmaker was written to demonstrate this. It simulates evolution of informational structures within an environment according to genetic rules. A red block defined by its genetic structure, subjected to a simulation of an urban environment and told that its survival depended on its ability to transport the population around, evolved to something very similar to a London bus in remarkably few generations!

10. THE QUANTUM POTENTIAL

David Bohm's Quantum Potential is a purely informational theory. Unhappy with the acceptance of the Copenhagen Interpretation of Quantum theory by most scientists Bohm set out to build a realist model that would reproduce the statistical predictions of Quantum Theory. He was told on good authority that this could not be done! The usual method of solution of the Schrodinger wave equation is to use a Taylor series expansion. This results in an equation for the wave function which is a polynomial in \hbar , Planck's constant. As \hbar is very small, terms in \hbar^2 are usually ignored. What Bohm did was to take the quadratic term into account when solving various real problems. In particular in the double slit experiment Bohm discovered that taking the quadratic term into account caused the photons leaving the slits to "wobble". These wiggles took exactly the right form such that a screen inserted into their path would display the well known interference pattern!

The quadratic term is interesting in two other ways. Firstly it takes the form

$$\text{del}^2(r)/r.$$

The unusual thing about this field - termed the quantum potential - is that it is independent of a scalar change in r . That is the effect of the term is undiminished by distance from the source! Multiplying r by a constant has no effect on the value of the term. Most physical fields take a form something like

$$\text{del}^2(r)/(r^3)$$

which has a decreasing effect as one moves away from the source. Multiplying r by a scalar constant c scales the value of the term by an amount $1/c^2$ giving an inverse square law effect. Quantum potential appears to exhibit some sort of undiminished action at a distance! Further the quadratic term is not related to the mass or charge or any other physical quantity, but only to the topology of the system. Quantum potential is a purely informational field. Thus a photon passing through a slit in the double slit experiment has immediate access, via the quantum potential, to information about the topology of the rest of the system.

11. QUANTUM LOGIC

Conversely, and even more strangely until one realises its inevitability if Physics were just information theory, parts of information theory are beginning to take their paradigms from physics. The proposal in this paper to use Huygens' Principle as a paradigm for parallel processing is an obvious example. A recent article in the BCS Computer Bulletin by van Rijsbergen surveys another important inroad. Recall Parker-Rhodes definition of information. Suppose that all the recorded information in the world were stored electronically. How do we retrieve the part we want? Rijsbergen argues that the problem of Information Retrieval is equivalent to the Quantum Mechanical one in which the observables are simple yes/no questions about the state of the system. Think of the states as documents in an information space and the observables as simple queries then the non-Boolean structure of both problems gives rise to the same Quantum Logic. He goes on to discuss modal logic in which the truth of a statement depends on its context.

12. CONCLUSIONS

The predeterministic materialist atomism of Newton and Maxwell had two (interrelated) theoretical problems (apart from the empirical ones that were discovered later). Firstly, the lack of a place in the theory for choice or free will, and secondly that physical fields were considered to be smoothly varying and thus real valued; implying that it must be possible to make measurements to any degree of accuracy and thus that a finite amount of space could hold an infinite amount of information. It is now estimated that the Universe is accurate to about 115 bits! In contrast, the Cartesian dualist view of Physics is very egocentric, that there exists mind, and a material world with which we interact. We consider the view that the universe consists of a number of interacting entities alone; or at least that information is exchanged and that perceptions matter, energy and even space are manifestations of this.

Assuming that a finite amount of space cannot hold an infinite amount of information and that an infinitesimal amount of space cannot hold a finite amount of information then information can be stored only as patterns or structures. So space, or at least topology, is a necessary condition for information storage. Conversely, time is a necessary condition for information communication. A particle is a conceptual carrier of communicated information. It is

also a positional indicator of stored information. Particles are the things which are organised. Adding information to a structure causes it to become more organised or to reorganise, ie to decrease its entropy. Adding noise (or heat energy) to a system causes it to become less organised, ie to increase its entropy.

Stonier's Second Axiom of Information, that "the information contained by a system is a function of the linkages binding simpler, into more complex units" and its corollary that "the universe is ordered into a hierarchy of information levels" constitute the mechanism via which space enables information storage. In a local continuum information is communicated hierarchically according to Jessel's formulation of Huygens' Principle. In a continuous valued network information is communicated according to the hierarchical formulation of Kron's Diakoptics. In a digital network we have proposed that information is transmitted in an analogous fashion. **Thus information is both communicated and stored in the same hierarchical manner.** Information can be input into a system via its initial conditions or by its boundary conditions (interactive input). In all these models information is passed from the boundaries between structures to the boundaries between their substructures. This picture is similar to that encapsulated by David Bohm as the *holomovement*.

New information can come from a number of sources, an idea, received knowledge, or observed knowledge. Information communicated between entities, be they living beings or computers, passes from the local memory of the transmitting agent to the receiving agent; from the source to the sink. Local memory, ie information storage, requires topology. Once known, new information becomes old information and is stored as structure. **The Bastin-Kilmister model of novelty (or discovery or observation) describes how such processing is related to the Combinatorial Hierarchy.** Feller's Theorem is claimed to enforce a 3+1 dimensionality on this structure. There are a number of weaknesses to the Combinatorial Hierarchy approach. It describes a very small (albeit otherwise unexplained) part of Physics; it does so in a way that is wider than Physics: why don't the coupling constants show up in other forms of information exchange, such as Sociological ones?; and it appears to provide no mechanism for uncertainty. Manthey's asynchronous model is one approach to the latter. It is entirely compatible with the communicating entities model; the boundaries in the Huygens' world view correspond to Topsy's interface to the world.

This paper proposes that a model of the universe as a set of interacting entities may generate much, or all, of the structure of Physics. In the extreme case there is no difference between epistemology and ontology. It is an inherently information based model, and one of communication. Much work needs to be done on the nature of information itself before such a model can mature. In particular, information appears to have two forms: subjective, relative information or (new) knowledge; and objective, absolute information or structure. These appear to be dual; acquired knowledge is stored as structure, structure is observed as knowledge. Structural information is recursive and hierarchical, spatially orientated and three dimensional. Acquiring knowledge has the properties of the combinatorial hierarchy, a unique, minimal four layer binary informational structure which ANPA associates with the four coupling constants of (grand) unified field theory. Information travelling between the entities appears to do so through the world of structures, as particles or waves. Jessel's formulation of Huygens Principle defines the rules of this transmission.

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This work arose from a remark of Tony Deakin at ANPA 14, after Mike Manthey's paper; Tony said excitedly to me "He has provided the mathematical theory for her" (indicating Alison Watson). I felt convinced and this spring there was an unexpected chance to push the matter on; Mike came to Lewes to see me and Alison had a vacant room to put him up for the few days. We talked, but since then, like everything else in ANPA, things have turned out more complex than expected. There are connections, but some of them are puzzling and what I am going to say now will probably not get assent from either of the other protagonists. I begin by distinguishing three main activities:

A. The original Parker-Rhodes construction (P-R), my rewriting of it to give it philosophical coherence (K) and Program Universe (PU) which cuts some Gordian knots.

B. Mike Manthey's discussion of sensors, much of which you have seen in the Newsletter, and which he will discuss later in this meeting, which issues in a Clifford algebra.

C. Alison Watson's metaphysics, as expressed in her thesis.

I shall argue (i) that there are detailed mathematical connections between A and B but not equivalence, and the differences are interesting, (ii) that there are detailed philosophical connections between A and C (not pace Deakin between B and C) and again the differences are interesting. So (i) will be a mathematical part of the paper and (ii) a philosophical one.

I summarise P-R in a more modern notation which leads directly to K:-
Frederick begins with two objects $\begin{bmatrix} 1 \\ 0 \end{bmatrix}$, $\begin{bmatrix} 0 \\ 1 \end{bmatrix}$, which, in a notation made obvious if I state that the column $[1 \ 1 \ 0 \ 1]^t$ is to be written 124, can be written 1,2.

Between them he defines an operation, discrimination, which is just mod 2 addition and is written +. The set [1, 2, 12] is then an example of a discriminately closed subset (dcs), the definition being that if a, b are distinct members of S, then a + b is in S. The pair 1, 2 generate three dcss, viz. S = [1, 2, 12], [1], [2]. Now, says Frederick, describe each dcs by a single element "at the next level", that is, by a non-singular linear operator represented by a matrix (P, Q) where P, Q are in S. (To clarify this notation, $\begin{bmatrix} 1 & 1 \\ 1 & 0 \end{bmatrix} = (12, 1)$.) The nature of this Parker-Rhodes "representation" is that a non-singular operator represents its dcs of proper eigenvectors, that is, those with eigenvalues 1. So the (unique) three operators have matrix forms, respectively, (1, 2), (1, 12), (12, 2). Treat these as three elements at the next level; they will generate $2^3 - 1 = 7$ dcss. Represent these at yet another level by 7 non-singular linear operators. This time these are not unique, unlike those in the first level change. Can they be represented by 4 x 4 matrices? Yes, easily. Do they in their turn generate $2^7 - 1 = 127$ dcss? One can choose them to do so. Can you represent these 127 dcss by 127 16 x 16 matrices? Frederick assumed so and we have since found several proofs. But these matrices generate $2^{127} - 1 = N$ (about 10^{38}) dcss and this sinks the progression; the choice mentioned above, to get the maximum number of dcss at the next level is quite impossible. (For the mathematician, the choice is that of choosing the operators linearly independent; obviously there cannot be so many linearly independent 256 x 256 matrices.)

I try to make this comprehensible rather than a mathematical trick. I see it as a description of a process; whether this is an ontological or an epistemological statement is not initially determined; such questions cannot arise until the process has developed sufficient complexity. But because this neutrality of language is hard to maintain in ordinary language, I describe the process from an epistemological view - the universe is seen as divided into an unknown and a known part. Objects become known; so have to be labelled. One can use as a label-alphabet [1, 2, 3, ..]. Discrimination is needed to check that an object is "genuinely" new, that is, does not belong to an

already labelled dcs and the process of testing it against a whole dcs gives rise to the linear operators. It all turns out very like P-R which is not surprising because it was intended to.

PU, on the other hand, is a machine process which proceeds by a rather subtle interplay of two operations:- PICK: discriminating two bit-strings from the memory and, if the result is non-zero, adding it to the memory but if not, TICK: adjoining a random bit to every string in play. In this way a growing population of bit-strings is constructed but the linear operator aspect of P-R and K is minimised. So much for my description of A; I ask you to commit it to memory while I talk about B.

Mike Manthey talks in terms of a set S of n sensors s_1, s_2, \dots, s_n . Here I shall assume that n is even. He defines what he calls a valuation f on sensors, which he quickly specialises to

$$f: S \rightarrow [-1, 1].$$

He constructs a vector space V over the integers, of which S is a basis, so any element of V is

$$v = \sum q_r s_r, \quad q_r \text{ integers}$$

where the addition is purely formal. It is an open question whether he will later want to embed this in V^* , say, where the definition is the same with the q_r allowed to be rationals. The value $f(v)$ is then defined by $f(v) = \sum q_r f(s_r)$. He considers changes in the values of the s_r ; such changes I shall call flows. I think his purpose in introducing V is to give him a new way of talking about flows. He also makes an unexpected change in notation; if $f(s) = 1$ changes to $f(s) = -1$ in a flow, he writes $s \rightarrow \bar{s}$, so that $f(\bar{s}) = 1$ after the change. He calls \bar{s} the complementary sensor. By introducing this notion he is able to operate the convention that any sensor he writes down has the value 1. For example, if $v = s_1 + \bar{s}_2$ occurs, this means that $f(s_1) = 1$ and $f(s_2) = -1$. In this way the valuation is "taken into" the algebra, as it were; it does not get mentioned any more. Mike interprets the formal operation + as "co-occurrence", which is of importance in his applications, and so this points to the importance of linear transformations as preserving +. BUT PLEASE NOTE

THAT + IS NOT DISCRIMINATION, and so these transformations are not the same as in P-R.

The way in which the vector space allows the discussion of flows is this: one constructs a Clifford algebra $C(V)$ on V simply by defining a product of sensors by

$$s_i s_j + s_j s_i = 2g_{ij}$$

where $g_{ij} = 0$ if $i \neq j$ and the g_{ii} have values ± 1 . It is probably general enough to take $+1$; again this is an open question. The real reason for this construction is the theorem that the linear transformations on V can be written

$$v \rightarrow v' = \sum_r a_r v b_r$$

where the a_r, b_r belong to V and one or other, say b_r , could be taken as s_r . The theorem goes back at least to my Ph.D. thesis of 1950 but may be earlier and something like it was known to A W Conway in the thirties. If you see the possibility of some connection between A and B, you will see this as exciting because the operations seen as level change by P-R and K are here put all on one level by the use of the Clifford product. Even more exciting is that, if you treat products as having such an important interpretation, you will want to consider automorphisms of the algebra, since they preserve both sums and products. The Clifford algebras (for even n) are normal simple and this means that any automorphism is inner, that is, has the form

$$v \rightarrow v' = a v a^{-1}.$$

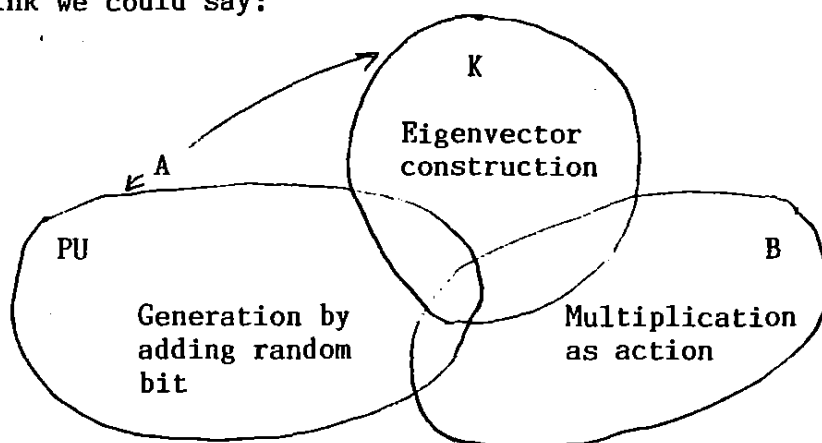
It is easy to see that for $n = 2$ the three possible actions correspond to the three flows.

Mike's theory goes on from there into the topology of simplicial complexes. I leave the further developments out to talk instead about the relations between A and B. The first steps are clear; the two values ± 1 correspond to 0, 1 in a bit-string. It is important to get the identification the right way round. For Mike, 1 is an "undisturbed" value which may be turned into -1 by a flow; so it is best to make 0 in PU correspond to 1 and 1 in PU to correspond to -1 . If $n = 2$, then we have the table:

$$\begin{array}{rcl}
s_1 + s_2 & & 0 \\
\bar{s}_1 + s_2 & \leftrightarrow & 1 \\
s_1 + \bar{s}_2 & & 2 \\
\bar{s}_1 + \bar{s}_2 & & 12
\end{array}$$

So far so good; but we cannot say that actions (flows) are PU's linear operators because Mike's addition is not discrimination. It is purely formal; it is much more like concatenation of bit-strings. There is a further more subtle difference. When Mike writes $s_1 + \bar{s}_2$ he is asserting that $f(s_1) = 1$ and $f(s_2) = -1$ but he is not automatically implying that $n = 2$. If $n = 4$, for example, writing this element would not say anything about the values of s_3 or s_4 , so you could not say it corresponds to $[0, 1, 0, 0]^t$; that would be, for Mike, $s_1 + \bar{s}_2 + s_3 + s_4$. If you want to write Mike's expressions into column matrix form, you would need something like $[0, 1, *, *]^t$ where * denotes a term about which nothing is being said. I am reminded of a similar device used by David McGoveran in constructing unorthodox statistics for his calculation of the correction to the fine-structure constant.

Let me sum up so far: Mike has constructed an algebraic structure which fits very well what he wants to do. It has two operations, neither of which is a discrimination operation; indeed, discrimination plays no part in his system. His elements have a bit-string description but only if one introduces *. I think we could say:



Once you have seen the substantial difference in detail between A and B you will see that it matters which you try to relate to the metaphysics of C and I shall argue, as I have argued to Alison with less than complete success, that A and C are related. So Tony's idea was very stimulating but not quite right.

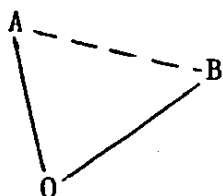
Before I go into the details of Alison's thesis, I want to try to eliminate one stumbling block. She has emphasised the basic difference between her very continuous descriptions and our discrete ones. I see this as a red herring; because the relation between the two is very like that in orthodox differential equation theory between a continuous description and its Poincaré map, which specifies how the moving point in phase space successively crosses a hyperplane. Very like, but not identical, for the Poincaré map, as Alison has emphasised to me, is a series of snapshots of the process. So the distinction in orthodox theory is an epistemic one which is different from here, where we have a primitive theory in which the epistemology/ontology distinction cannot initially be made. Moreover the mathematics of the CH is not an abstraction from some underlying continuous theory but a primitive statement. None the less, I think the continuous/discrete distinction is not all that important.

Alison's thesis discusses the genesis of form so she begins with what she calls an undifferentiated flux. Let us represent this by a symbol, 0. I start the discrete process with the same symbol, 0. It says no more than that the process is starting, just as Alison says no more because to do so would stop the flux being totally undifferentiated. Her next step is to talk about a act of resistance, A, in (or to) the flux which concludes in stasis. I would say that the discrete process (which is just a sequence) has as its next term something which is not 0. Call it a and because it is to play some part in the mathematics, call it an element. (Here A, a are the same letter to serve as a reminder, but not too much should be read into the notation.)

Next she says "A must be maintained in existence as the attention moves towards B so that the relation which will become AB grows, is left behind, is held beyond the now." How do I translate that? If a is to "be maintained" some other element is needed as well: b say. The phrase "as the attention moves towards B" sounds very continuous but it has a discrete content as well for it implies that a, b are different. That means that

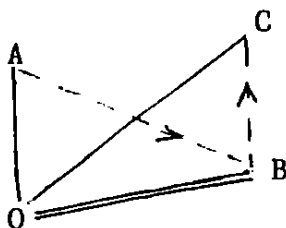
here some algebraic content enters; one has a , b and a relation Dab of being different. Define a new relation $Eab \leftrightarrow \sim Dab$; then "attention moves towards B so that the relation which will become AB grows" has a discrete skeleton: " a , b are tested to see which of E , D holds between them". Because this is a further step in the process, the result of the test is another element in the sequence. If Eab holds it means that a , b are not after all differentiated so the result must be the undifferentiated state, O . If Dab holds, the next member of the sequence must be other than O .

This lands us up in exactly the situation of the construction of the hierarchy. In my earlier presentations of it I have shown that, however the testing process actually operates, it is as if it issued with the language L earlier in the paper and $a = 1$, $b = 2$ and the test of 1 and 2 is 12. So this test is represented by discrimination and these three elements are a dcs. To my mind a pay-off begins to show at this point. I think it is a weakness in Alison's argument that she needs to help it out with some geometrical diagrams. Here for instance the situation is summarised by



What is she needing to do with this? Essentially to show the wholeness of the combined actions and this wholeness is just what is captured by the dcs $[1, 2, 12] = S$.

Her next step is to hold this triadic relation (O, A, B) "fixed" and "go on to C ".



So, by almost exactly the same argument, the "holding fixed and going on to C " is a continuous process with the discrete skeleton that the process must

determine whether c is one of 1, 2, 12 or not. One cannot test c against 1, 2, 12 "in turn" because what is in play here is S , so there has to be a test (S, c) which will give 0 if c is in S but not otherwise. This is a familiar argument in the CH and leads to the idea of a "characteristic function" for S . At this point it begins to look as if the whole Frederick construction exactly mirrors Alison's metaphysics!

But wait a minute: it is indeed true that the machinery fits the CH and the Watson metaphysics equally well and I think that this is because a single description is being given of a process, once with a bit of an ontological spin (Alison) and once with an epistemological one (the CH). They fit very well together in the initial stages in which epistemology and ontology cannot be distinguished but later stages seem to get progressively more different. The procedure of the CH is this: once one primary distinction between 1 and 2 has been made, giving rise to the three dcss [1], [2], [1, 2, 12] a whole tree of mappings and dcss grows up, giving successively 7, 127 and N dcss. Alison uses the same machinery differently. The two triadic relations in her diagram are captured by the dcss $S = [1, 2, 12]$ and $T = [2, 3, 23]$. To these must be added the degenerate ones [1], [2], [3]. The mappings for these dcss are therefore 5 in number, and so these generate at the next level a dcs of more than 7 members. It is an easy exercise for the reader to show that the dcs has 15 members in 4/9 of the cases and 31 in the remainder.

This difference in numbers of elements reminds me of the way that Mike begins with the same numbers as the CH and then finds differences. Both sets of differences of numbers are indications of a deeper structural difference. My conclusion to both parts of the paper is, then, that there are different ways in which the discrete process can go. I think it is an open question whether these different ways are unimportant artefacts of the algebra or whether they represent something of physical importance so far unrecognised.

THE COMBINATORIAL HIERARCHY RECAPITULATED¹

by

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Abstract. My talk at ANPA '93 presented a table based on the 4-period of the sign of the squares of actions of increasing arity that is embedded in the Combinatorial Hierarchy. Trying to understand this better causes me refine the exposition of the hierarchy in terms of co-occurrence, co-exclusion, and the boundary operator (∂) that I presented at ANPA '92.

1 Introduction

The table shown in Figure 1 points out that there is, embedded in combinatorial hierarchy, an additional structure based on the 4-period cycling of the squares of actions of increasing arity, corresponding (as Tony Deakin pointed out) to $i^n = (\sqrt{-1})^n$. The individual entries - especially above the particle level, are intended more to be suggestive than exact; certainly there are several generations reflecting the increasing complexity of atomic nuclei and electron shells. My attempt to better understand the import, if any, of this table has led me to try to refine the construction of the combinatorial hierarchy presented in [Man92].

2 The "Standard" Derivation

The CH is constructed from two inter-twined sequences (columns (b) and (d) below) and looks like this:

(a) level	(b) # symbols per level	(c) cumulative $\sum(b)$	(d) map dim.	(e) # of map elements	(f) comment
0	(1)	(1)	(1)	(1 × 1)	
1	3	3	4	4 × 4 = 16	16 > 7
2	7	10	16	16 × 16 = 256	256 > 127
3	127	137	256	256 × 256 = 65536	65536 < 2 ¹²⁷ - 1
4	2 ¹²⁷ - 1	2 ¹²⁷ + 136	(256) ²		cut-off reached

¹To appear in Proceedings of ANPA 15; Cambridge, England 1993.

↑
2ⁿ - 1
gener.

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Arity	s^2	Distinction	Comment
....			
1 ← 4,5	1		
	3	-1	
	2	-1	
4,5 → 1	1	organ	
	3	-1	env-conditioned zero-sum competition
	2	-1	zero-sum competition
1 ← 4,5	1	multi-cell	simple multi-cellular organisms
	3	-1	conditional inter-cellular interactions
	2	-1	inter-cellular interactions
4,5 → 1	1	cell-2	eukaryotic cells (w/DNA)
	3	-1	env-conditioned cellular-level evolution
	2	-1	zero-sum cellular-level evolution
1 ← 4,5	1	cell-1	one-celled life (RNA only?)
	3	-1	env-conditioned simple zero-sum molecular-level evolution
	2	-1	simple zero-sum molecular-level evolution
4,5 → 1	1	replicator-2	evolutionarily stable self-reproducing molecule: 'life'
	3	-1	conditional auto-catalysis
	2	-1	auto-catalysis
1 ← 4,5	1	replicator-1	catalytic unit; enzymic interactions
	3	-1	substrate-dependent molecular interaction
	2	-1	'fit' geometry-dependent molecular interaction
4,5 → 1	1	molecule-2	complex macro-molecules
	3	-1	folding intra-molecular polarity
	2	-1	handedness isomers
1 ← 4,5	1	molecule-1	simple molecules w/ bond angles ↔ crystals, simple polymers
	3	-1	co-valence co-valent interaction of atoms (nec. local)
	2	-1	valence ionic interaction of atoms
4,5 → 1	1	'atom'	presence/absence; 'mass' in 'space'
	3	-1	≈spin ↔ parity and charge
	2	-1	co-exclusion spin ↔ parity and charge
	1	-	co-occurrence inscrutables = synchronization 'sticks'
	-	-	none true indistinguishables: Parker-Rhodes' <i>inchoate</i> plane

Figure 1: A speculative structural hierarchy based on $s = (s_1 s_2 \dots s_n)^2$.

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Column (b) is simply the full number of ways a number of entities (symbols) can be combined - 1,2,3... at a time, which is $\sum_{p=1}^n \binom{n}{p} = 2^n - 1$. This sequence thus counts the number of symbols that can be formed from some given set of symbols by aggregation. The second sequence, column (d), is related to the number of symbols from column (b) which can via discrimination produce the remaining ones at the next level.

Quoting from one of Pierre's older SLAC reports,

More precisely, we invoke the concept of discriminate closure on these 'bit strings', and define a *discriminately closed subset* (Dcs) as a single non-null string, or as that set of non-null strings which, when any pair are discriminated yield another member of the set. If we start from linearly independent strings a, b, c, \dots (ie. $a|b \neq 0, b|c \neq 0, a|c \neq 0, a|b|c \neq 0, \dots$ we can form the Dcs's $\{a\}, \{b\}, \{c\}, \{a, b, a|b\}, \{b, c, b|c\}, \{a, c, a|c\}, \{a, b, c, a|b, b|c, a|c, a|b|c\}$. Starting with strings of 2 bits, we can form $2^2 - 1 = 3$ Dcs's, for example $\{(10)\}, \{(01)\}, \{(10), (01), (11)\}$.

To preserve this information about discriminate closure, we map these three sets by non-singular, linearly independent 2×2 matrices which have the members of these sets as eigen vectors. Rearranged as strings of four bits, these form a basis for $2^3 - 1 = 7$ Dcs's. Mapping these by 4×4 matrices we get 7 strings of 16 bits which form a basis for $2^7 - 1 = 127$ Dcs's. We have now organized the information content of 137 strings into three levels of complexity. We can repeat the process once more to obtain $2^{127} - 1 \approx 1.7 \times 10^{38}$ Dcs's composed of strings with 256 bits, but cannot go further because there are only 256×256 linearly independent matrices available to map them, which is many too few. Thus after four stages, the information-carrying capacity of our information-preserving mapping scheme is exhausted.

The thrust of the act of 'discrimination' is simply to express whether two² symbols are 'the same' or 'different'. Thus Parker-Rhodes' emphasis on indistinguishability is universally present in the structure - the combinatorial hierarchy (CH) - that emerges as discriminations are compounded. It seems to me as well that the essence of the idea of distinguishing two things implicitly places us in a discrete realm.

In the traditional presentation of the CH, the basic symbols are '1' and '0' and discrimination ('|') is defined as 'exclusive or' - hence $1|1 = 0|0 = 0 =$ indistinguishable and $1|0 = 0|1 = 1 =$ distinguishable. I note that the double use of the symbols as both values and meanings introduces an important tension. Since '|' can also be viewed as arithmetic addition modulo 2, we see that we are working with an 'additive algebra'. However, as [mm92] shows, one can also define the symbols to be '+1' and '-1' and define discrimination as multiplication - hence $+1 \times +1 = -1 \times -1 = 1 =$ indistinguishable and $+1 \times -1 = -1 \times +1 = -1 =$ distinguishable - which is a 'multiplicative algebra'. Presumably there are other possibilities as well.

Whatever the underlying algebra, the above procedure generates all possible distinctions, and the transition from one level to the next is actually a mapping of these distinctions to *new* symbols. Note that distinctions themselves can be distinguished,

²Distinctions of arity > 2 yield fewer than 4 levels, ie. engender *less* structure.

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so CH *structure* thus bookkeeps all of the various ways symbols - be they simple or compound - can be the same or different, that is, all the possible *distinctions* that can be drawn. The oft-quoted CH cardinals 3, 7, 127, $2^{127} + 136$ tell *how many* basic symbols/distinctions the CH structure contains, ie. these numbers are a by-product of the structure and the process which constructs it. [The task of constructing a physical theory on this foundation is thus to relate the distinctions so formed to known/traditional/useful distinctions such as space, time, charge, spin, etc. The difficulty of this endeavor is balanced by the guarantee that *nothing* is being left out, that is, all possible distinctions are present and must be accounted for.]

The initial symbols '0' and '1' are non-compound, whereas compound symbols are strings of these with length >1 . The symbol '0' *interpreted* as 'not distinct' is treated specially - ie. left out of the counting up to the cardinals - because two indistinguishable distinctions contribute (it would appear) no more than one of them. Although the way zero and the zero string pop up when one works with the CH more than justifies leaving it consistently out, since in a sense it's always there, the Clifford algebra setting (see next section) makes it conceptually clearer, since 'nothing' (ϕ) is clearly distinguished - symbolically - from 'indistinguishable', and 'indistinguishable distinctions' turn out to play an unexpected role.

The next issue is how to generate compound (ie. new) symbols from existing ones. There are presently three³ different 'stories' about this:

- (1) Clive and Ted's, where one imagines an unknown 'surround' that 'casts up' symbols (bit strings) which can be compared (ie. discriminated) with the ones in hand. One can at one's leisure apply the above described process and see how much of the CH one has, and by implication from what's missing, what one can expect;
- (2) Pierre's and my Program Universe (v.2), where one imagines a growing two-dimensional array of bit strings generated by two operations: Pick two strings at random from the array and discriminate them. If the result is not the zero-string, add it to the array and Pick again; else Tick, which appends a bit, randomly chosen for each string, to each string, and then Pick again. Thus the scenario is a bit-based Big Bang, and the growing set of growing strings constitutes the entities from which a physical theory is to be constructed. Pierre views the individual strings, quite definitely, as elementary particles (or at least their forerunners), and has pursued this interpretation with success. However, this may not be so, eg. perhaps particles should be viewed as invariants arising from interactions between the strings. Etc;
- (3) My AI-driven 'inference from sensory data' approach. Here, there is a boundary constituted by sensors having the possible values ± 1 . The basic distinction is 'happen at the same time' = indistinguishable (in time) versus 'exclude each other'

³Herb Doughty presented a fourth story, based on 'double fields' and Mersenne primes, a few years ago at Anpa West, but I unfortunately do not have his paper at hand.

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= distinguishable (in time) over two or more sensors. The result is a growing 'universe' of mutually orthogonal product-terms belonging to a (growing) Clifford algebra.

My mission is not to re-tell these stories, but rather to interpret (my understanding of) the intent or meaning of each of the steps in the construction process. I will do this by citing and commenting Pierre's description above, a description I tacitly regard as generic to both of the above 'bit string' stories.

- *If we start from linearly independent strings a, b, c, \dots (ie. $a|b \neq 0, b|c \neq 0, a|c \neq 0, a|b|c \neq 0, \dots$. That is, the initial (or non-compound) symbols are distinguishable. Note particularly the conceptual coupling of 'distinguishable' to 'linearly independent': they mean the same thing.*
- *We invoke the concept of discriminate closure on these 'bit strings', and define a discriminately closed subset (Dcs) as a single non-null string, or as that set of non-null strings which, when any pair are discriminated yield another member of the set. The conceptual intent of the Dcs concept is to provide simultaneously (1) a definition of how to create new symbols from existing ones, and (2) a criterion for what constitutes a usable distinction. Ad 1: new symbols are created by discriminating existing symbols. Ad 2: A set of symbols which is closed under discrimination constitutes a usable distinction, and this set will *in toto* constitute a new symbol at the next level.*

Referring to the example, given the initial symbols - which are, as it were, their own distinction - we get three Dcs's, $\{a\}$, $\{b\}$, and $\{a, b, a|b\}$. In terms of bit strings, if $a = 10, b = 01$, then the three Dcs's are $\{10\}$, $\{01\}$, and $\{10, 01, 11\}$. Notice that the third - compound - Dcs expresses that the fact that there is a 'whole', but what constitutes the 'parts' of this whole is ambiguous, since taking any two yields the third. This ambiguity can first be resolved at the next level.

- *To preserve this information about discriminate closure, we map these three sets by non-singular, linearly independent 2×2 matrices which have the members of these sets as eigen vectors. The key term in this sentence is 'linearly independent', because what we are after is to build a new level in which *each* of the three Dcs's has equivalent status, that is, each of the three Dcs's is distinct from the other two. The symbols constituting the new level are the three matrices. In addition, as Clive pointed out to me, insisting on linear independence also has the implicit effect of guaranteeing that we have a complete basis for constructing the next level. The requirement that each matrix have its 'parts' as its eigen vectors (ie. $Mx = kx$) ensures that nothing 'extra' gets imported or introduced by the matrices themselves, that is, they will behave as pure symbols whose only import will lie in*

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their combination with (ie. distinction from) other symbols. The 'non-singularity' is a similar requirement on good behavior. It bears mentioning that this whole way of talking about how the symbols and level transitions are constructed - in particular, the matrices - is intimately connected to the exclusive-or, bit-string *qua* vector world in which the construction is carried out. A different algebraic setting must search out its own equivalents, and it was indeed this search which gave birth to this paper.

We can diagram the mapping, or level transition, as follows (\mapsto means 'maps to', and I have included on the right the *ab initio* generation sequence):

level 1		level 2		level -1		level 0		level 1
ϕ								
a	\mapsto	p				0	\mapsto	01
b	\mapsto	q				1	\mapsto	10
$\{a, b, a b\}$	\mapsto	r						11
	

So at level 1, we get three distinct symbols, p, q, r . The fact that p, q are 'really' parts of a whole called r is properly invisible. It is precisely the invisibility of this distinction which allows one, at this level, to resolve the ambiguity mentioned earlier, namely by expressing the distinctions $p|r$ and $q|r$, that is, the part-whole distinction. We defer this momentarily.

- *Rearrang[ing these three matrices] as strings of four bits, these form a basis for $2^3 - 1 = 7$ Dcs's.* Speaking as the mathematical dyslexic I feel I am, I've always found this sentence mystifying. I can accept that a matrix is simply a more or less arbitrary arrangement of items, so why *not* arrange the items in a single column or row instead of two-by-two?! *But*, these matrices have a very particular structure - linear independence and certain eigen values - for the preservation of which I've never seen or heard any argument. Where's the theorem that says that if I have linearly independent matrices, then the vectors arising from a uniformly-carried-out columnar re-arrangement will also be linearly independent? What happens to the eigen values - since they 'disappear' in the rearrangement, why insist on them in the first place? Apparently all this is 'obvious', even though it seems that every time I leave something like this out, all I hear are whines from the mathematicians about precision and rigor and all that.

But okay, I accept that this is all right. The result, as stated, is that from the three

2 THE "STANDARD" DERIVATION

symbols/matrices we can form seven symbols in the same way as before:

level 1		level 2		level 3
ϕ				
a	\mapsto	p	\mapsto	s
b	\mapsto	q	\mapsto	t
$\{a, b, a b\}$	\mapsto	r	\mapsto	u
		$\{p, r, p r\}$	\mapsto	v
		$\{q, r, q r\}$	\mapsto	w
		$\{p, q, p q\}$	\mapsto	x
		$\{p, q, r, p q,$	\mapsto	y
		$p r, q r, p q r\}$		
				...

That $s \dots y$ indeed form Dcs's can be checked, eg. by expressing them as three-bit strings. Furthermore, there is a pattern to their formation, namely choose 1, 2, 3 at a time from the original three symbols. It is this pattern that gives rise to the CH cardinals as powers of 2, since $\sum_{i=1}^n \binom{n}{i} = 2^n - 1$. That there are no other Dcs's follows - in the bit string setting - from the fact that an n -bit string contains 2^n possibilities, and we are suppressing the zero string in our accounting.

However, there *is* one little problem, namely that $x = \{p, q, p|q\}$ is, dynamically speaking, indistinguishable from u , which is mapped from $\{a, b, a|b\}$, since $a \mapsto p$ and $b \mapsto q$. So one ought properly to delete this Dcs from this level, which certainly would seem to knock a hole in the CH's cardinal's values. I have not seen this issue aired in earlier discussions of the CH, and will return to it in the next section.

- *We have now organized the information content of 137 strings into three levels of complexity. We can repeat the process once more to obtain $2^{127} - 1 \approx 1.7 \times 10^{38}$ Dcs's composed of strings with 256 bits, but cannot go further because there are only 256×256 linearly independent matrices available to map them, which is many too few. Thus after four stages, the information-carrying capacity of our information-preserving mapping scheme is exhausted. This is a straightforward algebraic conclusion, but notice that it depends on the fact that we are dealing with square matrices, which again reflects the anchoring of the whole scheme in a particular linear algebra. In a different algebraic setting - such as my Clifford algebras - there is, as we will see, no obvious counterpart. On the (reasonably well-founded) assumption that the two settings are nevertheless isomorphic, it would appear that just as the cut-off is easily visible and anti-commutativity deeply buried in the standard bit-string rendition, so the situation is just the opposite in the Clifford algebra version.*

3 Doing It in a Clifford Algebra

This section recapitulates the preceding in the setting of a Clifford algebra, where the two symbols denoting in/distinguishability are ± 1 instead of $1, 0$, and the basic comparison operation is multiplication instead of exclusive-or/addition mod 2. I will write $+1$ as 1 , and -1 as $\tilde{1}$.

[It may be helpful to recall that my computational interpretation of 'distinct' or 'distinguishable' is 'mutually exclude', as in " $k = 1$ mutually excludes its having the value $\tilde{1}$ "; and my interpretation of 'indistinguishable' is 'co-occur', as in "do not exclude each other", eg. " $k = 1$ does not exclude $j = \tilde{1}$ ". Thus my computational interpretation is in the time domain. Recall also, cf. the coin demonstration, that co-occurrence yields information, namely that the things do not exclude each other.]

Let us start at the very beginning of the generation process, namely from the point where the Universe U is devoid of any structure. The story is a little different in the beginning:

Step: $U = \{0\}$. Since the algebraic value 'zero' in the complex plane (the simplest Clifford algebra) plays a role qualitatively similar to that of $\phi =$ the empty set in the standard story, I use it instead.

Step: $U = \{0, 1, \tilde{1}\}$, "there exists something that is different (ie. distinct) from nothing". I show $1, \tilde{1}$ appearing simultaneously for two reasons: (i) $0 = 1 + \tilde{1}$, which expresses in its symmetry the vacuum fluctuation, 'Universe as the ultimate free lunch' view, and (ii) not doing so, and multiplying (ie. discriminating) zero and either 1 or $\tilde{1}$ yields zero again, and no growth.⁴ Notice, as mentioned in the preceding section, that the roles of 'nothing' ($\phi \equiv 0$) and 'indistinguishable' ($\equiv 1$) are kept distinct in the present formulation, and hence the leaving of zero out of the cardinal-accounting nicely justified.

At this point we have (I claim) level 0 of the CH:

level -1		level 0
0	\mapsto	0
		1
		$\tilde{1}$

Step: $U = \{0, 1, \tilde{1}, s\}$. The variable s represents the closure of the set $\{1, \tilde{1}\}$ under multiplication, that is, it corresponds syntactically (but not semantically) to the set $\{a, b, a|b\}$ in the standard setting. Notice here that s has an entirely different status from that of the symbols a, b in that formulation, in that the latter are understood to be bound (in a very computational sense) to specific bit-string values, whereas s is a true variable, understood to be able to take one or the other of the two possible values $1, \tilde{1}$. In the Clifford algebra formulation presented in [Man92], the binding of a particular value to

⁴I find the introduction of special rules (eg. $0 \times 1 = 1$ when $|U| \leq 2$) aesthetically unsatisfactory. See also the next footnote.

3 DOING IT IN A CLIFFORD ALGEBRA

a variable (ie. symbol) in the algebra is captured by the valuation convention, which is ultimately a notational, rather than conceptual, affair.

I find this all very satisfactory, in that it reinforces the view that the CH is a structure for constructing and bookkeeping *distinctions*. Thus the *first* distinction that emerges is that "things can be different from each other", in contrast to the initial Universe, which is entirely undifferentiated. The symbol s denotes precisely this distinction, *and nothing more* - in particular, the particular attribute(s) by which two things differ. Moreover, since we insist that the distinctions the CH bookkeeps be distinct, each distinction appears exactly once (speaking syntactically/statically: see next step below), from whence it can be combined with other distinctions to produce yet more distinctions.

Howsoever, the expansion of U has reached a stage where there are no other combinations (Dcs's) available, and we have thus succeeded in filling out the first level of the CH. This motivates the transition (mapping) to the next level:

level 0		level 1
0	↦	0
1	↦	1
1̃	↦	1̃
{1, 1̃, 1 1̃}		

One may rightly wonder why I have used 'l' instead of 'x' for 'discrimination' in the third line. The reason is that, while scalar multiplication is the bottom-most expression of how to distinguish symbols, the distinction we wish to make transcends its expressive power. This is so because we wish to express that *both* $1 \times 1 = \tilde{1} \times \tilde{1} = 1$ *and* $1 \times \tilde{1} = \tilde{1} \times 1 = \tilde{1}$. In actuality, I view this as the primitive form of the boundary operator ∂ : $\partial s = 1 + \tilde{1} = 0$, in comparison and contrast to [Man92], where I define $\partial s = 1$. Said another way, the *both-and* problem expresses the need for (or, the implicit presence of) the distinction called temporal co-occurrence, which in the Clifford algebra is expressed (in my computational interpretation) by '+'.⁵ In this light, it would seem that the bit-string formulation expresses this aspect quite implicitly via its (otherwise conceptually uninterpreted) concatenation of bits to form strings thereof.

Step: We have again exhausted the distinctions available at the present level, and so

⁵One could alternatively, paralleling Clive's use of Conway's construction of the integers, proceed $0, 0 + 0 \mapsto 1$ and thence, transitting to the next level, $\tilde{1}$ and $1 + \tilde{1}$, ie. introducing co-occurrence first, and thereafter exclusion. Which order one chooses would thus appear to be a matter of taste.

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we map up again:

level 0		level 1		level 2
0	↦	0	↦	0
$\bar{1}$	↦	$\bar{1}$	↦	$\bar{1}$
$\tilde{1}$	↦	$\tilde{1}$	↦	$\tilde{1}$
		$\{1, \tilde{1}, 1 \tilde{1}\}$	↦	s
				$\{1, s, 1 s\}$
				$\{\tilde{1}, s, \tilde{1} s\}$
				$\{1, \tilde{1}, 1 \tilde{1}\}$
				$\{1, \tilde{1}, s, \{1, s, 1 s\}, \{\tilde{1}, s, \tilde{1} s\}, \{1, \tilde{1}, 1 \tilde{1}\}\}$
				$\{1, s, 1 s\} \{\tilde{1}, s, \tilde{1} s\} \{1, \tilde{1}, 1 \tilde{1}\}$

where it should be noted that the last two lines constitute a single symbol (corresponding syntactically to $\{p, q, r, p|q, p|r, q|r, p|q|r\}$).

Looking at the fourth line, the question of how to interpret $1|s$ immediately arises. It would appear that the distinction that is now rearing its head is that of 'part-whole'. On the other hand, by definition we cannot distinguish the parts of s since it *is* a whole. I suggest the following (reverse-Solomonic!) resolution to this dilemma: since 1 is indistinguishable from (another) 1, introduce namely *another* 1. This way we can have our cake and eat too! That is, *it is necessary (for the Universe) to generate a new instance ('copy') of 1* if there is to be further growth. That is, it is all well and good to show how one can *mathematically* create symbols, but these symbols - if they are not to inhabit some virtual never-never land - must be founded in something physically real, which it is up to the Universe to create.

On the other hand, it might also be the case that the theory is trying to tell us something. One can well ask in this connection about this requirement on the Universe: might this not be a case of the theoretical tail wagging the Ultimate dog?

*"Tell me Abe, if a tail is a leg, how many legs does a dog have?"
"Four! Calling a tail a leg doesn't make it a leg." -Abe Lincoln*

My answer, in support of both theory and Abe Lincoln, is that requiring the Universe to create something expresses the fact that a possibility to express a hitherto unexpressed distinction exists. We *know* that the part/whole distinction exists, so the Universe must have expressed it. The preceding analysis simply suggests how and at what stage this occurred. Put a different way, the *time* distinction implicit in the successively appearing distinctions must also be bookkept.

The same reasoning applies to the fifth line, $\tilde{1}|s$. We now have a new pair of 1, $\tilde{1}$, from which will automatically follow the sixth line, $1, \tilde{1}, 1|\tilde{1}$, which is an s distinct from the original s by virtue of its co-occurring with it. This may be clearer when the next step is written down.

4 SUMMARY AND CONCLUSION

Step:

level 0		level 1		level 2		level 3	
0	\mapsto	0	\mapsto	0	\mapsto	0	
1	\mapsto	1	\mapsto	1	\mapsto	1	
$\tilde{1}$	\mapsto	$\tilde{1}$	\mapsto	$\tilde{1}$	\mapsto	$\tilde{1}$	
		$\{1, \tilde{1}, 1 \tilde{1}\}$	\mapsto	s	\mapsto	s_1	
				$\{1, s, 1 s\}$	\mapsto	t	
				$\{\tilde{1}, s, \tilde{1} s\}$	\mapsto	u	
				$\{1, \tilde{1}, 1 \tilde{1}\}$	\mapsto	s_2	
				$\{1, \tilde{1}, s, \{1, s, 1 s\}, \{\tilde{1}, s, \tilde{1} s\}, \{1, \tilde{1}, 1 \tilde{1}\}\}$	\mapsto	$s_1 s_2$	
				$\{1, s, 1 s\} \{\tilde{1}, s, \tilde{1} s\} \{1, \tilde{1}, 1 \tilde{1}\}\}$			
							...

Here, the original instance of s is mapped to s_1 , and the second instance to s_2 . Having now two s 's, and invoking the co-exclusion of their co-occurring values - $\partial(s_1 s_2 + s_2 s_1) = (s_1 + \tilde{s}_2) + (\tilde{s}_1 + s_2)$ - argued in [Man92], we get the Clifford algebra's product $s_1 s_2 = -s_2 s_1$. Since $(s_1 s_2)^2 = -1$, we see that the new distinction that has appeared is chirality or $\text{spin}-\frac{1}{2}$. It is $s_1 s_2$ that corresponds semantically (but not syntactically) to $\{a, b, a|b\} = \{01, 10, 11\}$. In addition, the conjugate form of $s_1 s_2$ built over $(s_1 + s_2) \leftrightarrow (\tilde{s}_1 + \tilde{s}_2)$ can now also be inferred, though it is indistinguishable from the original at this level). Also, analogous to the preceding discussion, $t|u$ requires the generation of a new instance of $s_1 s_2$.

If we follow this line of thinking to its logical conclusion, the transition to each higher level recapitulates that which was novel at the level beneath it. Thus the $1 \rightarrow 2$ transition generated one new s , the $2 \rightarrow 3$ transition will generate (when all is said and done) yet another s , and finally the $3 \rightarrow 4$ transition one more. If I have counted correctly, this yields 4 s 's - call them s_1, s_2, s_3, s_4 . Since I have identified a photon with a 2-ary co-occurrences of primitive s 's, this means that to get a Universe with gravity requires a piddling *two* co-occurring photons, say $s_1 + s_2$ and $s_3 + s_4$, but *what* photons they were (are?)!

4 Summary and Conclusion

Comparing the computational, Clifford algebra construction of the CH to the standard one, we have seen several differences:

- The present construction's distinction between '0' = ϕ = 'nothing' and 'indistinguishable' = 1 I find clarifying.
- The 'generative imperative' that can be placed on the Universe by the duplication of $\{a, b, a|b\}$ by $p|q$ is present in both constructions, but is apparently easier to see in the more concrete, computational version.

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- There is a 'phase difference' of one level between the two constructions, as revealed by the syntactic match of $\{a, b, a|b\}$ with $\{1, \tilde{1}, 1|\tilde{1}\}$, versus its semantic match with s_1s_2 , which appears one level later. The import of this, if any, is unclear.
- The second, 'cutoff' series does not make any obvious appearance. As noted earlier, I ascribe this absence to the difference between an additive and a multiplicative algebra. The discovery (or lack thereof) of the cutoff series in the Clifford algebra setting will undoubtedly be very instructive.

In my opinion, the computational interpretation of the construction of the CH lends - not least due to its cognitive origin, but also simply because it too generates it - much weight to the traditional view that the CH is of fundamental significance.

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TALKING ABOUT CREATION -

A DIALOGUE

between PETER MARCER	and CLIVE KILMISTER
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Clive: Most discussions about the "early universe" have an irremediable naivety because the temporal neighbourhood of the creation event suffers acutely from a difficulty already familiar in a less serious form in all of cosmology, viz. what laws of physics should be assumed in a situation so different from the accustomed that even the concepts in terms of which they are formulated, time and space, do not exist but are in the process of being created?

Peter: I agree - the question is just how this problem should be approached. In our preliminary correspondence however we were both in agreement with the view provided by Alison Watson¹ that before the initial creative act one postulates a "pre-physics" of an undifferentiated flux or whole, which I would see as corresponding to the empty set \emptyset or zero 0, and an "act of resistance or interaction of the flux with itself" (a self-interaction that brings to mind the quantum idea of self-interference) resulting in an entity which I see as corresponding to a 1. This 1 is an early consequence of the birth-order process now begun, which gives rise to the structure of the universe, distinguishing it from the undifferentiated flux. This metaphysical picture can be connected with normal physical ideas if one identifies the notion of the undifferentiated flux with the dynamic quantum vacuum and the act of resistance with some measure of entropy. Such an identification brings in the Second Law at a very early stage just as Eddington thought was essential in any model cosmology. Moreover as

in your Brouwerian Foundation paper² a conceptual model for the postulated birth-order process is Conway's construction³ for the surreal numbers by means of which all numbers great and small may be created from the empty set \emptyset . In Conway's construction numbers are generated by a simple recursive meta operation G of the form that if L (left) and R (right) are disjoint subsets of the set S of all previously generated elements, then $(L | R)$ is adjoined to S ; the very first element to be generated is $(\emptyset | \emptyset)$ constructed from the empty set \emptyset and $(\emptyset | \emptyset) = 0$. In the Brouwerian Foundation of the Combinatorial Hierarchy, however, G is the meta operation such that L and R are not distinguished and so the fundamental logical operation between 0 and 1 is EXOR.

Clive: I agree that Alison provides a picture - I would almost say a poem - to help us in thinking. But the direction she goes on from that beginning does not seem to me to lead to the foundations I want for physics, though it does lead to other goodies. But I believe that one can only avoid the naivety I spoke of earlier by the use of such a primitive discrete theory as the Hierarchy, which grows organically. I see that as a mathematical form of Alison's picture.

Before I say more on that, though, some warning remarks are in order. This use of a primitive theory brings a further problem which is often expressed in the form of a felt need for a "physical interpretation" of the formalism. This puts the position wrongly, for the Combinatorial Hierarchy already has, I believe, as much physical content as is possible at this primitive stage. Sometimes the matter is expressed differently as the need to "reconstruct the orthodox physical description" out of the primitive theory. This is probably also wrong-headed because if some version of orthodox physics could be constructed in this way the possibility would surely carry with it the opportunity to "reflect back" this description to the moment of creation, contrary to what I said above. But even if it were not wrong, it would be an immense task

of great difficulty. My proposal is a different one. We have remarked that the language of physics is an inappropriate one for the temporal neighbourhood of the creation. The nature of the inappropriateness is that concepts like time have to be used before they have been developed and the result of this is that statements have to be made which conflict with the current laws of physics. Correspondingly the primitive discrete theory will prove inappropriate for a description of the complex continuum picture of the developed universe. I propose to regard the two theories, the discrete and the continuous, as two alternative ways of speaking, the appropriateness of one decreasing as that of the other increases. The interest then attaches to the intermediate state of the universe when neither form of description is very appropriate, but the two can help each other out.

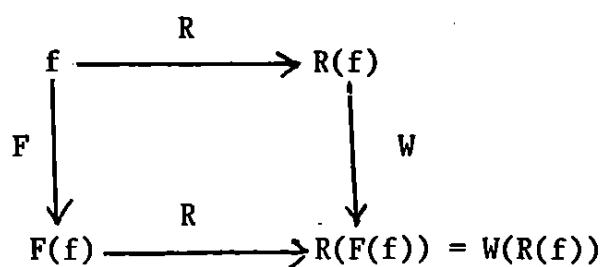
Peter: I very much favour the "reflect back" philosophy which you have tended to discard, for the following reasons:- firstly, Jablonski⁴ has shown that the fundamental logical operation of the Hierarchy EXOR models reversible computation at the binary level as a heat engine working in a Carnot cycle, giving credence to the postulate made earlier that Alison Watson's act of resistance can indeed be measured thermodynamically as entropy, as can the birth-ordering of the Hierarchy, which therefore would represent a binary symmetric channel or channels identified by Jablonski⁵ as a Fermi-Dirac system, and leading to the conclusion that therefore there must exist a complementary Bose-Einstein system which in the classical limit would be a continuum channel. This would surely be in agreement with the concept that the universe initially is an undifferentiated continuous whole (one). The usual quantum mechanical wave-particle dualism then helps one to understand how this whole has both fermionic and bosonic properties, representing the instability from which the structural evolution of the universe or birth-order flows.

Clive: Wait a minute! I wonder if there is any real disagreement between us on

reflecting back? I think it is only a question of how far back. I can't think you want to reflect back to the very act of creation (if indeed that is a meaningful phrase) of space and time. And you seem to confirm this when you talk of "the universe initially...an undifferentiated whole". When we have said that, we lay ourselves open to the question of where the whole came from just as one might ask Alison where her flux came from; there will not be answer of a causal type, for surely cause hasn't then be created, but decription is possible.

Peter: It is really structure that needs to be created and if one identifies the undifferentiated flux as the initial and residual flux from which structure is derived, with the quantum vacuum, then the appropriate description for this in the orthodox physics is in terms of creation and annihilation operators entirely suitable for the initial act of creation and any further minor acts that might follow. Thus the two theories or two alternative ways of speaking exist similtaneously, and it is not the laws of physics (as one will ultimately come to understand them) which change; the law is immutable but gives rise to different paradigms of structure described by different algorithms throughout the birth-order process, and one such structure is space-time itself, as indeed is the case with the Hierarchy. One is therefore not looking for law which can be formulated in terms of the coordinates x_1, x_2, x_3, t of space-time, but for law in terms of relationships from which the coordinate structure of space-time may be inferred.

For example, the processes of quantum mechanics may be expressed in relational form without reference to space-time as the irreducible commutation diagram below. This is simply a statement of the



fundamental spectral theorem of Hilbert and von Neumann where, for every vector f in the Hilbert space, each self-adjoint operator F can be expressed in the simplest possible way in the rotated axes R through the multiplicative weighting operator W . This diagram not only illustrates the importance of the non-commutativity of Hilbert space operators and commutation relations to quantum mechanics, but brings out the independence of certain structural relationships in quantum mechanics from space-time, such as is the case for quantum non-locality which represents the principal difference from classical physics and the essential mystery of the theory. And as Lou Kauffman⁶ has indeed shown in the case of the meta operation G which specifies all such relationships in terms of the parentheses (), such parentheses conceal the structure of special relativity.

Further evidence for the undifferentiated flux having implicit properties of its own surely comes from Parker-Rhodes's theory of indistinguishables⁷ from which the Combinatorial Hierarchy emerges as a secondary but principal structure?

Clive: Let me try to substantiate my earlier Ibsenite "presentation of the Claims of the Ideal". In the Hierarchy, the discrete process begins with a situation which is not distinguished in any way. One denotes it by the symbol 0. This is not to be read as zero, though the symbol is chosen so as to have the obvious overtones. An act occurs; it is denoted by 1. The temptation to ask what the act is, or where it occurs, or for how long, has to be resisted since none of these questions have meaning at this stage. The mathematics expresses no more than a primitive change. It would perhaps be best in an ideal world to get along as best we could without any picture but it is very difficult for the imagination to work in that austere way. Yet the usual physical picture is not, I insist, available. The next step is to consider a second act which is different from the first. It is necessary for the process to determine in some way that this second act is indeed

different. The corresponding situation is one which has been discussed frequently in ANPA and it is known that, however the process in fact determines it, it is as if it discriminated between 1 and the new element 2 by means of a binary operation + such that:

1. $a + b = 0$ if and only if $a = b$,

2. $a + b = b + a$,

3. $a + (b + c) = (a + b) + c$,

from which it follows that

4. $a + 0 = a$

since $a + (a + 0) = (a + a) + 0 = 0 + 0 = 0$. From this a whole complicated algebraic structure has been built up, with numerical consequences having obvious physical consequences (the numbers 3, 10, 137 and 10^{38} arising in a natural manner). This is not the place to elaborate the algebra.

Peter: It does however establish the importance of the operation EXOR to the Hierarchy, and the possible relevance of a thermodynamic interpretation of the 0 and 1 as indicated by the work of Jablonski referred to earlier.

Clive: I agree. We are forging a common intermediate position. The next question to be asked is, how can this be described in the language of physics, if at all? The single act could be regarded as the creation of a single particle. This is all one can say about it and so there is no room to ask (e.g.) about its mass, charge or spin. None yet exists, until presumably the numbers 3, 10, 137 and 10^{38} of the Hierarchy come about to allow, with the final two numbers, for example, the physical connotations of electromagnetism and gravitation. So one cannot yet refer to it as massless etc. and so one must coin the terms mass-free, spin-free and charge-free to apply to this case. Similarly, it makes no sense to ask about the conservation of energy at this stage. What can

then be said about the second act? It cannot be represented by the same particle nor can it be the anti-particle, since at this primitive stage the anti-particle would be the same as the original particle. We must therefore have two spin-free and mass-free particles. The discrimination operation then produces some kind of combination of the two. As an awful warning against too quick an attempt to connect this with the orthodox formalism, let us recall that just such an association of massive spin-zero particles arises there with the complex scalar field in orthodox theory and this gives rise to the Goldstone boson of mass zero linked with a massive boson. One speaks of spontaneous symmetry breaking. This would suggest identifying 1 with the Goldstone boson and 2 with a massive boson of energy E_2 and mass m_2 . Thus if the Goldstone boson has energy E_1 , the discrimination being regarded as a vertex would give rise to another massive boson of energy $E_1 + E_2$ and mass m , where $m^2 = m_2^2 + 2E_1(E_2 + p_2)$, with p_2 momentum. Even if m_2 is approaching zero, one would still have $m^2 = 4E_1E_2$.

The amount of structure envisaged here is quite out of place at such a primitive level, so that the particular mechanism can safely be rejected. None the less, it is clear that if discrimination is to be interpreted as a vertex and if energy is to be taken as conserved, the result of taking 1, 2 as massless is to give 12 a mass. This suggests, looking at the algebraic side of things, and observing how primitive^a stage has been reached, that conservation of energy is not something to be reached very quickly. The process has to continue and more acts take place and fall into their places in the Hierarchy before one reaches the point to which orthodox physics can be reflected back; such a reflection back cannot be quite to the initial act of creation, but the theory one is putting forward provides a continuity between the initial act, and some version of the orthodox view, because the relationship between the Hierarchy and orthodox physics is so close - to the extent to which the findings of both theories are common.

Peter: Yes, this is surely remarkable and must be explained; also the inflationary model of orthodox physics provides plausible predictions and paradigms for the experimental evidence by astronomy about the stages of cosmological evolution. I believe however that it may be possible to extend the orthodox view back to the initial act, so giving credence to the model you have just given and to discrimination as a vertex as the Hierarchy development requires. Such a reflection back concerns what is called dimensional confinement following new laboratory experiments and theoretical work in nanotechnology⁸. Here for example an individual electron may be progressively confined inside a suitable material structure so that the movement of the electron is reduced dimension by dimension until it becomes a quantum dot, the behaviour of which has been modelled by means of the Heisenberg uncertainty relation.

This shows that as confinement increases, the energy of the electron increases towards infinity but that its mass decreases towards zero⁹. And this is surely what is required in the case of the creation, when the universe itself exists without space and time as a 'quantum dot', and might be considered to be defined as its configuration space the Hilbert space in terms of the commutative diagram already given earlier.

Clive: Well, there still seems to be some difference here I can't quite bridge.

I am not at all sure, by the way, that I want to accept credence produced by reflecting back as far as you suggest. But taking your picture as a suggestive one, let me point up my difficulties with it, which, firstly, mirror my difficulties with some of the early parts of Alison's thesis and, secondly, rather to my surprise, also mirror old Kant's fundamental antinomies of pure reason. You say "the universe itself exists without space and time as a 'quantum dot'".

(i) One might bridle at 'itself' but actually that is OK. You put it in to emphasise how the dimensional confinement picture is being transferred to a different context.

(ii) 'universe exists, without...time'? What is the grammatical construing of that verb? It sounds like the continuous present, but how is that possible without time?

Peter: Surely time is encoded as information?

Clive: Does that help? But let me continue:

(iii) 'universe...exists, without ...space...as a 'quantum dot''. Can a dot, 'quantum' or otherwise, be understood 'without space'? (I guess you have anticipated this difficulty by your use of single quotes.)

I am sorely tempted to say to you: I could provisionally go along with your ideas so long as you realise that they apply only a moment later than what I am talking about. But I must resist this temptation to bring in temporal features too soon - that 'moment' is a word with too much metrical content.

Peter: Let me put it this way: at the very point or act of creation the universe is simply the description or prescriptive specification given by the commutative diagram postulated earlier, i.e. the quantum law, within which space-time is implicit and thus the universe can be considered to constitute a 'quantum dot' from which it evolves by means of the birth-order process which the Hierarchy describes or alternatively but equivalently as I see it, where within the orthodox model, the behaviour of such a dot is regulated by the canonical commutation relations governing Heisenberg uncertainty. Now Hermann Weyl's discovery¹⁰ that the canonical commutation relations appropriate to the Heisenberg uncertainty relations are the structure relations of a certain two step nilpotent Heisenberg Lie group $A(\mathbb{R})$ indicates that not only can quantum uncertainty be overcome under the right circumstances, which I would claim appertain in the dimensional confinement of the early creation, since group operations are invertible, but that this group does indeed provide a full mathematical model of the processes by which a quantum mechanical behaviour can be reduced dimension by dimension.¹¹ This would mean that one could obtain the

usual predictions of quantum theory without ever referring to complex numbered "quantum mechanical amplitudes". And indeed Grossing¹² has shown this to be the case on the basis of quantum cybernetics by deducing a very simple formula for transition and certain conditional probabilities using real numbers only. This relates intuitively understandable and, in principle, directly observable physical quantities without the use of such amplitudes. More cannot be said here but it can be inferred that this particular form of the real line (a preferred coordinate system?) ought to correspond to that of the birth-ordering already proposed and the thermodynamic measure entropy, as well as - I would infer - to the Hierarchy itself. Thus one may indeed envisage the first act, as the creation of a mass-free, spin-free, charge-free elementary particle of enormous energy and the second act as, say, the division of this first particle into two particles, similar to the process of parametric down-conversion of photons carried out in the laboratory¹³. I choose this particular form of vertex because it ensures that the two emerging particles will exhibit quantum non-locality should they interfere at some subsequent stage. Thus the first act of creation from the undifferentiated flux or dynamic quantum vacuum might be said to be no different from the spontaneous creation of a particle from the quantum vacuum now, except that the vacuum in the new case would be entirely structure and field free and without space-time¹⁴. This would then be the meaning of mass-free, spin-free and charge-free - that these terms require a minimum of structure arising from the birth-ordering in order to give them the meaning which we all understand. Indeed, one might even say that such properties do not fully exist until the birth-order process has reached the stage at which there are conscious beings like ourselves capable of carrying out laboratory experiments to determine them in accordance with corresponding theoretical predictions. However, if the reflection back is as I postulate it to be, one may infer that the informal verbalised meaning of the terms such as mass, spin, charge and space-time is invariant for the purpose of constructing a model of creation. That is the same Platonism that you, Clive, have assumed to hold for mathematics!

Clive: I must interrupt you to protect my reputation against the charge of platonism. I suppose that some time I shall have to say, positively, what I am, but to continue in a negative vein, let me say that I reject the platonist label as fervently as last year I rejected Viv's labelling me as a Cartesian dualist. Plato, and all platonists, believe that mathematics is about a realm of mathematical forms, non-physical and so beyond perception. They then have the serious problem of saying how we can know anything about them. When I use mathematical symbols in the hierarchy algebra, they denote something physical.

Peter: I do not think we disagree. Let me put it another way - if syntax can retain its validity down to the moment of the creation describing the processes at work, then I conclude that so must semantics and for me semantics can only be addressed as physical meaning. This I gather is your view too. And thus I conclude that one may talk of energy, of momentum, of angular momentum and of space-time at the time of the creation in the qualitative sense if one is clear that the actual quantitative definitions only follow from the birth-order process later. The reason I said it was because I believe it is possible to prove that the birth-ordering is unique and modelled by the Hierarchy¹⁵. I am also convinced that if the creation is modelled as dimensional confinement, then it corresponds to an optimal control of an uncertain quantum system^{16,17}. This can now be demonstrated in the laboratory for a sample of molecules using a laser controlled by a computer and a genetic algorithm so as to be able to learn how to evolve the optimum output of some chemical structure¹⁸. Indeed, I would go so far as to hypothesize that we are ourselves the output of such an evolution, where optimal control of our chemical structure is brought about by our genetic code or algorithm and where such an evolution or birth-ordering has taken place because the Creation itself constitutes such an optimum control - surely an essential criterion for a universe

that must, I believe, be self-organising¹⁹. However, let me now return to basics and the fundamental structure to the Creation - namely, space-time itself. It seems to me that you, Clive, and Ted solved a great measure of how this structure comes to be in your very early papers entitled The Concept of Order, and in particular in The Space-Time Structure²⁰. These papers display the importance of group structure to the properties of space-time and to the fundamental properties of matter such as mass, spin and charge when, in the process of the birth-ordering, these are assigned their characteristic numerical values. Such a Platonistic scenario would then allow the extrapolation that the first act may indeed be inferred to be the creation of a single photon of immense energy $h\nu$. Such a photon is of 'course its own anti-particle, in line with your argument earlier that the second act cannot be the creation of the anti-particle.

Clive: Well, I find lots to agree with there. Indeed, the universe must be self-organising: there's nothing else to organise it! And it is nice to have had your continued support through the years for the Concept of Order papers which so few people ever read. But now I notice that the trouble we had in our earlier correspondence over why a photon was the correct "realisation" of the initial act is averted here by describing it as an extrapolation. Maybe this is just an assumption? I wonder too about its frequency or energy. If you want to talk about frequency you must already (after only the first act!) have time created. This goes against my grain because I see time as being possible only when one has a number of acts. But leaving that, I suppose you say the frequency is "immense" because you have in mind conservation of energy, and you need the energy "later on". I find myself back on the same hobby-horse; maybe we have not yet got enough structure to talk about conservation of energy.

Peter: In a quantum holographic model such as the Heisenberg Group $A(R)$ provides your objection can be overcome, because time as information, i.e. geometrically encoded, can become time or

frequency by geometric decoding, the inverse process; here evolution or the birth-order process would be by adaptive resonance. Thus such a particle, characterised by its typical oscillatory frequency ν , would be considered a discrete excited state of the vacuum or undifferentiated flux which is in phase with the "wave"-like oscillation of the surrounding vacuum. Thus one considers a quantum system as a feedback system¹² with a given reference signal that can compensate disturbances relative to the reference point, which is the particle's frequency, ν . The waves act as mediators between the particle and the surrounding objects, constituting a feedback loop through the particle's environment. The Hierarchy process describes the evolution of both particles and environment - the latter taking on eventually the properties of Lorentz invariant space-time. Thus even with the appearance of the first discrete excited state or particle at the initial act of creation, one may be able to assign a spin one, as a photon would require, if one considers that such a spin would, as the above scenario requires, produce a corresponding change in the environment, or a first step towards the space-time structure as it happens in the Hierarchy.

A mathematical elaboration in terms of the techniques of Grossing's quantum cybernetics¹² shows how this might happen and also sets the scene for what the two step nilpotent Heisenberg Lie group $A(R)$, determining quantum parallelism or nonlocality and quantum interference effects, would say is possible at the time of the creation. And this must, I believe, concern the creation of the space-time structure itself or its basic constituent operations, and be related to Clive and Ted's work on the Concept of Order and the Space Time Structure²⁰. One is surely looking for a boundary condition for a quantum system at the Creation which resolves the dichotomy between quantum mechanics and general relativity, suggesting a semi-classical behaviour such as is indicated by the commutative diagram (1). This might be the optimal control of the quantum system - a feedback algorithm i.e. Program Universe of the Hierarchy, which one may represent by a matrix of possible

(0, 1) states arranged according to two axes, TICK - corresponding to v_0 above, and PICK - corresponding to the discrimination vertices or bifurcations. Thus I conclude that the Hierarchy is a model of Z_2 of the birth and emergence of structure including the domains of Lorentz invariant space-time relative to the undifferentiated flux.

However, it seems essential to consider the convergence between the Hierarchy model of discrete quantum physics and that of continuous quantum physics according to the orthodox model that characterises the history of the development of the Hierarchy. Take for example (one among many) the recent paper by Pierre Noyes entitled "On the correspondence limit of relativistic quantum mechanics" (SLAC PUB 6010 May 1993). Here Pierre quotes the Feynman-Dyson-Tanimura proof of the classical field equations and explains the relevance of this proof in relation to the Hierarchy. However, using the same equations as Tanimura, I gave a derivation of the Hierarchy by means of the Brouwerian Foundation in my paper in ANPA 10, 135-143, see page 139. Similarly in another paper by Brian Clement, Peter Coveney and myself, entitled "Surreal numbers and optimal encodings for universal computation as a physical process: an interpretation of the genetic code" (CCAI Journal 10, 1/2, 149-163, 1993) it is concluded with Tanimura that these equations do not require the existence of non-commuting operators but only, following Lou Kauffman, that the bracket expressions $[,]$ satisfy the conditions given by Tanimura. Here the surreal number fields specified by such bracket expressions not only lead to Kilmister's Brouwerian Foundation, but are a sufficient and necessary foundation of Lie and Clifford transformational systems or division of the system space into Lie products and their quantizations, bosons and Clifford products and their quantizations, fermions.

The destruction of existing order and the creation or emergence of new order including Lorentz invariant space-time (and, by inference, ultimately of observers) as per the Hierarchy birth-order process, defines the passage of time as it is observed. Could it therefore

that present structure is all there is, i.e. that all structure is being continually destroyed and reborn on a very short scale of order? One must then ask how this can be - for there must indeed be an historical record of knowledge of what has happened so far, if the birth-order process is to progress and not forever repeat the initial creative act. The orthodox model where the undifferentiated flux is identified with the dynamic quantum vacuum offers an answer to this in the form of the Berry phase. The phase in a quantum system contains a complete record of how long the system has been away, where it has been in space-time, and what states it has passed through, which would be known in their entirety each time the destruction of the entire system takes place, allowing it to be recreated with new order at the next moment of creation. Such a conceptual model could well be in good agreement with that recently put forward by Viv Pope²¹ for example. It is not, therefore, the Hierarchy itself that constitutes physical law - it models structure and the birth of structure according to a whole sequence of paradigms. It is the rules or processes by means of which the Hierarchy is generated which are the law, and the so-called conservation laws are simply invariants of the birth-order process produced as it takes place, as the Hierarchy confirms.

Clive: I feel a bit swept along by an undifferentiated flux I can't resist! More seriously, I hope that these identifications are mostly going to prove correct - the fact that I cannot say more is only a reflection of my usual slowness in accepting new thoughts, giving me undue caution. We are still in need of a bridge between us but I think that now we have each made a half-way arch towards each other; it's up to me to think quickly so that we can join them up before they fall into the river (or flux).

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PART 2

Philosophical Alternatives.

ANTI-GRAVITY: the key to 21st Century Physics*

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This paper was read at the 1992 ANPA meeting but was then inadvertently omitted from the Proceedings.

Abstract

The masses, coupling constants and cosmological parameters obtained using our *discrete* and *combinatorial physics* based on *discrimination* between *bit-strings* indicate that we can achieve the unification of quantum mechanics with relativity which had become the goal of twentieth century physics. To broaden our case we show that limitations on measurement of the position and velocity of an individual massive particle observed in a colliding beam scattering experiment imply real, rational commutation relations between position and velocity. Prior to this limit being pushed down to quantum effects, the lower bound is set by the available technology, but is otherwise *scale invariant*. Replacing force by force per unit mass and force per unit charge allows us to take over the Feynman-Dyson proof of the Maxwell Equations and extend it to weak gravity. The crossing symmetry of the individual scattering processes when one or more particles are replaced by anti-particles predicts both Coulomb attraction (for charged particles) *and* a Newtonian repulsion between any particle and its anti-particle. Previous quantum results remain intact, and predict the expected relativistic fine structure and spin dependencies. Experimental confirmation of this anti-gravity prediction would inaugurate the physics of the twenty-first century.

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1. WE NEED A NEW STRATEGY

The ANPA program has achieved a number of quantitative successes in calculating most of the fundamental mass ratios, coupling constants, and cosmological parameters needed in elementary particle physics and physical cosmology. These are summarized in the Table which concludes this paper. One might think that this success, which conventional “theories of everything” are aiming at, but have no more than vague ideas as to how to accomplish quantitatively, would provoke some interest among physicists and cosmologists. Yet when I finally succeeded in getting a short announcement published in the magazine that goes to all US Physicists,^[1] I only got *one* enquiry — a brief “What the hell is going on?”! I replied with technical details, but got no response. I have also tried to involve several elder statesman of my acquaintance, but among the theorists have garnered little interest.

The stock response is “Predict something that hasn’t been observed.” Of course no other theorist is doing that in our sense. They usually take a generous amount of both structure and parameters from existing experiments and attempt to compute a correction or two that might be observable. To play that game, we have to analyse nearly half a century of theoretical and experimental work by thousands of the best physicists in the world and recast it in our own terms. I am making progress along these lines, but without the help of eager and conventionally trained colleagues, cannot hope for any rapid developments. Even the top quark mass is getting pinned down; this is the last well defined parameter that could be predicted prior to experimental observation. Improvement on the values of the Kobiyashi-Maskawa mixing angles will get us little recognition. There are enough theories of neutrino masses around to insure that one of ours would be bound to have a successful conventional alternative. About all we can do is make the negative prediction that there should be no Higgs mesons with simple structure. However, we can expect many of the effects which will be used to “discover” Higgses are also contained in our theory. A clean discrimination between our theory and conventional alternatives will take even more work than getting the K-M parameters right, and will require many of the same steps.

Of course some members of the ANPA community resist the idea that we are trying to construct a new physical theory to be evaluated using the same criteria as those employed by the establishment. But, at least to the jaundiced eye of this physicist, I see no evidence that conceptual clarity and philosophical purity will do us much good. Many mathematicians and computer scientists claim just that, and I see no likelihood that we will stand out among the host of competitors. Physicists pay no attention to that vast body of literature in any case. Those of us who want

to convince *physicists* that the ANPA program has led to exciting new results will have to find a new strategy.

Fortunately, experimental high energy physicists are more willing than the theorists to entertain new ideas. They are properly distrustful of theorists, and unhappy with an experimental situation that relies so heavily on intricate theoretical calculations to “measure” *anything*. Maurice Goldhaber was intrigued with the idea that anti-matter might fall up, and suggested looking into tests with muonium and anti-muonium. Direct free fall tests are impossible because of the 2.2 microsecond lifetime. But he is looking into another possibility, which — so far — he is keeping close to his chest. The experimental groups working with anti-protons and trying to produce anti-hydrogen atoms have a lively interest in the prediction that anti-protons will fall up which Starson and I made at ANPA WEST 7.^[2] I have recently reviewed their experimental programs.^[3]

Making a case for anti-gravity has provoked more interest in the ANPA program among physicists than anything else to date. I propose to follow it up vigorously. I believe that even if the prediction fails, we will get more constructive attention from that failure than from any improvement in our quantitative predictions, no matter how impressive. But even within ANPA, I have failed to elicit any attempts to improve on or to refute my arguments for anti-gravity. I hope that this paper will stimulate or provoke some constructive criticism.

2. BOHR-ROSENFELD REVISITED

Bohr and Rosenfeld.^[4,5] proved that the restrictions on measurability due to the *non-relativistic* uncertainty principle applied to the charges and currents which detect the fields can be used to *derive* the commutation relations between the electric field E and the magnetic field H which are more easily obtained by the legemanderain of “second quantization”. Basically, this is possible because the theory involves only h and c , leaving it *scale invariant*. This allowed them to use as complicated an apparatus as they liked *within* a wavelength of the radiation. Their apparatus consisting of rigid rods and springs, massive charged objects and current loops. The rods and springs are used to compensate, in so far as possible, for radiation reaction, and can get pretty complicated. One post-doc who reviewed the paper at a SLAC seminar called it an exercise in nineteenth century electrical and mechanical engineering!

In the course of preparing the final version of my paper for PIRT III,^[6] I came to realize that the non-commutativity of position and momentum measurements made using macroscopic counters can be cast in a scale-invariant form by making angular momentum per unit mass (area change per unit time) the basis of

quantization rather than angular momentum. Then the units of quantization of length and time and the measurement of mass ratios depend only on space-time measurements. For instance they can be related to the smallest measured velocity in units of c , and a scale invariant quantity set by technological assumptions. Thus the basis for the Bohr-Rosenfeld argument can be recast *without* introducing Planck's constant provided only that the sources and sinks of the field are relativistic charged particles. This removes the restriction of their paper to non-relativistic quantum mechanics, which is obviously desirable.

Once one has scale invariant commutation relations between position, velocity and angular momentum per unit mass, the very peculiar proof of Maxwell's Equations which Feynman showed to Dyson in October, 1948 but refused to publish during his lifetime^[1] becomes understandable. I had argued elsewhere that this derivation is rigorous within the framework of bit-string physics.^[8,9] The new derivation presented here is scale invariant, making the proof even more general. It therefore seems worth while to present this new result before discussing the gravitational field.

3. PROOF OF THE MAXWELL EQUATIONS

The Feynman-Dyson proof of the Maxwell Equations starts with Newton's Second Law

$$m\ddot{x}_j = F_j(x, \dot{x}, t); \quad j \in 1, 2, 3 \quad D-1$$

and the commutation relations

$$[x_j, x_k] = 0 \quad D-2$$

$$[x_j, \dot{x}_k] = i\hbar\delta_{jk} \quad D-3$$

and proves that there exist fields $E(x, t)$ and $H(x, t)$ satisfying the Lorentz force equation

$$F_j = E_j + \epsilon_{jkl}\dot{x}_k H_l \quad D-4$$

and the Maxwell Equations

$$\text{div } H = 0 \quad D-5$$

$$\frac{\partial H}{\partial t} + \text{curl } E = 0 \quad D-6$$

The proof relies on the Jacobi identities and taking a total derivative with respect to time, but involves no formal subtleties.

Because our theory is relativistic, we measure all speeds in units of c . Since, by definition, $c = 299\,792\,458\text{ m sec}^{-1}$ we can always pick our dimensional scales in such a way that these speeds for any massive particle in any one direction are rational fractions less than unity.

Our first step is to eliminate the concept of mass from the problem in favor of mass ratios measured relative to some standard particle beam using only space, time, velocity and velocity change measurements. For this purpose we use *counter telescopes* consisting of two *counters* with thickness Δl containing recording clocks having the time between ticks Δt . We pick our units such that $\Delta l = c\Delta t = 1$, making all measurable distances and times *integers*. This commits us to insuring that we never talk about fractional space and time intervals as *measurable*. If the spacial interval between the counters is L and the time interval between two sequential counter firings is T we attribute the counter firings to the passage of a particle with velocity $V = L/T$. All data discussed here will be collected at a slow enough rates so that the interval between the passage of particles allows this measurement to be unambiguous. We also assume that, to an accuracy to be discussed, all four of the telescopes introduced below (eight counters) record the *same* speed.

Although, by hypothesis, $V = L/T$ must be a rational fraction less than unity, we will not in general be able to measure L and/or T to the nearest integer. To represent this fact we define

$$v = \frac{t'_1 - t_1}{t'_1 + t_1} = V = \frac{L}{T}; \quad L = N(t'_1 - t_1); \quad T = N(t'_1 + t_1) \quad (3.1)$$

We assume that t'_1 and t_1 are known to the nearest integer and that N can be estimated but not directly measured. By interference techniques we do not have time to discuss in this paper, one can measure relative path lengths and determine N to the nearest integer. What remains unobservable is the time t in any interval $0 \leq t = n_i \Delta t \leq t_1 + t'_1$. In this finite and discrete language, we are talking about a periodic phenomenon with N periods, each of duration $\mathcal{T}(v) = t_1 + t'_1$ whose *absolute* phase is unknown within a period. The fraction $t/\mathcal{T} < 1$ is our conceptual equivalent of the unobservable phase of quantum mechanics in a *scale invariant* context bounded from below by measurement accuracy rather than something related to Planck's constant.

Our paradigm for position and velocity measurement is to use four counter telescopes 11', 22', 33', 44' all pointed at the same region. To a first approximation, the lines 11', etc. all pass through a "circle of confusion" X of radius unity. We assume that the first two counter telescopes fire in the sequence 11'22' and the second pair in the sequence 33'44', and that 1'23'4 lie on a circle of radius d

centered at X . We assume that the lines $1'2$ of length b and $3'4$ of length b' are parallel and are bisected by a line perpendicular to them through X . That is we have two isosceles triangles with a common vertex and parallel bases. Calling their inferred heights h, h' and angles $\pi - \theta, \pi - \theta'$ we have, as a first approximation,

$$h^2 = d^2 - \frac{1}{4}b^2 = 2d^2 \sin^2 \frac{\theta}{2} = h^2 \left[\left(\frac{d}{b} \right)^2 - \frac{1}{4} \right] \quad (3.2)$$

and similarly for h', θ' . We take as our coordinate directions j parallel to the altitudes h, h' and k parallel to the bases b, b' , and assign coordinates (x_j, x_k) as follows:

$$1' : (0, 0); \quad X : (h, b/2); \quad 2 : (0, b) \quad (3.3)$$

We now relate this geometry to the common velocity v registered by all four counter telescopes and the fact that we can only measure times to an accuracy $\Delta T = t_1 + t'_1$. Then

$$1'X = X2 = d = 2v\Delta T; \quad 1'2 = b = \left(\frac{b}{d} \right) 2v\Delta T \quad (3.4)$$

and the velocity components are

$$v_j^{1' \rightarrow X} = \left(\frac{h}{d} \right) v; \quad v_j^{X \rightarrow 2} = -\left(\frac{h}{d} \right) v; \quad v_k^{1'2} = \left(\frac{b}{2d} \right) v; \quad v_j^2 + v_k^2 = v^2 \quad (3.5)$$

In order to make this into a scattering experiment, we assume that each time we get the sequence of firings $11'22'$ we also get the sequence of firings $33'44'$. For sufficiently weak beams, this will be unambiguous. We attribute this confluence of events to the scattering of one particle from each beam within the region X . We can then *define* the ratio of the mass m' of the particles in the second beam to the mass m of the particles in the first beam by the equality

$$m'b' = mb \quad (3.6)$$

It is a matter of experience that the *scale invariant* equality $m'/m = b/b'$ is independent of the common measured velocity v for all known pairs of particles which can be compared in this way and hence defines a velocity invariant scale for all particles relative to any one type. Note that we make the comparison at the *same velocity* to avoid the complications of relativistic kinematics. This is why our theory can remove the puzzle stressed by Dyson that the Feynman derivation seems to produce peaceful coexistence between Newtonian and non-relativistic quantum mechanics and the Lorentz invariant Maxwell equations they seem to imply.

This step allows us to replace forces — which historically related masses compared inertially to masses compared using weight — by mass ratios using the relativistic equivalent of Newton's Third Law, a step we freely acknowledge was suggested to us by Mach in his *Science of Mechanics*. The advantage of using this macroscopic and operational *change* in the velocity $2v \sin^2 \frac{\theta}{2}$ is that we can measure both the magnitude v and the scattering angle θ using macroscopic counter telescopes. Although we have described this situation as if the particles met at a point, all we can measure macroscopically are the scattering angles θ, θ' and the common rational fraction velocity to some finite accuracy. Thus, the "interaction" could well be *non-local*. As we have shown elsewhere,^[10] this description is invariant under appropriate rational velocity boosts and finite angular rotations. We claim this is the appropriate starting point for a *scale invariant relativistic action at a distance* theory. Comparison of the different mass beams at the *same* speed allows us to defer discussion of relativistic kinematics to a later point in the development.

We can now start the proof, replacing Dyson's F_j by $f_j \equiv \frac{F_j}{m}$. We use a common time interval ΔT to measure all velocities $\dot{x}_i \equiv v_i$ and all velocity changes Δv_j (rather than discussing accelerations \ddot{x}_j). Then Newton's Second Law, (D-1), becomes

$$f_j = \Delta v_j \quad N - 1$$

Because the eight counters occupy fixed positions, the coordinate $x_k = b/2$ of the midpoint between 1' and 2 and between 3' and 4 can be chosen independent of how we decide to interpret the measurement of position and velocity "at" X . Therefore Dyson's postulate (D-2) holds for us as well.

Our next step is to view this impulsive velocity change as a *measurement* of position x_j and velocity v_j of the particle in the first beam, to the limited accuracy allowed by the "circle of confusion" around X produced by our assumption that we cannot give meaning to distances less than Δl and times less than Δt . We have defined our units so that this is a circle of radius 1, until we fix the x_k coordinate by (D-2). Then it becomes a line segment of length one between two coordinates $x_j^1 = h_1$ and $x_j^2 = h_2$. The lines from either h_1 or h_2 to either counter will have lengths

$$d_1^2 = h_1^2 + b^2/4; \quad d_2^2 = h_2^2 + b^2/4 \quad (3.7)$$

If d_1 runs from 1' to h_1 , the velocity

$$v_j^{1' \rightarrow h_1} = +\left(\frac{h_1}{d_1}\right)v \quad (3.8)$$

which differs from the v_j in 3.5 by $[(h_1/d_1) - (h/d)]v$. Since our measurement philosophy does not allow us to assign the momentum change to a point, the line

d_2 must then run from h_2 to 2 and the corresponding velocity component is

$$v_j^{h_2 \rightarrow 2} = -\left(\frac{h_2}{d_2}\right)v \quad (3.9)$$

which differs from the v_j in 3.5 by $[(h/d) - (h_2/d_2)]v$. We can now attribute the position measurement to position h_1 followed by a velocity measurement at position h_2 , i.e. $x_j = h_1$, $|v_j| = (h_2/d_2)v$, or in the opposite order, i.e. $|v_j| = (h_1/d_1)v$, $x_j = h_2$. Hence $[x_j, v_j] = \frac{h_1 h_2 (d_1 - d_2) v}{d_1 d_2} \neq 0$ It is of little interest what this constant is. All we need in this paper is that we can replace Dyson's (D-3) by

$$[x_j, v_j] = C \delta_{jk} \quad N - 3$$

where C is fixed by the accuracy achieved or postulated in the technology of scattering measurements. Examining the remaining steps in the Dyson proof, we find that they only require the commutator to be a *constant* independent of x_j, v_j , and *not* on this constant being imaginary. Therefore N-3 is a satisfactory replacement for D-3 and removes Planck's constant from the problem altogether, provided only we do not encounter explicit quantum phenomena, such as the quantization of radiation independent of measurement accuracy below some threshold.

Equation D-4, interpreted as the force on a particle of charge e is a force per unit charge rather than a force per unit mass. But as used to be well known, using only macroscopic measurements of particle trajectories with static electric and magnetic fields gives us only e/m and not e or m separately. So, once again we can make a scale invariant choice of units such that F_j in (D-4) is the same as f_j in (N-1), leaving us with

$$f_j = E_j + \epsilon_{jkl} v_k H_l \quad N - 4$$

We now have in hand all the ingredients necessary to carry through steps (D-9) to (D-21), the final step in the Dyson proof, which has now become fully algebraic. The algebra is uninformative and will not be reproduced here. The only subtlety is the interpretation of total and partial derivatives as discrete differences along the lines of our derivation of the free particle Dirac equation. We will return to this problem on another occasion. One significant fact about the algebra used in the proof is that it no where makes use of the imaginary equation $i^2 = -1$. McGovern has remarked that the "i" in quantum mechanics a "book keeping device" of no deep significance. We have provided here a specific example of how this observation can be illustrated.

4. QUANTIZED CONIC SECTIONS

Our approach to the Bohr-Sommerfeld problem^[11] starts from our basic postulate that events can, but need not, occur only when they are an integral number of deBroglie wave lengths apart. We can then approximate circular orbits by an integral number of straight line segments representing velocities $\beta_n = 1/137n$ and the closure constraint $2\pi r = j\lambda$

In that approach, we take double slit interference as primitive rather than macroscopic velocity change. If a beam of particles of some velocity v is incident on a slit with spacing w followed by a detector screen a distance D downstream and the spacing between interference fringes on the screen is s , the deBroglie wavelength λ is given in terms of laboratory length standards by the relation

$$\lambda = \frac{ws}{D} \quad (4.1)$$

Then if a beam of particles with a different mass m' but the *same* velocity v is incident on the same arrangement and produces a fringe spacing s' , we can *define* the mass ratio by

$$m's' = ms \quad (4.2)$$

The similarity to Eq. 3.6 should be transparent. In discrete physics we think of 3.6 (Newton's Third Law) as *derived* from our quantum mechanical relation 4.2. The advantage of using 3.6 as basic is that we can then treat the classical theory as possessing non-commutativity, but in a scale invariant way down to the point where an *absolute* measurement of \hbar or e has been made.

Once we have recognized that λ , in an appropriate context, continues to represent the minimal measurable distance between distinct events our "scale invariant" treatment of scattering limited by accuracy of measurement can be applied to any macroscopic problem which is on a scale such that Planck's constant does not need to enter the analysis. Our analysis then provides a "correspondence limit" for *relativistic* quantum mechanics in all such cases. In particular, we claim to have proved in the last chapter that Maxwell's Equations can be reinterpreted as a *necessary* consequence of any relativistic action at a distance theory which is careful to incorporate macroscopic limits on measurement, and hence *also* as the correspondence limit of our relativistic particle theory.

Since the primary focus of this paper is on gravitation in the macroscopic limit, our primary interest is in elliptical and hyperbolic orbits rather than in radiation. We will return to quantum effects in Chapter 7, but here need only the connection between Rutherford scattering analysed classically, the analagous

problem for gravitating objects, and the relationship between hyperbolic and bound orbits. At the level of analysis we need to establish anti-gravity we can ignore both the gravitational "fine structure" splitting and the loss of energy due to radiation. Then the Coulomb problem differs from gravitation only in that (a) the coupling constant is much weaker and (b) there is currently no empirical evidence for anti-gravity (i.e. hyperbolic orbits corresponding to short range repulsion).

Since I spent some time at ANPA 13^[12] discussing the relationship between Galileo's pendulum experiment, Newton's circular orbit paradigm, circular velocities indistinguishable from c (black holes) and our quantum theory, I will defer a detailed "scale invariant" treatment along the lines sketched above to another occasion. I simply note that if we take r_1 as the perihelion distance, $|r_1 - r_2|$ as the distance between foci and $\beta = (k_1 - k_2)/(k_1 + k_2)$ as the velocity at perihelion, we can construct a quantized theory of "conic sections" in terms of three of the four integers r_i, k_i . We then specify the fourth in terms of a macroscopic scale parameter such as the maximum path length of the periodic bound state orbits we use to establish our time resolution, or the maximum size of the scattering chamber we use to measure scattering angles. This in turn can be used to specify the accuracy in the ratio of asymptotic to perihelion velocities we can measure.

5. CROSSING SYMMETRY PREDICTS ANTIGRAVITY

In our discussion of the Maxwell Equations, we made use of a scattering chamber with two entrance and two exit counter telescopes for two particle beams of different mass. This gives us eight counter firings and four velocities determined by space-time measurements. If all four particles are charged, and we back these up by measurements of the radius of curvature in a magnetic field backed up by a third counter to insure that the same *vis* still valid we end up with 16 pieces of information, and can use these to form four energy-momentum 4-vectors which are conserved pairwise between the initial and the final states. These allow us to define our discrete version of the usual Mandelstam variables^[13]. Then *any* 2-2 scattering process which can be reduced to a finite number of convergent Feynman diagrams can be calculated for our discrete variables, which have the limits of measurement already built in. Details will be presented elsewhere.

One important fact about 2-2 Feynman diagrams expressed in terms of relativistically invariant variables and quantum numbers is that they are *crossing symmetric*. Suppose we have a diagram that represents a process in which a particle of mass m_1 , energy E_1 , momentum P_1 , angular momentum J_1 , and some collection of discrete quantum numbers Q_1 interacts with particle 2 similarly described to produce two particles 3 and 4 similarly described. Crossing symmetry

asserts that, where the free particle kinematics of the initial and final free particle states allow, the same diagram with one, two, three or four particles changed to anti-particles represents a physical process whose probability amplitude can be computed from the same diagram in that appropriate kinematic region.

In our bit-string theory, this crossing symmetry derives from the fact that, if we make the proper identification between quantum numbers and kinematic variables derived from bit-strings, interchanging 0's and 1's in a bit-string corresponds to interchanging particle and antiparticle. In particular, this is true of our representation of the standard model of quarks and leptons using strings of 16 bits, although the published demonstrations of this statement are incomplete. If we interchange the 0's and 1's in *all* the strings for a theory in which the combinatorial hierarchy construction has closed, we produce a dual theory which is formally distinct but which is indistinguishable so far as *all* physical predictions go. I have called this Amson invariance. In conventional theories this is the CPT theorem: changing all particles to anti-particles, reversing their velocities ($P_i \rightarrow -P_i$), and making a mirror reflection across three perpendicular planes ($J_i \rightarrow -J_i$) can have no observable consequences. In particular, this theorem requires particles and anti-particles to have identical *inertial* masses. But in the absence of an accepted theory of quantum gravity, gravitational mass (or better "gravitational charge") could either reverse or stay the same.

It is important to realize that crossing symmetry is more restrictive than CPT invariance. For instance, since we know that protons fall toward the earth, all it says that anti-protons fall toward an anti-earth. This is not helpful for constructing an *experiment crisis!* But crossing symmetry applied to the coulomb problem tells us that anti-particles have opposite electric charge to particles and hence that if a particle is attracted toward a center, an anti-particle will be repelled by it. This follows immediately from the conic section formalism we have developed. But for gravitation, the definition of inertial mass remains the same as for coulomb attraction, and the same crossing symmetry applies. Hence, since particles are known to attract each other gravitationally, a particle and its anti-particle should repel each other. *Our prediction of anti-gravity is that simple.* It remains to try to meet objections.

6. THE CONVENTIONAL WISDOM*

To begin with, our prediction is in flat contradiction with the equivalence principle (i.e. that there is no way to detect a difference between gravitational and inertial mass) and hence with General Relativity. For many physicists this is already sufficient reason to dismiss anti-gravity out of hand. Only particle theorists and others who believe in CPT invariance will pursue the matter further. But the usual context in which CPT invariance arises is in the second quantized relativistic field theory. In such theories the electromagnetic field has massless quanta with spin 1 while gravitation has massless quanta with spin 2. There is a general argument that, although the force between two particles which exchange spin 1 quanta is repulsive between a pair of particles or a pair of anti-particles, and attractive between a particle antiparticle pair, it is always attractive between *any* two systems which exchange spin 2 quanta.

However, if one looks at the “proof” of this theorem in more detail, one finds that it does not just depend on the spin of the quanta.^[14] In the case of any pair of particles which interact by exchanging massless quanta with integral spin j (in our case $j=1$ or 2) the momentum change p (or force) must vanish like p^j as p goes to zero. This would be a disaster for the conventional theories, because the major effect observed for small p in electromagnetism is the Coulomb or electrostatic force between charges. For gravitation the only directly measured force is ordinary Newtonian gravity. The spin-2 “gravitons” which the theory predicts cannot be directly detected, and whether classical gravitational radiation has been detected or not is controversial. The way conventional theory gets around this disaster is to insist that the theory be gauge invariant as well as Lorentz invariant. The low momentum limit— if one believes the somewhat tricky mathematics — then produces the desired Coulombic and Newtonian forces out of this theorists hat. But, unlike fields which have a direct connection with the observed motions of test particles, “potentials” whether “gauge” or other, have no directly observable consequences. One is permitted to view them as theoretical inventions, rather than as a transcription of empirical fact into mathematics. I made the technical argument at the Munich Workshop on anti-hydrogen in April, 1992.^[15]

The end conclusion is that *if* anti-protons “fall” up, one will have to abandon *both* the equivalence principle (i.e. gravitational mass is identical to inertial mass) *and* relativistic gauge invariance. Such an experimental result would kill two theories with one measurement, which is a good investment when one is looking for a crucial experiment. Fortunately experimentalists are not deterred by theoreti-

* Quoted from Ref 3, with some modifications.

cal arguments, and are forging ahead as carefully as they can. We may have the answer in five years.

7. QUANTUM CONSIDERATIONS

Until the last chapter we could ignore “spin” because our fine structure comes from our relativistic analysis of the limitations of measurement and does not depend on the existence of an indivisible unit for orbital angular momentum. Historically it was Bohr’s quantization of angular momentum via the quantization of energy that gave a first version of quantum mechanics. His relativistic treatment was an after thought, and Sommerfeld’s successful extension did not require the concept of spin.

Our relativistic treatment of Kepler’s Laws shows that we can define an impact parameter from the relation $2\pi r = j\lambda = jh/p$ and that if we define $j = r/\lambda$, we have that the square of the area swept out in the time it takes to move λ is $\Delta A^2 = \lambda^4(j^2 - \frac{1}{4})$. Geometrical examination of the alternatives $\ell = j \pm \frac{1}{2}$ shows that they correspond to the straight line of length λ being taken as the tangent or the chord, respectively, showing that $(\Delta A/\lambda^2)^2 = \ell(\ell+1)$ gives the quantum mechanical result (i.e. “ ℓ^2 ” $\rightarrow \ell(\ell+1)$) for the square of the orbital angular momentum ℓ because we are taking the geometric mean between the distinct values computed from the inscribed and circumscribed polygon. This is consistent, because the maximum linear distance between them is h/mc . If we tried to measure this difference to the accuracy of $\pm h/2mc$, we would be able to create a particle anti-particle pair, and would have to include their degrees of freedom in the analysis before we could proceed.

The same analysis shows that a transition between the two possibilities changes ℓ by \hbar , which is equivalent to the spin-flip transition between $\pm \frac{1}{2}\hbar$ and $\mp \frac{1}{2}\hbar$. So interchange of massless spin 1 quanta interacting with an orbiting spin $\frac{1}{2}$ particle, with probability reduced by a factor of $1/137$ compared to the Coulomb interaction, is consistent with our picture. We get the same results as QED to order $1/137^2$ without any need for gauge invariance.

The same argument shows that the Coulomb interaction, which only depends on the direction toward the attracting center and the local acceleration its field produces is spin independent and velocity independent, while the spin flip transition depends on either the traveling photon interacting with the moving charge or the magnetic field produced by the center acting on the moving charge depending on which description you wish to use. Thus we can distinguish electric from magnetic forces as static or velocity dependent as we did in Maxwell’s Equations or as spin

dependent or spin-independent in the quantum theory. The pictures support each other.

When we come to gravity, the positive protons, negative electrons and neutral neutrons all attract each other as well as particles of the same mass with the standard Newtonian interaction. The velocity dependent forces only show up in the bending of starlight by the sun and the precession of the perihelion of Mercury. As we have argued elsewhere, both effects are explained by spin 2 gravitons.^[16] In terms of spin, this is explicable if, as before the Newtonian term is spin independent, while the spin dependence (down by $GMm/\hbar c$) allows only the five distinct triplet-triplet transitions. In terms of velocity dependence this implies the extreme non-locality of coupling the motion of both objects by two velocity dependencies. This is, of course, another way of saying that the interaction is scalar (i.e. Newtonian) -tensor and distinct from the scalar (i.e. Coulombic) -vector electromagnetic interaction. All of this fits neatly into the crossing symmetry argument for anti-gravity and hence reinforces it.

8. PRINCIPLES AND RESULTS OF MY APPROACH

In order to summarize the position I take with respect to the establishment, I quote from a recent letter to a colleague:

Our principles are finiteness, discreteness, finite computability, absolute non-uniqueness* and our procedures must be strictly constructive. For us, the mathematics in which the Book of Nature is written is finite *and* discrete. We model nature by *context sensitive* bits of information. In this sense we are participant observers.

Physics, as a science of measurement, can expect that at least some of the structures uncovered in nature could result from the way we perform experiments. For example, Stillman Drake^[17] has discovered that Galileo measured the ratio of the time it takes for a pendulum to swing to the vertical through a small arc to the time it takes a body to fall from rest through an equal distance as $948/850 = 1.1082\dots$ We now compute this ratio as $\pi/2\sqrt{2} = 1.1107\dots$ Thus Galileo *measured* this constant to about 0.3 % accuracy (Ref. 13). fall and pendulums oscillate" independent of the units of length and time.

In any theory satisfying our principles which counts events by a single sequence of integers, any metric when extended to large counts can have at most *three* homogeneous and isotropic dimensions in our finite and discrete sense.^[18] More complex

* eg. In the absence of further information, all members of a (necessarily finite) collection must be given equal weight.

degrees of freedom, indirectly inferred to be present at “short distance” automatically “compactify”. Hence we can expect to observe at most three absolutely conserved quantum numbers at macroscopic distances and times. Guided by current experience, we can take these to be lepton number, charge (or the z-component of weak isospin), and baryon number. These are reflected in the experimentally uncontroverted stability of the proton, electron and electron-type neutrino. This choice is empirical but not arbitrary, since structures with appropriate conservation laws isomorphic with this interpretation arise in our construction.

Take the chiral neutrino as specifying two states with lepton number ± 1 and no charge. They couple to the neutral vector boson Z_0 . In the absence of additional information, these states *close*. The 4 electron states couple to two helical gamma's and the coulomb interaction. These seven states can be generated by any 3-vertex which includes two electron states and an appropriate gamma. These $3 + 7 = 10$ states when considered together then generate the W^\pm . This completes the leptonic sector in the first generation of the standard model of quarks and leptons. Bit-strings of length 6 provide a compact representation of these states which *closes* under *discrimination* (exclusive-or), and conserves both lepton number and the z component of weak isospin at each vertex. No unobserved states are predicted at this level of complexity, and no observed states are missing.

Two flavors of spin $\frac{1}{2}$ quarks and three colored gluons provide the seven elements of the baryonic sector which generate the inferred 127 quark-antiquark, 3 quark, 3 antiquark, 8 gluon ... states (16 fermions times a color octet minus the state with no quantum numbers) needed for the “valence level” description of the quark model. Bit-strings of length 8 provide a compact model using seven *discriminately independent* basis strings and again close producing only the appropriate states at this level of complexity. Combining them with the leptonic states allows the strings representing the vector bosons to be extended to length 14, producing all the vertices and only the vertices which occur in the standard weak-electromagnetic unification of the first generation of the standard model. Extending the whole scheme to strings of length 16 we get the three generations which are observed experimentally (and a slot with the quantum numbers of the top quark). The quarks have baryon number $1/3$ and charges $\pm 1/3, \pm 2/3$ as required. The $0 \leftrightarrow 1$ bit-string symmetry makes CPT invariance automatic. As already noted, if we have only three large distance quantum numbers color (although conserved) is confined, and generation number is not conserved in weak decays.

We are now in a position to talk about the 137. *Empirically* only one of the 137 states required by the standard model of quarks and leptons corresponds to the coulomb interaction. Hence, by our principle of absolute non-uniqueness,

the probability of this interaction occurring is $1/137$ in the absence of further information.

Our basic quantum mechanical postulates are that (a) the square of the invariant interval between two events connected by a "particle" which carries conserved quantum numbers and conserved 3-momentum between them, is the product of two integers times $(h/mc)^2$ and that (b) space-like correlations for particle states with the same constant velocity can occur only an integer number n_λ of deBroglie wavelengths ($\lambda = h/p$) apart. These give us relativistic kinematics and the usual commutation relations for position, momentum and angular momentum.

If we model the hydrogen atom by events a distance r from a center we must have $n_\lambda \lambda = 2\pi r$. This interpretation is supported by noting that if the radius vector sweeps out equal areas in equal times, $\Delta A/\lambda^2 = (n_\lambda^2 - 1/4)(1/2\pi)^2$ and with $\ell = n_\lambda - 1/2$, the angular momentum is $\ell(\ell + 1)\hbar^2$. Since these events occur with probability $1/137n_\lambda$, we get (Ref. 11) the relativistic Bohr formula^[10] for the hydrogen spectrum. When we include a second degree of freedom, and take proper account of the ambiguities in counting, we get not only the Sommerfeld formula but the formula for α to which you object. Similarly, the fact that the basic Fermi interaction involves 16 possible states of four fermions gives us $\sqrt{2}G_F = (256m_p)^{-2}$ where the square root comes from the conventional interaction Lagrangian to which experimental numbers are compared, and m_p comes from the stability of the proton.

I am willing to grant that the original Amson, Bastin, Kilmister, Parker-Rhodes sequence $3, 10, 137, 2^{127} + 136$, STOP —discovered in 1961 after a decade of disciplined research — does *sound* like numerology. That was my own first response. I was willing to think there might be something to it *after* I had used the Dyson argument to identify the last two numbers as the maximum number of charged particle pairs or baryons one can *count* within the Compton wavelengths $h/2mc$ or $h/m_p c$ by, respectively, electrostatic or gravitostatic means. In fact one of my research objectives until the mid 1980's was to find a way to kill the theory and get on to something more promising. What convinced me that the evolving construction could be the starting point for a *new* physics and physical cosmology was McGoveran's calculation of the Sommerfeld formula and correction to α plus the fact that the same arguments applied to other coupling constants consistently improved agreement with experiment. I really don't think it fair any longer to call our theory "numerology".

When you assert that the dielectric constant of diamond can be calculated from first principles, you must assume (correct me if I am wrong) that you already *know* a number of physical constants. Of course one can relate the standards of mass, length and time as measured in the laboratory to three dimensional constants (which could be c, \hbar and G) that occur, self-consistently, in several structures

derived from “first principles”. But to get to diamond you will also need α , m_e , and M_C in well defined relation to those units. Otherwise your calculation has no potential empirical test.

You must admit that, in your framework, these three numbers are too complicated to calculate from first principles. In fact, when Weinberg discusses *how* a finite coupling constant might emerge from currently acceptable theory, his errors are so large that he cannot even contemplate a quantitative prediction that can be confronted by experiment. In contrast my values for α , and m_e are good to six or seven significant figures, and I can argue that my “first principles” allow me to predict that the common isotopes of carbon will have masses of approximately 12 and 13 proton masses. I have systematic ways of improving these estimates, and also— thanks to my physical cosmology — of estimating the relative abundance of these two isotopes on a terrestrial-type planet with an age of 4.5×10^9 years in a solar system of the kind in which we are conducting experiments. Somewhere along this line my calculation from “first principles” would find empirical supplements useful, but I believe no where near as soon as yours.

I would locate the difference in point of view between us as coming from our different views of “space-time”. If the “quantum vacuum” (which I would prefer to call a “quantum plenum”) of renormalized second quantized relativistic field theory is the underlying concept, its properties certainly change as you “squeeze” it. The received wisdom today is that if the squeezing produces an energy density something like 10^{16} times that of the proton the “strong”, “electromagnetic” and “weak” interactions come together (one basic “coupling constant” — grand unification) and that if one can extend the theory another three orders of magnitude, gravitation will find its appropriate place in the scheme. It seems to me that adopting “principles”, however beautiful, that force one to go thirteen orders of magnitude beyond currently possible experimental tests to define fundamental parameters is — to say the least — a peculiar methodology for a physicist.

On the other hand, if one starts here and now with separated charges and massive particles and “empty” or “constructed” space as the first approximation, one can *measure* masses and coupling constants in a well defined way. If one can — as we claim — get good approximations for these values from “first principles” and systematically improve the predictions, I fail to see why such values cannot be considered “primordial”. After the universe becomes optically thin, we predict about 2×10^{-10} baryons per photon. This both is in agreement with observation and supports our “empty space” philosophy.

I have recently succeeded^[20] in deriving the solutions of the free particle Dirac equation by summing the “vacuum fluctuations” in such a way that they cancel out leaving the *physical* mass of the particle as a first approximation. The calculation

is simple, and I will be happy to write it out for you if you are interested. The hydrogen atom and fine structure we already have, as noted above. "Running" coupling constants are unitarity corrections to the low energy values from which we start. We should have the Lamb shift, etc. before too long.

Since I know you are concerned about "time", I beg you to consider the proposition that, for finite beings who can count, keep records, and retrieve those records, time is simply a finite counting parameter for these recorded or remembered events which can be put into correspondence with the integers interpreted as irreversible counting numbers. In the absence of further information, events which are assigned to the same integer must be given equal weight. This is one way to see why "indistinguishables" must enter our theory in an essential way and lead us into new mathematical territory.

9. CONCLUSION

All we need is a major experimental success, such as anti-gravity, to put us on the map.

ON TO THE 21ST CENTURY!

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PREDICTIONS FROM A FUNDAMENTAL THEORY

Table: Coupling constants, mass ratios and cosmological parameters predicted by the finite and discrete unification of quantum mechanics and relativity. Empirical Input: c, \hbar and m_p as understood in the "Review of Particle Properties", Particle Data Group, *Physics Letters*, B 239, 12 April 1990.

COUPLING CONSTANTS

Coupling Constant	Calculated	Observed
$G^{-1} \frac{\hbar c}{m_p^2}$	$[2^{127} + 136] \times [1 - \frac{1}{3 \cdot 7 \cdot 10}] = 1.693\ 37 \dots \times 10^{38}$	$[1.69358(21) \times 10^{38}]$
$G_F m_p^2 / \hbar c$	$[256^2 \sqrt{2}]^{-1} \times [1 - \frac{1}{3 \cdot 7}] = 1.02\ 758 \dots \times 10^{-5}$	$[1.02\ 682(2) \times 10^{-5}]$
$\sin^2 \theta_{Weak}$	$0.25 [1 - \frac{1}{3 \cdot 7}]^2 = 0.2267 \dots$	$[0.2259(46)]$
$\alpha^{-1}(m_e)$	$137 \times [1 - \frac{1}{30 \times 127}]^{-1} = 137.0359\ 674 \dots$	$[137.0359\ 895(61)]$
$G_{\pi NN}^2$	$[(\frac{2M_N}{m_\pi})^2 - 1]^{\frac{1}{2}} = [195]^{\frac{1}{2}} = 13.96..$	$[13, 3(3), > 13.9?]$

MASS RATIOS

Mass ratio	Calculated	Observed
m_p / m_e	$\frac{137\pi}{\frac{3}{14} (1 + \frac{2}{7} + \frac{4}{49}) \frac{4}{5}} = 1836.15\ 1497 \dots$	$[1836.15\ 2701(37)]$
m_π^\pm / m_e	$275 [1 - \frac{2}{2 \cdot 3 \cdot 7 \cdot 7}] = 273.12\ 92 \dots$	$[273.12\ 67(4)]$
m_{π^0} / m_e	$274 [1 - \frac{3}{2 \cdot 3 \cdot 7 \cdot 2}] = 264.2\ 143 \dots$	$[264.1\ 373(6)]$
m_μ / m_e	$3 \cdot 7 \cdot 10 [1 - \frac{3}{3 \cdot 7 \cdot 10}] = 207$	$[206.768\ 26(13)]$

COSMOLOGICAL PARAMETERS

Parameter	Calculated	Observed
$\Omega_{vis} / \Omega_{closure}$	0.01175	$[0.005 \lesssim \Omega \lesssim 0.02]$
Baryons/Photon	$\frac{1}{2564} = 2.328 \dots \times 10^{-10}$	$\sim 2 \times 10^{-10}$
M_{dark} / M_{vis}	12.7	> 10

DECOHERENCE, DETERMINISM and CHAOS*

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Abstract

We assume that "fields" are to be measured by the acceleration of a "test particle" which belongs to a class of particles whose ratios of charge to mass and gravitational to inertial mass are Lorentz invariant. We relate the measurement accuracy in space, $\Delta\ell$, and in time, Δt , by the scale invariant definition of two constants c , and κ : $\frac{\Delta\ell}{c\Delta t} \equiv 1$; $\frac{\Delta\ell^2}{\kappa\Delta t} \equiv 2\pi$. Taking the experimental velocity resolution $\Delta v_x = \Delta\ell/T\Delta t = N\Delta\ell/NT\Delta t$ we derive the bracket expression $[x, v_x] \propto \kappa$ where $x = N\Delta\ell$. Then it is a *deductive* consequence that the only fields which can act on such particles are structurally indistinguishable from electromagnetic and gravitational fields in the sense that they satisfy the finite difference version of the free space Maxwell equations and Einstein geodesic equations. Such a scale invariant theory becomes the proper correspondence limit for any relativistic particle theory which breaks scale invariance by taking $m_e\kappa = \hbar$. Here we use m_e because it defines the threshold distance for position measurement, $\hbar/2m_e c$, below which the non-classical process of electron-positron pair creation is observed, and above which that phenomenon cannot be *directly* observed. The coherence length $L = NT\Delta\ell$ specifies the maximum distance within which quantum mechanical interference effects can be observed. For non-overlapping "wave packets" of this length, the *deterministic* classical equations with particulate sources and sinks apply. But the characterization of a deterministic system as chaotic requires a specification of boundary conditions to a precision which violates the constraint due to measurement accuracy or electron-positron pair creation. Hence the number of degrees of freedom used in a model fixes whether the system is quantum coherent or classically decoherent but (approximately) deterministic and limits the applicability of chaos theory, removing certain paradoxes.

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1. INTRODUCTION

The Gordian knot that I tried to disentangle in this paper — rather than just slashing at it with Occam's Razor in my usual cavalier fashion — is the intricate connection between classical and quantum coherence, classical determinism, and deterministic chaos. In the event, Clive Kilmister characterized my paper as reminiscent of the South Sea Bubble. I respond to some of his remarks early on in Chapter 3 (at the end of Section 3.2 and beginning of section 3.3).

In my opinion, the approach I present here has broad implications with respect to both the correspondence limit of relativistic quantum mechanics^[1] and "wave function collapse"^[2]. Here we will emphasize only the connections between coherence, determinism and chaos. I will pursue the impact of this analysis on the foundations of quantum mechanics on another occasion.

The phenomenon of "coherence" occurs in any wave theory. Experimentally it shows up when two or more distinct beams combine to produce interference fringes. "Decoherence" then corresponds to the disappearance of these interference fringes when the experimental parameters are changed. In theoretical language the difference between coherent and decoherent situations can often be accounted for by assuming that the beams correspond to "wave packets" which can interfere only when they overlap. In chapter 2 we present a specific geometrical paradigm which makes this qualitative idea into a class of measurements that cover both classical (electromagnetic) and quantum (deBroglie) wave interference.

The critical step in this analysis is the assumption that measurement accuracy must be taken seriously as a logical (epistemological, ontological, metaphysical,...?) constraint which can be *fixed* in a quantitative sense by *context*. Starting from the usual "meaning" of length and time measurement in the physics community, we argue that this means that *practice* sets a fixed bound on the shortest length and the shortest time that can be meaningfully specified experimentally by any current technology. We call these *intervals* $\Delta\ell$ and Δt respectively. Then, any measured space or time interval can be specified by an *integer* (or a range of integers) times these dimensional (in the physicist's sense) units. We also assume that the limiting velocity for information transfer is a fixed rational fraction unique to any system of space and time measurements we invoke, which constrains our length-time units by the scale-invariant equation $\Delta\ell = c\Delta t$.

Unfortunately our derivation of bracket expressions from these assumptions has so far failed to pass muster with Clive Kilmister. So Chapter 3 indicates what needs to be done rather than what has been actually demonstrated to his satisfaction. Rather than go into that controversy here, we simply note that if our contention is correct these finite and discrete bracket expressions derived from

measurement accuracy allow us to take over, practically unaltered, Feynman's proof of the Maxwell equations^[3] as reconstructed by Dyson^[4] and the generalization of the proof to the Einstein gravitational geodesic equations given by Tanimura.^[5] Since we have discussed in more detail elsewhere my attempt to take over the Tanimura proof^[6,7], details are omitted.

Chapter 4 reminds us that if the usual *local* deterministic conclusions are drawn from the field equations and the Lorentz force law, the predictions of the theory become ambiguous. We interpret this fact as due to the naive assumption that difference equations imply a unique continuum limit. We conclude that local determinism is meaningful only when we can accept *incoherence* between radiation sources, radiation field, and radiation sinks as a valid *approximation*.

Chapter 5 makes use of the fact that practically all solutions of classical, "deterministic" equations are chaotic in the sense that one must supply as much information in the boundary conditions as the "prediction" is supposed to yield. This clearly vitiates the concept of "determinism" as usually employed when physics is invoked to support the philosophical concept that goes by that name. If our analysis is correct, boundary conditions which violate the restriction to finite measurement accuracy because of their precision are *inconsistent* with the operationally *meaningless* or *pseudo* precision required to obtain chaotic predictions. This dissolves the paradox of "chaotic determinism".

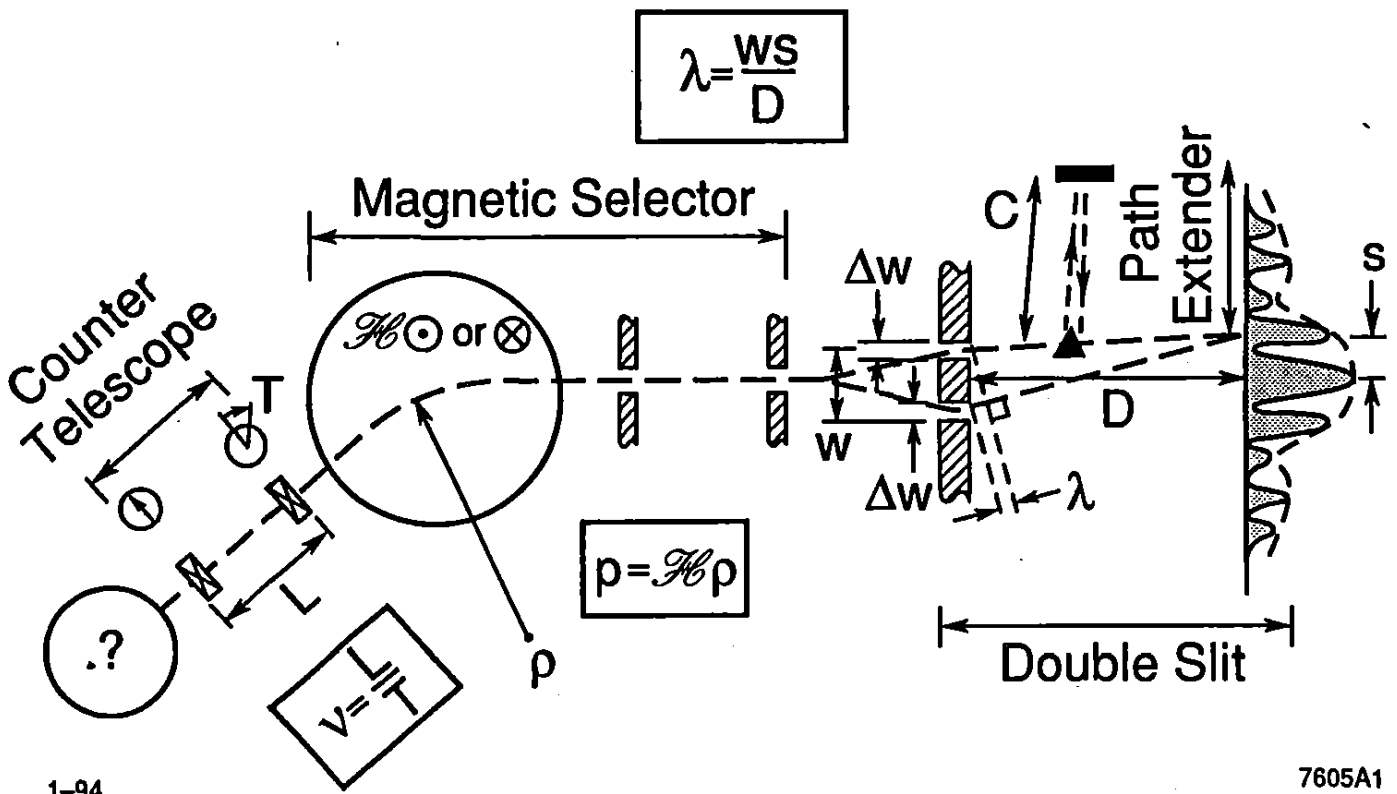
2. COHERENCE

2.1 THE GEOMETRICAL PARADIGM

To give form to our discussion of coherence and decoherence, we use the devices schematically illustrated in figure 1. We assume, initially, that the "source" labeled by a question mark emits charged particles with a unique charge-to-mass ratio and a unique velocity v . Devices which we will use to insure that, to some finite accuracy, these assumptions are true are included in the figure, and will be discussed in more detail subsequently. For the moment we omit the "path extender". We start from the case when the detection screen beyond the double slit^[8] exhibits a double slit interference pattern whose envelope is the single slit diffraction pattern for a slit of width Δw and a distance D from the detector array. We set the parameters such that the spacing from the center of the pattern to the first interference fringe is s . Then the "wavelength" λ exhibited by this coherent interference between the beams from the two slits is measured and can be calculated from the equation

$$\lambda = \frac{ws}{D} \quad (2.1)$$

We note that w , s and D are length intervals that can be measured by conventional



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macroscopic methods such as rods calibrated against international standards. We take this as the paradigmatic case for specifying what we mean by “coherence”. We emphasize that, so far, only *length* measurements are implied and hence that our diagram is *scale invariant*.

Figure 1. Measurement of coherence and decoherence of de Broglie waves using a counter telescope, magnetic selector, and a double slit with a path extender in one arm.

In order to measure the “coherence length” we insert into the hypothetical “path” of the particle coming from one of the slits a “path extender”, schematically represented by a wedge whose sides are mirrors. One face of the wedge reflects the beam to a second mirror which returns it to the second face of the wedge, which in turn returns it to the direction it followed in the paradigmatic case. The distance C from the wedge to the mirror is adjustable. $C = 0$ corresponds to the simplest double slit paradigm. We find experimentally that for a source of a particular type the fringe system disappears when we reach a value C_{max} or larger. We can then define the *coherence length* C_{coh} by

$$C_{coh} \equiv 2C_{max} \quad (2.2)$$

Note that so far the definition still depends directly on geometrical measurements. Indirectly the specification depends on the *sensitivity* of the detector array, since the *intensity* of the pattern along the detector array and (if the array records individual particulate events) the *probability* of a particular region of the array being activated decreases as C increases. The disappearance of the interference pattern is our paradigm for *decoherence*.

To go further in our analysis, we must measure the velocity v , or if this velocity is close to the limiting velocity for information transfer — for which we use the conventional symbol c — the momentum. Then we can define a second critical parameter called the *coherence time* and symbolized by T_{coh} by the relationship

$$C_{coh} = vT_{coh} \quad (2.3)$$

Use a detector array which measures the *time* of arrival of individual particles by means of a clock synchronized to the firing of the first counter in the counter telescope using the Einstein convention. In the situation where the interference fringes have disappeared, we can distinguish two paths emerging from the double slit by noting that all particles which follow the longer path arrive at the detector with a time delay greater by at least $T_{coh} = C_{coh}/v$ compared to the particles which traverse the shorter path. Various checks on this statement can depend on the measurement accuracy to which we can establish all the relevant parameters. Several such checks will occur to any experimental particle physicist. Since these checks are irrelevant to our main theme, we stop our articulation of the basic paradigm at this point, and focus on the accuracy to which we can measure velocity or momentum. The main point we wish to establish is simply that in a carefully specified context, *outside* of some coherence length or coherence time, particles can be said to follow two (or more) distinct trajectories for at least part of their history between production and detection. Inside that length, two coherent beams of the same type of particle can be made to interfere with a characteristic wavelength that can be measured geometrically.

2.2 SPACE-TIME VELOCITY MEASUREMENT

The “counter telescope” we have included in figure 1 consists of two devices which *record* the time of firing *or of not firing* during some time interval. The distance between the two counters is L and the time delay between the two recordings is T . These two recordings are NO-YES *events* in that whether the individual counters do not fire (“NO”) or do fire (“YES”) is recorded by two distinguishable symbols in two correlated records. These records can be repeatedly examined without destroying this distinction or the sequential ordering. In this context the

velocity of a particle v is measured by a YES_1, YES_2 pair of events and is calculated by the ratio

$$v = \frac{L}{T} \quad (2.4)$$

The *accuracy* to which this constitutes — or can constitute — a *measurement* of this velocity cannot be adequately discussed in an article of this length. We simply note that what are called “particles” in high energy elementary particle physics have never been demonstrated to have velocities greater than the scale parameter

$$c \equiv 299\,792\,458 \text{ m sec}^{-1} \quad (2.5)$$

Further, there is no accepted situation in which *information* in the physical or computer science sense has been transferred at a velocity greater than this value. Demonstrable exceptions to these statements would be of extreme interest to the physics and computer science communities.

2.3 ENERGY-MOMENTUM VELOCITY MEASUREMENT

The “magnetic selector” we have included in figure 1 can also be considered to be a device capable of measuring velocity when it is properly calibrated. However the calibration procedures are more complicated than the direct calibration of rods and clocks which suffice for space-time velocity measurement. It is here that our restriction to a particular type of particle begins to become important.

If the particle is electromagnetically neutral, or if the space-time velocity is not distinguishable from c (up to the maximum value of \mathcal{H} available to us), no deflection is observed and the inverse radius of curvature ρ^{-1} is indistinguishable from zero. We exclude these cases for the moment because the measuring device invoked gives no information not already provided by the counter telescope. However, when a deflection (finite ρ) is observed, we find that for fixed \mathcal{H} the radius of curvature ρ changes with velocity. To cut a long story short, we find that if we measure velocity in units of c by defining

$$v \equiv \beta(v)c \quad (2.6)$$

and keep the magnetic field fixed,

$$\rho^2(v) \propto \frac{\beta^2}{1 - \beta^2}; \quad \rho^{-2}(v) \propto \frac{1 - \beta^2}{\beta^2} \quad (2.7)$$

This clearly allows us to calibrate our magnetic field to space-time measurements and, for a particular class of particles, to specify higher and lower magnetic fields

over some range by the velocity-independent (over that range) definition

$$\mathcal{H} = \frac{\rho(v)}{\rho_0(v)} \mathcal{H}_0 \quad (2.8)$$

leaving open the units in which we ultimately decide to measure magnetic fields.

If, as is often the case in high energy physics, it is more convenient to measure radius of curvature rather than space-time velocity, we can relate this approach to the space-component of the “four velocity” $(u_0, \vec{u}) = (\gamma, \gamma\vec{\beta})$ with $\gamma^2\beta^2 = \gamma^2 - 1$ and

$$\beta^2(u) = \frac{u^2}{1 + u^2}; \quad \gamma^2(u) = 1 + u^2; \quad u = \pm|\vec{u}| \quad (2.9)$$

For a particular type of particle, this tells us that u^2 is proportional to ρ^2 , and in a more articulated theory allows us to measure momentum by radius of curvature in a calibrated magnetic field. In this context we can ignore the (fixed) rest-mass of our “test particles” and keep our “momentum” measurements restricted to the “space-component of four velocity” or “momentum per unit mass”.

Similarly, if we measure energy by the temperature rise in a calorimeter calibrated to the ideal gas law for particles of the same mass, i.e. measure pressure per unit mass rather than pressure, we can verify that this is consistent with the usual relativistic single particle kinematics

$$\frac{E^2}{m^2} = 1 + u^2; \quad \frac{E^2}{m^2} - \frac{p^2}{m^2} = 1 \quad (2.10)$$

and so on.

2.4 SCALE INVARIANCE

We have been at some pains to remove the mass scale from our basic paradigm for “coherence” and “decoherence” because our basic argument below rests on the fact that we can derive “bracket expressions” similar to the commutators of quantum mechanics, using only measurement of space and time with accuracy bounded from below. Then it takes a *physical* phenomenon involving Planck’s constant to recover quantum mechanics. This can be done in a number of ways, eg historically by the analysis of black body radiation, photo-effect, line spectra of atoms, finite size and stability of atoms measured using deviations from the ideal gas law, and so on. The cleanest breakpoint for the *relativistic* quantum mechanics which concerns us is the creation of electron-positron pairs or the less direct but predicted and confirmed effects (eg Lamb shift, vacuum polarization

in p-p scattering,...) of these degrees of freedom. This is possible because the whole idea of a "test-particle" is basic to the classical definition of "fields". Once the degrees of freedom due to the possibility of particle-antiparticle pair creation have to be included in the theory, even the concept of a "test particle" generates nonsense.

3. CLASSICAL FIELDS from MEASUREMENT ACCURACY

3.1 THE FEYNMAN-DYSON-TANIMURA PROOF

Tanimura (Ref.5) makes the following remarkable claims in his abstract:

"R.P.Feynman showed F.J.Dyson a proof of the Lorentz force law and the homogeneous Maxwell equations, which he obtained starting from Newton's law of motion and the commutation relations between position and velocity for a single nonrelativistic particle. We formulate both a special relativistic and a general relativistic versions [sic] of Feynman's derivation. Especially in the general relativistic version we prove that the only possible fields that can consistently act on a quantum mechanical particle are scalar, gauge and gravitational fields. We also extend Feynman's scheme to the case of non-Abelian gauge theory in the special relativistic context."

The formulation of the Feynman theorem as reconstructed by Dyson is simple. In Tanimura's notation:

Given

A single particle trajectory $x(t)$ in terms of three mutually perpendicular coordinates $x_i(t)$, $i, j, k \in 1, 2, 3$ subject to the constraints

$$[x_i, x_j] = 0; m[x_i, \dot{x}_j] = i\hbar\delta_{ij}; m\ddot{x}_k = F_k(x, \dot{x}; t) \quad (3.1)$$

then

the force components $F_k(x, \dot{x}; t)$ can be expressed in terms of two functions $E(x, t)$, $B(x, t)$ which depend only the coordinate components x_i and the time t and not on the velocity components \dot{x}_j ; these functions are related to the force by the component equations

$$F_i(x, \dot{x}; t) = E_i(x, t) + \epsilon_{ijk} \langle \dot{x}_j B_k(x, t) \rangle \quad (3.2)$$

and E, B satisfy the equations

$$\text{div } B = 0; \partial B / \partial t + \text{rot } E = 0 \quad (3.3)$$

Here the Weyl ordering $\langle \rangle$ is defined by

$$\langle ab \rangle \equiv \frac{1}{2}[ab + ba]; \quad \langle abc \rangle \equiv \frac{1}{6}[abc + bca + cab + acb + cba + bac], \text{ etc.} \quad (3.4)$$

3.2 SCALE INVARIANT POSTULATES

The postulates can be made even simpler once one invokes scale invariance. The Feynman postulates are independent of or linear in m . Therefore they can be replaced by the *scale invariant* postulates

$$f_k(x, \dot{x}; t) = \ddot{x}_k; \quad [x_i, x_j] = 0; \quad [x_i, \dot{x}_j] = \kappa \delta_{ij} \quad (3.5)$$

where κ is any fixed constant with dimensions of area over time $[L^2/T]$ and f_k has the dimensions of acceleration $[L/T^2]$. Keeping these postulates consistent with the scale parameter c as the limiting velocity for information transfer can clearly be done without breaking scale invariance. This removes the apparent paradox noted by Dyson (Ref. 4) of being able to derive Lorentz invariant equations from the Galilean invariant non-relativistic commutation relations.

The remaining physical point that needs to be made clear is that the "fields" referred to in classical relativistic field theory are *defined* in terms of their action on a *single* test particle, as we did in relating \mathcal{H} to 4-velocity and radius of curvature in our geometrical paradigm. Thus, if we measure the *acceleration* of that particle in a Lorentz invariant way (force per unit rest mass) *and* the force per unit charge is also defined by acceleration *and* the charge per unit rest mass of the test particle is *also* a Lorentz invariant *then* our electromagnetic field theory itself becomes an LT scale invariant theory. That is, once we replace the Feynman postulates by (3.5) and define $\mathcal{E}(x, t) = E/Q = F_E/m$ and $\mathcal{B}(x, t) = B/Q = F_B/m$, we need only derive the scale invariant version of equations (3.2), (3.3) obtained by the obvious notational change $F_i \rightarrow f_i$, $E_i \rightarrow \mathcal{E}_i$, $B_i \rightarrow \mathcal{B}_i$. Extension to gravitation makes more use of the concept of path and requires that the ratio of gravitational to inertial mass of the test particle is also a Lorentz invariant.

As noted in the introduction, Clive Kilmister objected strongly at ANPA 15 to the thesis presented in this paper. I hope to renew the discussion at ANPA 16. But first I will need him to separate his criticism of Tanimura's proof from his criticism of my generalization. So far as I know, no one has faulted the formal steps in Tanimura's proof. It follows that my scale-invariant proof is just as valid as Tanimura's in a formal sense. I assume that the acceptance of Tanimura's paper by *Annals of Physics* requires Clive to take up other issues about that proof with the author or the journal rather than with me. Otherwise, it appears that Clive must

either object to postulating the commutation relations of non-relativistic quantum mechanics or the simple algebraic steps I have taken above to make them scale invariant and consistent with the limiting velocity of special relativity or to my standard use of the classical *definition* of field as the acceleration of a test particle caused by that field.

3.3 MEASUREMENT ACCURACY AND SCALE INVARIANT BRACKET EXPRESSIONS

Where Clive has valid objections is with regard to my various attempts to establish scale invariant bracket expressions directly from operational arguments. If he is willing to accept McGoveran's *ordering operator calculus*. — which I was under the impression was the case after sitting in on two day-long sessions between Clive and David McGoveran in two separate years — a rigorous derivation of scale invariant commutation relations from finiteness and discreteness already exists. The proof starts by deriving the transport operator and establishes the Lorentz transformations before going on to the bracket expressions.^[9] Quantum mechanics often is claimed to view measurement accuracy restrictions as the cause or consequence of the commutation relations. This was extensively discussed by Heisenberg, Bohr and Einstein, so I thought I was just spelling out something that is usually taken for granted. I review briefly here what is needed for the Tanimura proof and try to give it heuristic support.

Replacing \dot{x}_j by v_j , to remove the implication that we are talking about derivatives rather than finite differences, the essential equation we need to establish is

$$[x_i, v_j] = \kappa \delta_{ij} \quad (3.6)$$

where κ is some constant proportional to $\Delta \ell^2 / \Delta t$. Here our finite measurement accuracy assumption takes the form that any distance measurement L can always be represented by a finite integer (which is less in magnitude than some maximum integer N picked in advance) times the shortest distance $\Delta \ell$ which can be measured, directly or indirectly, using currently available technology. Since we impose the scale invariant restriction $\Delta \ell = c \Delta t$, all times are also integers in units of Δt .

We take as our paradigm for a quasi-local measurement of position x and velocity v_x a counter telescope whose entrance counter is a distance $x_1 = ct_1 = cn_1 \Delta t$ from a reference clock and mirror and whose exit counter is a distance $x_2 = ct_2 = cn_2 \Delta t$ from the same referents. Let the time interval between the two sequential firings of the counter be $T = (n_1 + n_2) \Delta t$. Clearly, the length of the telescope is $L = x_2 - x_1 = (n_2 - n_1) \Delta \ell$. Hence the velocity of the particle causing

the two firings is

$$v_x = \frac{L}{T} = \frac{n_2 - n_1}{n_1 + n_2} c \quad (3.7)$$

Note that the two clocks have been synchronized by the Einstein convention so that a light signal sent toward the mirror when the entrance counter fires and reflected back will arrive at the second counter in coincidence with the second firing.

Our paradigm gives our velocity measurement a Lorentz invariant significance. But this still does *not* allow us to assign an absolute meaning to both x and v_x . However we use additional measurements to further localize x within the interval $x_2 - x_1$, we cannot know its value to better than $\Delta\ell$. The best we can do is to assign it to some position which is ambiguous between $x_- \in [x_1, x_1 + \Delta\ell, x_1 + 2\Delta\ell, \dots, x_2 - \Delta\ell]$ and $x_+ = x_- + \Delta\ell$. Between these two locations the velocity is, as measured locally, $+c$. Thus, using only quasi-local information, the product " xv_x " is ambiguous depending on whether we use x_- or x_+ . Defining the difference as the bracket expression, and using c for v_x , we have that, for local measurements, the minimum uncertainty is given by

$$[x, v_x] \equiv x_+ v_x(t) - x_- v_x(t) = c\Delta\ell \equiv -[v_x, x] \quad (3.8)$$

If we wish to include finite rotations as well as finite velocity measurements, it is convenient to define κ as $c\Delta\ell/2\pi$ rather than $c\Delta\ell$, but we will not discuss this refinement here, as it is not needed directly in the Tanimura proof. What is needed is the assumption that we can measure position coordinates independently in three directions (within our integer restrictions), and hence that the ambiguity between position and velocity measurements along any one of these directions does not couple directly to these other directions. We can then claim that, at least heuristically, our counter telescope paradigm allows us to give relativistically invariant significance to the two basic equations

$$[x_i, x_j] = 0; \quad [x_i, v_j] = \kappa\delta_{i,j} \quad (3.9)$$

3.4 ADDITIONAL ALGEBRAIC RELATIONS

Subject to our requirement of not going beyond the finite limits to which our measurements can refer, the fact that the x_i can be represented by integers, and the v_j by rational fractions, allows us to assume that, for λ, μ constants subject to the same restrictions and $A, B, C \in x_i, v_j$, where $i, j \in 1, 2, 3$, the bracket expression has the properties

$$\begin{aligned} [\lambda A + \mu B, C] &= \lambda[A, C] + \mu[B, C] \\ [A, \lambda B + \mu C] &= \lambda[A, B] + \mu[A, C] \end{aligned} \quad (3.10)$$

$$[A, \mu] = 0$$

The Tanimura proof refers to functions $g(x, t)$ which are not functions of v_j and accelerations $a_k(x, v; t)$ which are functions of velocity as well as position, but of no "higher derivatives". Since these are also subject to our finite integer and rational fraction restrictions, we can assume that they are polynomials whose powers have context sensitive restrictions. If n is the highest power of x which is allowed to occur, then for any component

$$[v_i, x_j^n] = \delta_{ij}[v_i, x_i^n] = \delta_{ij}(-\kappa x_i^{n-1} + x_i[v_i, x_i^{n-1}]) = -n\kappa x_i^{n-1} \delta_{ij} \quad (3.11)$$

This allows us to specify the usual symbol $\partial g(x, t)/\partial x_k$ for all such functions we consider by the equality

$$[v_k, g(x, t)] = -\kappa \partial g / \partial x_k \quad (3.12)$$

Note also that

$$[x_i, g(x, t)] = 0 \Rightarrow g(x, t) \text{ independent of } v_i \quad (3.13)$$

It remains to define the symbols $[v_i, v_j]$ and $a_k(x, v; t)$ in our context. Since (within the restriction to polynomials mentioned above) we are now talking about *functions* of x, v , and t , we can introduce the concept of a *path*

$$x(t) = (x_i(t), x_j(t), x_k(t); t) \quad (3.14)$$

for the single particle we are considering. Then the bracket expression we derived

above is equivalent to the definitions

$$\begin{aligned}
 x_i(t + \Delta t) &\equiv x_i(t) + v_i(t)\Delta t \\
 [x_i, v_j] &\equiv [x_i(t + \Delta t)v_j(t) - v_i(t + \Delta t)x_j(t)] \\
 &= [x_iv_j(t) - x_jv_i(t)] \equiv \kappa\delta_{ij}
 \end{aligned} \tag{3.15}$$

Taking the obvious step of saying that if time changes by Δt , then

$$v_j(t + \Delta t) \equiv v_j(t) + a_j\Delta t \tag{3.16}$$

and defining

$$[v_i, v_j] \equiv v_i(t + \Delta t)v_j(t) - v_j(t + \Delta t)v_i(t)$$

we have that

$$[v_i, v_j] + [x_i, a_j] = 0 \tag{3.17}$$

Now that we know what we mean by $[v_i, v_j]$ it is straightforward to establish the Jacobi identity

$$[A, [B, C]] + [B, [C, A]] + [C, [A, B]] = 0 \tag{3.18}$$

for the symbols $A, B, C \in x_i, v_j$. The same type of argument makes it easy to establish the fact that, in our context

$$g_k(x, t) = \kappa^{-1}\epsilon_{ijk}[v_i, v_j] \Rightarrow$$

$$\partial g_k/\partial t + [v_j, \partial g_k/\partial x_j] = \kappa^{-1}\epsilon_{klm}[v_l, a_m] \tag{3.19}$$

It is then straightforward to follow through the steps of the Tanimura proof, and his generalizations, as formal algebraic derivations.

4. DETERMINISM FROM DECOHERENCE

We summarize the results of Chapter 3 by the conclusion that we can always attribute the acceleration of a single test particle to the classical (electromagnetic and gravitational) fields provided only that:

- a) *Newton's second law holds in the sense that the acceleration of a single particle is a function only of position, velocity and time.*
- b) *$c \equiv 299\,792\,458\text{ m sec}^{-1}$ is the limiting velocity for information transfer.*
- c) *Kepler's second law holds in the finite and discrete sense that the line from a center to a particle moving with constant velocity past that center sweeps out an area per unit time which is an integer times some appropriate constant κ . [This point is discussed more fully in Ref. 6 and elsewhere^[10,11].]*
- d) *The shortest length interval we can measure is $\Delta\ell$ and the smallest time interval we can measure is Δt .*
- e) *Our length and time units are subject to the scale invariant constraints*

$$\frac{\Delta\ell}{c\Delta t} = 1; \quad \frac{\Delta\ell^2}{\kappa\Delta t} = 2\pi$$

- f) *The charge per unit mass for the test particle whose acceleration defines the electromagnetic field and the ratio of gravitational to inertial mass for the test particle whose acceleration defines the gravitational field are both invariant under the finite and discrete Lorentz boosts and rotations our finite measurement accuracy allows us to specify.*

Although our derivation of the classical field equations and the Lorentz force law uses finite differences, the temptation is almost irresistible to go to the continuum limit and interpret the result as a local, deterministic theory embedded in the continuum space-time of special relativity, or for gravitation to go on to the curved space interpretation. Even in nineteenth century physics this step has its problems. Given the field, the trajectory of the test-particle is determined, or given the trajectory, the field emitted by the test particle is determined. And given a free space field distribution, the propagation of this field forward in time can be deterministically computed (if one accepts continuum mathematics as valid). But this works only when (a) the stability of the test particle is assumed from *outside* the classical theory; (b) the reaction of the field produced by the test particle back on the particle is ignored (This "self-energy" is infinite and classically cannot be renormalized.); (c) for two or more particles the reaction of the field generated by the second particle back on the first is ignored; ... and so on. In other words, the theory is locally deterministic only if sources and sinks of the radiation are treated

as incoherent. In this sense, we argue that the classical determinism is, even in its own terms, a decoherent *approximation*.

Wheeler and Feynman attempted to meet this problem back in the 1940's by making the sources and the sinks of all fields coherent and replacing the field by relativistic action-at-a-distance. I intend, on another occasion, to see if their theory could be reconstructed from the finite and discrete starting point used in this paper. But even without this detailed development, I trust I have made it clear that classical *local* determinism always implicitly assumes *decoherence*.

5. CHAOS FROM DETERMINISM

A great deal of attention is now being paid to the numerical solution of classical, deterministic equations of various types. It turns out that the solutions of these equations in almost all cases are chaotically unstable in the sense that even when the trajectory in phase space is bounded for a while, successive iterations of the equations produce trajectories whose departure from the early motion grows exponentially and can be characterized by a Liapunov exponent greater than unity. We can take this behavior as one definition of what we mean by *chaos*. The equations for classical fields we have derived from measurement accuracy are no exception to this generalization.

A mathematically well studied example is the restricted three body problem in which the test (or "third") particle has negligible mass. We consider the case in which the third particle is launched along the axis through the center of mass perpendicular to the plane containing two massive particles rotating under Newtonian gravity about that center. The position on that axis and the velocity along that axis which initiates the motion are specified as the initial "boundary condition". Then (I quote^[12])

"...In particular, the following remarkable theorem can be proved. Let t_1, t_2, \dots be the times at which the particle intersects the plane of motion of the other two particles. Let s_k be the largest integer equal to or less than the difference between t_{k+1} and t_k times a constant. [The constant is the reciprocal of the period of the motion of the two particles in the plane.] Variation in the s_k 's obviously measures the irregularity in the periodic motion. The theorem, due to the Russian mathematicians Sitkinov^[13] and Alekseev^[14] as formulated in Moser,^[15] is this.

THEOREM 5. *Given that the eccentricity of the elliptic orbits is positive but not too large, there exists an integer, say α , such that any infinite sequence of terms s_k with $s_k \geq \alpha$, corresponds to a solution of the deterministic differential equation governing the motion of the third particle."*

with the corrolary

“CORROLARY. Any random sequence of heads and tails corresponds to a solution of the deterministic differential equation governing the motion of the third particle.”

In other words, if such a system could be constructed, it would provide a perfect random number generator!

The fact is that practically all solutions of classical, “deterministic” equations are chaotic in the sense that one must supply as much information in the boundary conditions as the “prediction” is supposed to yield. This clearly vitiates the concept of “determinism” as usually employed when physics is invoked to support the philosophical concept that goes by that name. The situation is sometimes summarized by the paradoxical phrase “chaotic determinism”. However, if our analysis is correct, the physical situation is somewhat subtler than this. The deterministic equations for the motion of a test particle were derived initially by postulating a finite measurement accuracy. Hence, boundary conditions which violate this assumption because of their precision are *inconsistent* with the unrealizable precision required to obtain chaotic predictions. This dissolves the phenomenon of “chaotic determinism” into an artifact produced by assuming precise classical equations *and* precise boundary conditions which ignore the physical necessity of measuring particle positions and velocities.

We emphasize that our argument up to this point invokes only “classical” physics and measurement accuracy. Although we make use of a small number of algebraic relations which would not have occurred to us had we not been guided by experience with quantum mechanics [and bit-string physics!], *no* use is made of operators, Hilbert space, Planck’s constant, *or* of any of the physical phenomena that led to the development of quantum mechanics, *or* of any of the conceptual baggage that the historical process which led to the construction of quantum mechanics brought in its train. Fixed measurement accuracy is enough to make “classical physics” non-commutative — *viz* finite rotations of a rigid body — independent of any quantum considerations.

We are not alone in seeing the relevance to the foundations of quantum mechanics of recent developments in *classical* physics. For example Macauley^[16] remarks that

“...Born and Heisenberg argued strongly that physics should not be based upon nonobservable concepts— because of this , Max Born argued for the elimination of the continuum concept from physics. By restricting to computable numbers in classical dynamics, we take a small step in that direction. It means that formal Hilbert space theory cannot be the final foundation for quantum mechanics, because Hilbert space is built on the generalization to function space of the idea of

the continuum, the completeness of the real number system (a space is complete when all the limits of all the convergent sequences in the space also belong to the space). But this introduces noncomputability into the foundations of quantum mechanics, because almost all functions that can be defined are noncomputable (see Turing, 1937)."

6. CONCLUSIONS

We claim by now to have made our case that modern work on fractals and chaos theory has already removed the presumption that classical physics is "deterministic". Further, we claim that in so far as classical relativistic field theory (i.e. electromagnetism and gravitation) are scale invariant, they are self-consistent only if the idea of "test-particle" is introduced from *outside* the theory. Einstein spent the last years of his life trying to use singularities in the metric as "particles" or to get them out of the non-linearities in a grand unified theory — in vain. So classical physics in this sense *cannot* be the fundamental theory. However, we claim to have shown that if we introduce a "scale invariance bounded from below" by measurement accuracy, then Tanimura's generalization of the Feynman proof as reconstructed by Dyson allows us to make a *consistent* classical theory for *decoherent* sources and sinks. Restoring coherence to classical physics via relativistic action-at-a distance is left as a task for the future.

Relativistic quantum mechanics, properly reconstructed from a finite and discrete basis, emerges in much better shape. The concept of "particles" has to be replaced by NO-YES particulate events, and particle-antiparticle pair creation and annihilation properly formulated. Much of the necessary work has, as I have claimed for some time, already been accomplished by McGoveran and myself. The breaking of scale invariance at half the electron Compton wavelength tells us where classical coherence and decoherence have to give way to quantum coherence and decoherence. The transition is smooth from the point of view of measurement accuracy. Of course much still needs to be done, but that is what ANPA is all about.

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**Normal Realism: A Challenge to Physicists
and
Rustic Relativity**

by

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Abstract to both papers

These papers are designed to convince physicists that the old and tacit reasons for seeking a physical reality 'behind' or 'underlying' the appearances, which motivates so much of modern physics and cosmology, are no longer philosophically viable. The logical consequence of this, of course, is that insofar as this remains the motive for doing theoretical physics its survival is purely vestigial and its pursuit philosophically vain. In short, the message of these papers is that the current scientific aim of looking beyond the direct and instrumental observations of things for original 'hidden mechanisms' of creation, evolution, perception and suchlike, needs to be philosophically revised.

The first paper explains, logically and in detail why this is so, and the second paper gives some examples of how simply and efficiently physics can operate without that Cartesian assumption of dual reality. Comments on how these papers were received reveal difficulties in even contemplating this, difficulties which owe more to psychology and sociology than to physics.

Prologue

Just to remind us, and for the benefit of the general reader, ANPA signifies the Alternative Natural Philosophy Association, whose meetings are held at the Universities of Cambridge, England (ANPA East), and Stanford, California (ANPA West). Its primary purpose, as described in the ANPA literature, is 'to consider coherent models based on a minimum number of assumptions, to bring together major areas of thought and experience within a natural philosophy alternative to the prevailing scientific attitude.' The Association, it says, 'will remain open to new ideas and modes of action however suggested, which might serve the primary purpose.' 'Well,' Philosophy says to Physics, here, 'If that's what you want, then that's what you get!' In the following we see what happens when that philosophical challenge is accepted.

A theme which has gained much unpopularity at ANPA is as described in the following pair of papers, delivered verbatim in September, 1993. The first of these describes in logical detail a new development of philosophy, in the modern Linguistic mode, called Normal Realism, whose aim is to employ methods of linguistic analysis in the service of science. The second paper gives an example of how this service to science can be put into effect.

For those who know nothing about it, Linguistic Analysis is a philosophical method developed by the later Ludwig Wittgenstein and others such as G.E. Moore, Gilbert Ryle and J.L. Austin. Its aim is to remove from common language its tendency to generate spurious

philosophical and scientific problems of the sort Wittgenstein called *Scheinprobleme*. These are problems arising mostly from the way in which the seventeenth-century philosopher-scientist Descartes, by a catastrophic misuse of ordinary language, artificially split the world we see before us into two metaphysical divisions thereafter distinguished as 'Matter' and 'Mind'. Since then, philosophers and scientists have been plagued by spurious problems such as, typically, 'How can mind know matter?' or, in physics, 'What is the object *really* like behind our observations of it?' Questions like this are unanswerable because in the way Descartes defined them, Matter and Mind are categories which logically exclude each other. Matter is essentially mindless - that is, without any knowledge of anything at all - and Mind is essentially non-material, with no knowledge of anything but itself other than via senses provided by a God who, Descartes was convinced, 'is no deceiver'. In agnostic science, the lack of any such religious conviction leaves an epistemological gap between things and our perceptions of them. Scientific ingenuity has filled this gap with all sorts of theories of interconnection, such as 'void', 'ether', 'fields', 'light-waves', 'photons', 'gravitons' and a whole gobbledygook of mechanistic and geometric explanations as to how these entities behave in the space separating us, as observers, from the world of self-sufficient matter. These ideas, theoretically unstable though they continue to be - and are philosophically guaranteed to remain - are now so much a part of the cultural 'package' that it is difficult to imagine how we could ever manage without them.

The developments in modern philosophy which reveal the spuriousness of the Cartesian schismatology therefore threaten the whole structure of our Western society which, for better or worse, has developed around that Cartesian way of thinking. This is because those philosophical developments now require science to become part and parcel of the ordinary democratic process. But that means having to cancel the prestigious game of interpreting spatial interconnections, on which so many scientific reputations and institutions have been built, to start again from a kind of linguistic, common-sense 'scratch'. However, the suggestion that we *get rid* of that spurious issue of 'the void' between us and physical reality, together with all the various theories as to how it is to be bridged, is not likely to be well-received. It is as if someone with a laser vaporises the fox when the hunters are all dressed up, in full cry after it. The fact that this does the job those hunters intended, and in the most humane and efficient way possible, is hardly likely to win the heartfelt thanks of those involved in the chase.

Tensions of that purely psycho-social sort may be discerned in the account given here of how the philosophy of Normal Realism and of its use to science was received by a physics association dedicated to the freedom of expression for unorthodox approaches to the subject.

Paper 1

Normal Realism: A Challenge to Physicists

by
N. V. Pope

When I look at a physical object, what am I seeing, the object or my mental impression of that object? This is a classical philosophical question and there are two classical answers to it. One is the Phenomenalist's answer, that what we see, in standard or 'paradigm' conditions - that is, when not being fooled by things like mirrors, illusionists, hallucinogenic drugs or whatever - is *the object itself*. The other is the so-called 'realist' response, which is that we never see the object as such but only its effects on our sense-organs due to influences travelling between the object and ourselves at speeds never exceeding that of light. The real object, these Realists say, is therefore always something 'out there', behind and beyond what we see, so that what we see is never, even at best, anything more than a *subjective representation*, or 'pale shade' of the real thing.

To this the phenomenalist replies 'But if we never see the object as it really is, then how can we ever know that our impressions of it are anything like it - or even that there is any underlying object there at all?' So far as Phenomenalism is concerned, therefore, all Realist talk of 'underlying objects' which are more real than those we perceive is sheer nonsense.

But, say the Realists, that is no more nonsensical than the Phenomenalists' notion that things can exist only 'inside our heads' - that is, in our perceptions of them. For how, they ask, can any practical science like physics possibly be conducted on such an assumption? Besides, they say, hasn't physics proved beyond all doubt that objects are separated from our perceptions of them by space, across which nothing can travel faster than the finite speed of light?

So here we have something of a 'Mexican stand-off' between those two warring factions, roughly aligned with 'physics' on the one hand (the Realists) and 'philosophy' on the other (the Phenomenalists), each convinced that the other's outlook is nonsensical. The Realists see themselves as seeking to determine the way they believe things 'really' are behind our perceptions of them and the Phenomenalists see themselves as seeking reality in logically and mathematically refining what we actually (that is, directly and instrumentally) perceive.

However, there is a joke in all this. It is the traditional idea that there is some kind of 'light-barrier' separating the object and the observer, that light forms some kind of ultimate intermediary between things and our perceptions of them. If it were not for this institutionalised 'light-barrier' idea, the logic of the Phenomenalists' argument would automatically prevail. That is to say, we customarily think of those quantum elements of light which we call 'photons' as little particles which take time to travel across some kind of intervening 'void'. If, instead of that, they could be thought of as bits of *immediate and instantaneous contact* between object and observer - that is, if they could be thought of as *events common to both* - then at that basic photonic level, objects and our perceptions of them would be one and the same and the Phenomenalists' position would be unassailable.

But that, as Gilbert Lewis demonstrated as far back as 1926, is precisely the consequence of Einstein's Special Theory of Relativity, in which the relativistic 'proper-time' and 'proper distance' of a photonic contact are always nil. This means, in Lewis's words, that no matter how far apart, in holistic observational terms, we might judge the emitter and absorber of a photon to be, in microphysical, or photonic, terms they are literally 'touching'.

However, so ingrained in our science is the traditional, yet nonsensical, notion of a self-extended 'void' across which those photons have to 'travel' that although just about every student of Relativity has heard of Lewis's demonstration, he knows no more what to do with that knowledge than a cow with a musket. Yet, as Aristotle once remarked, the idea of a void separating things is a self-contradiction, because since a 'void' means literally, a nothing, then to say that things are separated by a void means that they are separated by a nothing, which means that they are not separated. So Aristotle and Lewis concur on that point, that there is no need to distinguish between the ultimate quantum elements of physical objects and the ultimate quantum elements of our perceptions of them, for the elements of those physical objects and of our perceptions of them are the same.

This means that at the quantum level there is no basic distinction between the way things are constructed 'physically' and the way they are constructed 'mentally', since the same quantum elements and the same principles of logical and mathematical construction are common to both. As soon as this relativistic consequence of quantum emitter-absorber indistinguishability is realised it makes nonsense of the traditional conflict between 'Realism' and 'Phenomenalism'. In that case, there is nothing to prevent those artificial academic divisions of 'Physics' and 'Philosophy' from merging into something like what used to be called Natural Philosophy. Attempts at such a merger were documented in the 1970s, in a form which, for identificatory purposes, was called Normal Realism. In Normal Realism, to the extent that objects and our perceptions of them (*qua* logical constructions) are concurrent, the object as we properly perceive it and the object as it really is are the same, in the same way that when I properly 'tune-in' to what you are saying, or writing, I can sensibly say that the thoughts you and I are having are to that extent *the same*.

And just as there are always, in such cases, thoughts you may have which I am not privy to, so there are always things going on in and behind the objects of perception which we don't necessarily perceive. But that is far from implying the radical sort of 'mental-material' duality on which Realism, is based because the only way in which this lack of perception 'fails' is in the matter of the *completeness* of our knowledge of things. That does not make those things of which our knowledge is lacking *inaccessible* to us in the way they would be if the elements of those things and our perceptions of them were separated in the dualistic way the Realists suppose.

What organises our perceptions is, of course, *language*, which is just another form of that same natural logic in terms of which objects themselves are constructed. This is what the Greeks called *logos*, a now archaic word for which there is no adequate modern equivalent but whose vestiges survive in the word 'logic' and in those various '-ologies' we use to distinguish departments of science, such as geology, zoology, palaeontology ... and so on. The logic

(including mathematics) we use to construct our theories of what there *is* are, in essence, common to both - that is, to language and to *logos*. So the more of sheer subjectivity we winnow-out of scientific language and the more of objective logic we replace it by, the more 'tuned-in' to physical reality our scientific perceptions become. Also, which is most significant, this process is not balked by any epistemological 'veil of illusion' of the sort which traditional dualism places between things and our perception of them.

However, due to the inevitable accumulation of imperfections, the language we customarily use in describing scientific experience may just as easily blind us to objective reality as bring it to a fine cognitive focus. This is why, to the annoyance of many physicists, Linguistic philosophers like Austin, Ryle and Wittgenstein place so much stress on 'linguistic analysis' as an approach to reality. This is a method, not unlike psychoanalysis, whose aim is to refine-out from the way we currently use language, all the age-old accumulation of sheer metaphysical claptrap. Unfortunately, the modern academic schism between Science and Philosophy has prevented Linguistic philosophers from mobilising linguistic analysis in the service of science, where in some respects that sort of service is most sorely needed. The only way Education has been able to operate on such a 'schizophrenic' basis has been by instituting a sort of academic apartheid, separating the two factions into administrative categories of 'Arts' and 'Science'. In this way, the traditional conflict is contained, but only at the cost of making 'reality' something which is almost unmentionable in sophisticated circles.

Normal Realism applies linguistic analysis to those uses of scientific language which it reveals to be not only unnecessary but also confusing, as, for example, by unthinkingly perpetuating the old and outworn precepts. Central among those precepts is the notion, pregnant with dualism, that the way things really are is one thing and the way we describe them is another. This leads to the assumption that in physics we needn't give a damn about language because it is the 'real' things that physics is interested in, whereas the 'language' which concerns the philosophers is 'mere dressing'.

In mitigation, of course, it has to be said that at the conceptual 'cutting-edge' of science, where things and the properties of things are discovered which may not necessarily fit neatly into the usual ordinary-language categories and divisions, it may be necessary to invent all sorts of strange and bizarre ways of describing those new phenomena - some of which descriptions may eventually prove useful and some not, but all of which, in one way or another, add to the conceptual clutter. Exotic experiences in areas like cosmology and particle-physics, lie on the outermost fringes of human experience and therefore inevitably involve the most probing and tenuous adaptations of language. These are remotest from the tried and tested uses of language which have been evolved over millennia by ordinary folk like hunters, farmers, sailors, merchants, housewives, engineers and so on, who live 'cheek by jowl' with nature on the most common-sense practical levels and which uses of language linguistic philosophers like J.L. Austin identify as 'Ordinary Language'. So far, the only way those 'linguistic' philosophers have been able to preserve the integrity of that common-sense core of language has been to keep it well apart from the doings of what they disparagingly call 'scientism' - to which segregation the academic Arts-Science division is, of course, well-adapted. The aim of Normal Realism is to ignore that intellectual 'apartheid' and facilitate a proper linguistic exchange between science and common-sense.

This does not by any means entail taking ordinary language as an 'oracle of truth'. As Normal Realism sees it, the aim of philosophers is not to act as 'Language-Police' on behalf of some idealistically conceived 'Ordinary Language' but to provide and maintain, as far as possible, a common-language basis for democratic dialogue between science and the common man. This is not so 'Utopian' as it sounds. It is fully cognisant of the fact that insofar as the more 'dodgy' language of new and half-baked theoretical science has infiltrate ordinary language, much of it via the popular 'Gee-Whizz' type of science media, that ordinary language has lost whatever pristine innocence it ever had. So there is no way in which 'ordinary language' - especially these days - can be taken, as it stands, as *a priori* in the dogmatic sense of that phrase. But intellectually corrupted though that ordinary language may be, it remains for better or worse 'the only game in town'. That is to say, it is psychologically and socially the best hope we can ever have of understanding the world we live in. To tidy it up, to prune it and nurture it along logical lines, by methods of linguistic analysis, seems preferable to letting it become, more and more, just a thicket of didactic deadwood.

For practising scientists, of course, this philosophical concern for the integrity of common language might threaten to put a severe drag on scientific progress. So, as far as Normal Realism is concerned, that is where the philosophers come in, not as purely descriptive note-takers of what scientists are currently doing, which is what the old 'Philosophy of Science' tended to be, but as partners in the business. As such, their contributions may be prescriptive rather than just descriptive, serving as consultants to the trade, as it were, exploring, testing and advising new ways of making leaner and more efficient uses of scientific language, preventing it from obscuring natural truth and reality - 'blinding us with science', as the saying goes. This by no means requires those philosophers to *do* science, that is, to conduct laboratory experiments or in any other way to 'get under the feet' of the scientists. In that respect, despite the promise of greater co-operation between the two disciplines, something of the old academic division of labour has to be respectfully maintained.

There also remain, of course, the more traditional roles of philosophers, such as acting as custodians and interpreters of the history of ideas and expanders of knowledge into domains such as metaphysics, ethics and theology. However, the need to explore new, systematic and logical ways of keeping scientific language 'down to earth' - that is to say, in touch with reality according to the common language meaning of that word - opens up an area of philosophical employment which for far too long has remained academically closed-off. But now, looking at the naïveté with which so many physicists apply 'do-it-yourself' philosophy to their subject and seeing what a mess they make of it, I am more and more convinced that this kind of employment for philosophers in the services of science is urgently needed. As I think I have told you, or written somewhere, John Bell once said to me, many years ago, at CERN, 'Where the hell are you philosophers? We are struggling to articulate our findings, here, and it's "open house", so why aren't you here in droves helping us?' 'Good question!' I said, and went off to do something about it.

So here I am, trying to do just that. An example of how I employ philosophy in this way can be seen, by anyone who is interested, in my tail-end talk on Sunday, called 'Rustic Relativity'. This is an application of Normal Realism to the language of Relativity and Quantum

Physics, showing how certain central ideas in those two notoriously divided areas have been obscured by being over-interpreted and how, when properly trimmed and clarified, these ideas logically and naturally combine. Anyone who follows this will see very clearly that an attention to 'proper usage' in language is far from being merely cosmetic. In the meantime, the length of this paper has been curtailed so as to allow maximum opportunity for discussion of these philosophical remarks of mine and how they may relate to the Combinatorial Hierarchies, a subject on which I have recently had some interesting correspondence with Clive and Ted.¹ My final write-up for the Proceedings will take account of points raised in this discussion.

To start off, here is my opening sally. From what I have said about constructions there is obviously some need, to say the least, for discussions of combinatorial principles in the logical constructions of natural phenomena. I stress phenomena because, for those reasons I have explained, I reject as meaningless all dualistic double-talk about 'hidden mechanisms' or 'hidden variables' underlying what we see, touch or otherwise sense, either directly or by means of instruments. So, whatever mechanical, geometrical, or combinatorial principles apply to phenomena apply, so far as I am concerned, as much to the objects of perception as to our perceptions of those objects, for, as I say, in the last analysis there is no absolute distinction. By the same token I reject as nonsensical all talk of a self-sufficient 'vacuum' or 'void' as something which can do anything, contain anything, or possess any property or attribute in its own right. For those same reasons I reject all talk of such things as 'waves in a vacuum', 'vacuum vortices', space-travelling 'photons', 'virtual particles', 'superluminal action -at-a-distance' and so forth. Like 'the first moments of creation', 'the beginning of time', 'the expanding universe', 'black holes'... etcetera, etcetera, these things are prime examples of the sort of nonsense which Normal Realism absolutely and categorically rejects.

But more to the point of the Combinatorial Hierarchies, what Normal Realism also rejects, according to its lights, is any talk of mathematics, geometry, or whatever, as residing in some abstract, Platonic 'world-apart'. Hawking's idea that we and everything we see before us, our lives, our loves, our aspirations, our triumphs and disasters, our this, that and the other, are all manifestations of some primordial Mathematical Equation is, to me, not just nonsense but nonsense in neon lights. As I see it, there can be only one true starting-point for our scientific studies, whether of the microcosm or macrocosm. That common epistemological 'Square One' is, to me, what we perceive right there before us, as we describe it in ordinary everyday language. We may analyse anything we perceive right down to its ultimate phenomenological irreducibles and then study how those irreducibles interrelate or combine to form the things and systems of things we perceive. Insofar as the Combinatorial Hierarchies does this, then I am all for it and keen to imbibe those combinatorial principles. But insofar as those principles are thought to have some absolute, ghostly and primordial pre-existence, out of which the world 'materialises' like spirits out of ectoplasm, then I am definitely 'agin it'. Over to you!

¹ Professor C.W. Kilmister and Dr. T. Bastin.

Paper 2

A Rustic Rediscovery of Relativity

by

N. V. Pope

An Intuitive, Common Language Approach to Relativity Theory
Developed in Discussions at the 'Blue Anchor' pub on the Gower Coast

Preface

The usual academic language employed for articles of this kind is set aside in the following for the simple reason that it fails to reach the sorts of ordinary intelligent folk the article is intended to reach. This text is therefore the end-product of a gradual winnowing-out, in genuine bar-room discussion, of the usual specialised language that clearly doesn't work when those on whom it is inflicted leave to sit elsewhere - or choose a different pub.

The few who have survived this protracted process at the 'Blue Anchor' are, as a member jocularly called them, 'The Committee', and what appears here is a text which, after many failed attempts and as many altered scripts, the Committee has passed as putting the case for the relativity of time 'most clearly and unarguably'. How it will be received by one's academic colleagues remains to be seen.

* * *

That was written prior to my reading of the paper at the ANPA 15 conference at Cambridge. My intention, in presenting the paper, had certainly not been to slight my academic colleagues. Nevertheless, some of my listeners were deeply offended, to the point of asking what was the purpose of 'discussing relativistic physics with morons' and even accusing me of 'corrupting the populace', a classic charge if ever there was! Perhaps the most telling protest, though, was this, from a well-known and highly respected - usually urbane - Conference member:

How very strange that a number of excellent fellows on the Gower peninsula are able to formulate something which in many ways is equivalent to Relativity when, at the turn of the century and before, it cost a very great number of dollars to carry out the experiments by which the theory was originally discovered. I think Viv is going to answer that they weren't thinking about it in the right way and that it's really obvious if they thought about it, so all that money could have been saved. *I would not believe that!* I think that *cannot be true!* So I ask myself, how has it been managed by this "Committee"? I am led to the conclusion that *it must be connected with the strength of the beer at "The Blue Anchor"*, because Viv accuses people like Einstein, and people who draw certain diagrams, of "playing God". But it's Viv who is playing God, because he had two pieces of information coming in; one of them was a time-sort of information and the other was a distance-sort of information. And *for no (bleep-bleep) reason at all* he drew them on a piece of paper, at right angles and used Pythagoras. But Pythagoras *had (bleep)-all to do with the business, because he could have drawn them any way he liked!*¹

At the close of the conference I was offered a drink, with the invitation: 'What will you have, Viv, wine, gin or hemlock?' I trust that on cooler consideration of the argument and of its

¹ In later correspondence this forthright criticism was as forthrightly withdrawn, see Footnote 4.

implications for physics my academic colleagues will allow me to settle for just the wine or the gin.

Part One: An Ideal Intuitive Approach

It is a fine summer night and I'm sitting here on the patio having a quiet, contemplative drink. The tide is in on the marsh and I'm looking across it at the lights on the other side of the estuary. What do I see? Do I see the light from those lights leave their sources, travel across the distance and then enter my eye to create in my brain a mental impression of the light-source? Of course I don't, because in seeing the light 'reach' me I am also, at that same instant, seeing it 'leave' its source. So what we customarily think of as 'those two events' are, in fact, one and the same. It is the same, of course, for any other observer or observing instrument, no matter where placed. Also, it is a well-known fact that light in space (that is, in a vacuum or void) cannot be observed. In any case, wherever there is anything to detect light is, by definition, not a vacuum.

So where did I get this impression that things and my observations of those things are separated by light travelling in that way? From our scientific traditions, where else? Well, let's pretend for the moment that we'd never learned those traditions and let's continue to muse on what we actually, naively perceive, right there in front of us.

From any one of those twinkling lights in itself it would be difficult for me to gauge its distance. It might be a light on the hill, the wing-light of an aeroplane, an artificial satellite or a distant star. So I fetch my binoculars and focus it on one of those lights. What do I see? A whole pattern of smaller twinkles in a form which I recognise as a street lamp. From that I can gauge the distance as, say, roughly four miles, which I could measure exactly if I had a theodolite or some other such instrument. But what about those smaller twinkles? Suppose I reduce every twinkle right down to the smallest twinkles there are - quantum twinkles, let's call them. Without any pattern to those twinkles - and that includes comparing the directions of other twinkles from the same source from different viewpoints, as in triangulation and other parallax methods - how can I possibly gauge their distance? So none of those quantum twinkles in itself has, for me, where I sit, any distance in it - nor time, since I see the twinkle and its source simultaneously. The only way I can tell the distance of an object is from those *patterns* of twinkles which form the object in my normal field of vision, in the same way that patterns of paint on a flat canvas inform me of the distances of objects in a landscape.

A landscape, however, being static, has only three dimensions. To bring it alive we must add another dimension, and that extra, animating dimension is, of course, time. But to think of time as something that goes on all by itself, not only in all things everywhere but also in the spaces between those things is absurd. Time is what is ticked by clocks, and any object we see is a clock.² And those objects/clocks may *move* as well as tell time. In that case, they measure distance and time in some proportion or other between two dimensional extremes, or limits. One of those limits is that of *all-distance-and-no-time*; the other is that of *all-time-and-no-distance*.

² Spectroscopically speaking, every atom of every object has an optical *period*, which is Planck's constant h divided by the optical energy.

Now let's just suppose that this had been the way motion was measured originally. That is to say, let's imagine that instead of measuring distances and times in the customary metres and seconds we had happened, by sheer chance, to employ the same units for both distance and time, in the way we measure vertical and horizontal distances in the same units - miles, metres or whatever. All measures of motion might then have been expressed as ratios of numbers of those units in the one dimension, the *all-distance-and-no-time* dimension, to numbers of those same units in the other dimension, the *all-time-and-no-distance* dimension. The logical result of that would have been to remove all necessity for thinking of time as something indescribably mysterious and allowing it to be seen for what it is, just the remaining dimension of ordinary, live geometry.

Now, regardless of how unlikely may be the possibility of such a historical coincidence in choosing the same units for both distance and time, that possibility cannot be logically excluded. Had it occurred, the consequences would have been most interesting. For instance, with distance being already time, there would have been no reason to be surprised at Roemer's discovery, confirmed by Doppler, Fizeau, Michelson, *et al.*, that as objects increase or decrease their distances from us they respectively add or subtract those distances to or from their observed durations. Nor would there have been any need to interpret that phenomenon in the now customary way, as due to the 'speed' of any optical agency or intermediary, called 'light' or whatever. So in our customary ways of thinking, that concept of 'the speed of light' is no more than circumstantial and therefore logically redundant.

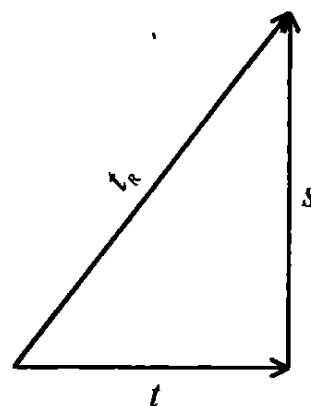


Figure. 1

Another consequence of this imagined fortuitous geometrical merging of observational space and time would have been the effect which was discovered by Lorentz and Einstein, at the end of the nineteenth century and expressed in a form which, after nigh on a century of interpreting it in the usual way, continues to mystify us. This is what has been technically called 'relativistic time-dilation', on the evidence of which modern physics is built and on which point it takes its departure from classical physics. The way this would have arisen, in our idealised situation, would have been simply as a common-sense result of applying ordinary Pythagoras to the dimensional components of motion already described. For instance, if s is the observational distance travelled by an object in a time t as measured by the object (see Figure 1), then the geometrical distance-time resultant, t_R , of those two dimensional components, represented by the hypotenuse of that triangle in the figure (all in idealised units, of course) is, by Pythagoras:³

$$t_R = \sqrt{s^2 + t^2} \quad (1)$$

Now in those ideal circumstances, *that is all 'Relativity' need have amounted to*. So we could, dare I suggest, have been spared all the - albeit illustrious - historical rigmarole about 'light' and how it is supposed to travel 'in the ether', or '*in vacuo*', by wave-propagation,

³ The objection to this use of Pythagoras, which was expressed at the outset will be dealt with in due course.

light-particles (photons) or whatever, which has led so circuitously, via the observations of Michelson & Morley, *et al.*, to modern relativistic physics with all its paradoxical implications about 'action-at-a-distance' and so on. What theoretical shape physics might have taken in that imagined event is not pertinent to speculate on at this stage. Suffice it to say that the essential mathematical consequences of that 'Ideal Relativity' can be shown (see Part Two) to be *precisely the same as those of Einsteinian Special Relativity*. So, at least, we can be assured that the purely factual implications of that ideal theory would be familiar to exponents of modern relativistic physics.

One special consequence of that ideal theory, however, might well have been to avert that *alienation from common-sense* which characterises current Relativity. This, of course, is because the theorem of Pythagoras is much simpler as a basis for relativity than the notoriously unfriendly mathematics of the standard orthodox theory. For instance, just about anyone can see that, logically, if distance is time, then the ticks of a clock which, relatively to us, marks distance as well as time are more widely spread-out than when the clock stands there and ticks only time. So if we watch a pair of identical clocks, one of which stays still while the other travels some distance away from us, we should expect to find that the travelling clock, due to its ticks being spread-out or rarefied by the feeding-in of the extra distance-time, has visibly slowed relatively to the other. That is no mystery. Indeed, given the starting-premise that distances and times are geometrically composite, it would be a mystery if that time-dilation didn't happen. And, of course, the use of Pythagoras in calculating that time-dilation follows as a matter of course.⁴

But isn't that time lost by the travelling clock regained if the clock reverses its outward direction of travel and returns to base? Well, certainly, reversing the outward motion and returning the clocks together subtracts the intervening distance-time. This answers to what, classically, is known as the Doppler effect and it would compensate exactly for the time lost by each party to the motion relatively to the other if it were not for the fact, which just about anyone with any maths at all knows, that squaring a negative makes it a positive. So no matter whether s , in formula (1) is positive or negative (i.e., outward or inward, respectively), the squaring of s in that formula makes it *uniformly positive*. That is to say, for any non-zero value of s , regardless of its direction, and regardless of what Doppler effects it produces, the formula always expresses a *lengthening*, never a shortening. So in returning to base, the travelling clock does regain some of the time it lost on the way out, namely, the distance-time over which it has travelled. But there is still the difference $t_r - t$ to be accounted for, according to the formula, and whether this is added or subtracted depends, *not* on whether the motion is outward or inward, but on *which party to the motion takes the reversing action* (This is explained in the Appendix. See also, Footnote 4). It is that difference between the times registered by the moving object and by the observer at the conclusion of the round trip which answers precisely to what physicists call 'relativistic time-dilation' (or 'relativistic time-contraction' of course. for the non-reversing participant).

⁴ This automatic use of Pythagoras has been challenged on the grounds that, as an objector put it, setting them at right-angles to each other is the *convenient* way of representing two independent variables. But that, he says, doesn't mean that the hypotenuse is significant. An instance, he gives is that of an economist setting out GNP against years. The *points* along the curve are significant, says the critic, but not the *lengths* between them. My reply was that although this is true of independent variables, like GNP and time, it is not true of *dependent* variables such as, say, the height and horizontal-distance components of an incline or gradient. Similarly, when distance and time become constantly related in the ratio of units c , then like length-dimensions, they are not just graphically but also *geometrically* related. My critic now gracefully accepts this and comments that in his view, progress has been made.

Part Two: Implications for Physics of this Ideal Intuitive Approach

Simply looking, then, at the way things are placed, how they change, move and so on, in one's visual field, reveals that *time does not go on at the same rate* for all objects (clocks) in that field - which, of course, is what Relativity is all about. For instance, suppose I see a number of travellers leave some starting-point together and then, having travelled all sorts of different distances in the meantime, rendezvous back at the same spot. When this happens I will see that when they all meet up they will have aged differently, not only relatively to me but also relatively to each other, those which have aged most being the ones which have moved slowest relatively to me and vice versa. So any idea that these differences in ageing are only apparent and that behind them marches some single overall time which goes on everywhere, not only among objects but also in the spaces between, is scotched by the fact that all those travellers properly applying the same Pythagorean formula⁵ will concur as to how much they have aged relatively to each other and to me. For how can there possibly be any single overall background-time to so many different on-the-spot ageings? It is therefore plain that these time-differences due to observed motion, far from being subjective, or 'merely apparent' are objectively real.

So although we started out discussing what is 'only apparent' we end-up with what is undoubtedly real; that is, with absolute differences in ageing between relatively moving observers. It only *seems* that there is one time for all of us, such as Greenwich Mean Time, because the speeds of human beings relatively to each other are so comparatively small. For instance, the fastest and farthest I have ever travelled is from Heathrow to Vancouver and back, which is a round trip of about 26,000 kilometres. This usually takes, by direct flight, excluding the time spent in Canada, about 19 hours overall. If I feed that data into the Pythagorean equation, (1), or its Einsteinian equivalent, equation (4) (see following), the amount I have aged less than the folks at home during that interval is one forty-millionth of a second, which is, of course, negligible for most practical purposes. This allows us to retain the impression that all life on this planet ages at the same rate, set by standard GMT. To extend this GMT to 'the universe as a whole' seems a natural step. It is only when we deal with the distances and speeds of remote astronomical bodies and microphysical particles that these ageing-differences become significant. And in those fields of study the relativistic formula is taken as standard, telling us that the single, universal time-background which persists in our traditional imaginations is nowhere to be found in nature.

'Is that it, then,' says someone, 'a poor-man's reconstruction of Einstein's Theory of Relativity?' 'No,' I reply, 'What we have here is not Einstein's *theory* but Einstein's *formula* for relativistic time-dilation, including, of course, that formula's standard implications for the relativity of length, mass and so on. But now we have derived that same formula by different,

⁵ A common mistake in the use of this formula - or the Einsteinian equivalent (see following) - is to assume that when you move relatively to me, your observations and my observations of that motion are symmetrical, with the paradoxical result that when we return together each of us ends up older than the other. Whilst it is true that the velocity of something moving *uniformly* relative to me is symmetrical with my opposite velocity relative to it, this does not apply to *non-uniform* motion. For instance, if one or the other of us reverses his direction to bring us back together, that reversal will be seen by you and by me at *different times*. This destroys observational symmetry and decides, objectively, which of us ages relatively to which. (See Appendix, 'The Relativistic Clock Non-Paradox'.)

albeit corroborative means. However, as we shall see, the consequences of this changed approach are in some ways as different from Einstein's as his were from Newton's.'

How the famous and notoriously abstruse formula of Einstein and Lorentz for the relativity of time follows from our simple Pythagorean equation, (1), can be shown very easily. Expressing that simple equation in *conventional* units of metres and seconds (which are related by the constant c)⁶ makes it

$$t_R = \sqrt{(s/c)^2 + t^2} \quad (2)$$

And since s , in conventional Relativity, is vt_R then substituting this equivalent expression for s in (2) therefore produces

$$t_R = \sqrt{(vt_R/c)^2 + t^2} \quad (3)$$

Simplified, this becomes

$$t_R = t / \sqrt{1 - (v^2/c^2)} \quad (4)$$

which is the well-known standard formula for time-dilation in Einstein's Special Theory of Relativity, the formula from which everything else in that theory follows.

One of the main implications, then, of this direct Pythagorean or geometrical approach is not only that it corroborates Relativity in common-sense observational terms but also that in so doing it *greatly simplifies our educational understanding* of that theory by basing it on simple, well-understood Pythagoras rather than on the intuitively difficult formula of Lorentz and Einstein. This does not mean that it will be easier for those who are more used to the Einsteinian theory. Indeed, the opposite might well be the case. However, that is not a philosophical matter but a matter of expediency. From the philosophical point of view the fact is that this intuitive theory is *intrinsically* simpler, because it is more conceptually economical, thereby fulfilling the criterion which academics call 'Occam's razor'. For instance, it makes redundant the traditional notion of the 'finite speed of light in a vacuum', on which Einstein's theory is based. If I flash you a signal, then no matter how far apart you and I are, you will receive my flash as soon as I send it, that is, *instantly*, in the way I see those lights across the marsh. If you then directly return the signal (by mirror, say) then I in turn will also see that response *instantly*, in the same way. But since the distance in metres which I measure between you and that first flash, divided by the constant c , is a time in seconds,⁷ the time I will measure between signalling to you and seeing your reply will be the sum of those two distance-times, exactly *as if* the signal had travelled from me to you and back at 'the finite speed of light'. It only seems contradictory to us that the signal itself is *instantaneous* in the two directions but *takes time* to cover that distance because we are not used to thinking of time in relativistic terms. But that, as we have seen, is what Relativity is all about, the differences in ageing-rates and distance-determinations for *different* things - in this extreme case, the signal and the observer, where the signal travels no distance and ages not at all, whilst to the observer it travels the distance $2s$ and ages to the extent $2s/c$.

⁶ This is now no longer the 'speed of light' but merely a dimensional constant - what Herman Bondi calls a 'conversion factor'

⁷ That is, omitting any relaying medium in between, such as air, glass, or whatever.

To say, then, that the distance-time ratio c is due to the 'absolute speed of light in space' not only adds nothing whatever to what has already been said but is also downright confusing. It is as though someone were to say that the constant ratio of metres in the length of a runway, say, to feet in the height above the airfield constituted some strange kind of 'slope', or asymptote, which sets an absolute limit to the angles of ascent and descent of aircraft.

Another thing to notice is this, which should be of interest to physicists of classical persuasion. The intuitive theory offers the same conditions for the *immediacy of operation* of classical conservation laws as was offered by Newtonian physics prior to the Relativistic fiction that no physical influence can pass between one body and another 'faster than the finite speed of light'. If that were the case, then there could be no overall balance of energy, angular momentum and so on, especially in a large system of objects such as a galaxy of stars, where many of those objects might have grown old and died before they could influence one another in that or any other kind of way. This is as ridiculous to contemplate as to imagine how a child on a see-saw can continue to go up and down on one end in a balancing response to someone on the other end who had long since left and gone home.

That this 'finite speed of physical causality' is a fiction can be seen if we put this so-called 'speed c ' in place of v in equation (4) and then solve for t , the time (technically called the proper-time) of the light-signal, which comes out at zero. The intrinsic distance $s = ct$ travelled by the signal then also comes out at zero, confirming what we said at the start about there being *no distance nor time* involved in seeing the lights across the marsh. So it follows that nothing either can nor needs to travel faster than the 'speed of light' (at 'superluminal speeds', in modern science-jargon) to maintain the overall balance of bodies at a distance in the instantaneous way that is required by the classical conservation laws. Since this follows from the Einsteinian theory it is surprising, to say the least, that this consequence has never been realised - or, at least, never properly stressed - by Relativists. This will be discussed in more detail in our Conclusion.

Let us now return to the 'Blue Anchor'. 'What you are saying, it seems to me,' says a member of The Committee, 'is that this is the theory Einstein *should* have written instead of fudging the issue with all that crap about "light-velocity"'. 'Yes,' I reply, 'with all due respect to Einstein, he was, after all, no more than just a *guy*, like the rest of us. And without knowing it, that *guy* over-intellectualised something which, if we were allowed to think about it democratically in the way he no doubt would have wanted, could now be seen to be a matter of more or less plain common-sense. For if time is change (and what else can time possibly be?) then, obviously, *time is different for all bodies changing faster or slower relatively to each other*. So where there is no change - in an atom, say, between absorbing one quantum of energy and emitting another - how can there possibly be time? As far as the atom is concerned, what difference can there be between our saying that the interval between those events is a microsecond or a million billion years? The only measure of time that can signify is the *statistical* measure of the changes in other things in general that we observe in between those two atomic events. To imagine that where nothing goes on, time 'ticks on' in the ordinary way is nonsense.

By the same token, any idea that microphysical particles, in between their quantum interactions with one another, have determinate space-time trajectories is also nonsense. It is the physical bodies *as wholes*, as *objects of observation in relation to other objects*, which have continuity, not their 'ultimate particles', whatever those may be. And that observational continuity *cannot be anything but statistical*. There is no sensible question of where an 'elementary particle' resides, what it is doing, where it is going, or whatever, in between one quantum manifestation and another.

So there is no reason why anyone should have been confounded by Heisenberg's discovery of the principle of indeterminacy. That *indeterminacy* of microphysical events - indeed the indeterminacy of the very existence (i.e. persistence in time) of 'microphysical particles' - is perfectly understandable and predictable.

The only influences which govern the motions and other activities of bodies are therefore, as I say, statistical ones in the form of, for example, Charles' law, the law of entropy and suchlike, which make no sense other than as applied to bodies and systems of bodies as observational wholes. The essential condition of the operation of those statistical influences, or *causes*, is that the activities of the ultimate parts are *random*. That is, those parts have to be free of any mechanical, electrical, magnetic, geometrical or any other kind of interlinking or binding-together and therefore free to fulfil the distributional *probabilities* defined by the statistical law, And those holistic probability-statistical influences, as we have seen, are *instantaneous*, not limited by any 'finite speed of light'.

Another way of saying all that is that the ultimate bits of physical phenomena, of matter and material processes are *events*, not permanent particles. 'So you see,' I said to my interrogators at the "Blue Anchor", 'although this intuitive theory supports Einstein's Special Theory of Relativity in every important respect, the differences between them, so far as physical and philosophical implications are concerned, are far from trivial.'

'Are you going to publish that?' asks one of them.

'It'll never get past the censors!' says another.

Conclusions

'All the difficulties in understanding this,' someone says, 'boil down to two things. One is having to abandon the age-old idea that behind it all there is just one overall, "cosmical" time in which all these events, all these differences in ageing and so on, are measured. The other is having to accept what you said at the start about those lights across the marsh - the light from the hill, the stars or whatever - that without forming patterns of distribution in our observational fields there would be *no distance* in those lights. Although I accept that Relativity confirms all this,⁸ it is difficult to conceive that there can be no distance nor time in light-contacts between

⁸ Present at one of the meetings had been two French visitors, a Professor of Physics and a Professor of Mathematics, both of whom had confirmed to the satisfaction of the company the validity of the mathematics and the relevance for Physics of some of the conclusions drawn.

bodies which are, in some cases, light-years apart. Because whichever way you look at it, it seems contradictory to suggest that things can be both *apart and together* in the same instance.

'So although I accept the logic of your argument at every stage,' my critic concluded, 'and although I am reasonably persuaded by those who *are au fait* with physics and so on, that the consequences of this theory are significant, I still can't imagine how I'm supposed to think of the world in those terms; and on those grounds. My mind, I'm afraid, rejects it.'

'Yes,' I said, 'Perhaps that's the biggest difficulty a radical theory like this has to face, and I haven't a clue as to how that psychological difficulty can be surmounted. All I know is that if no-one can successfully fault these arguments, if these arguments satisfy all the criteria of conceptual economy and so on, and if in that way they reveal the redundancy of some of the central conceptions in our historical ways of thinking about physical reality, then it seems plain that those historical ways of thinking *have* to be reassessed. After all, the possibility that our historical interpretations of nature have gone astray somewhere is not all that difficult to contemplate. I mean, it's not as though the builders of our science-history, venerable though they undoubtedly were and will undoubtedly remain, were *divine* beings. They were *men*, and men are notoriously fallible.'

'So the approach I take,' I told him, 'is what academics call the *empirical* one. That is to say, although I cannot presume to say what, in the end, "The Truth" of all this might be, I am at least convinced that it *is not* what we customarily imagine it to be, either in common-sense or in science. So you could say I'm adopting the stance of the typical scientific adventurer, or explorer, who simply follows his logical and mathematical nose into areas which are there for the discovering. That these areas will be strange and unfamiliar is no more than a tautology. Once you embark on discussions of this philosophical sort, that loss of familiarity is only to be expected.'

'I realise, of course,' I said, 'that not everyone is happy to cast off, as it were, from a continent of familiar ideas with no guarantee, nor even any immediate prospect, of anything but remaining philosophically 'at sea' for a very long time, perhaps indefinitely. Most people might therefore, and quite properly, settle for philosophical familiarity, no matter how much contempt it might breed in them, rather than "sail so far abroad". Indeed, in the end, to choose familiarity might well prove the wiser course! (After all, "curiosity," as they say, "killed the cat.") So I am by no means suggesting that *everyone* should be prepared to cast himself adrift in that philosophical fashion, far less be "press-ganged" into such a venture by the likes of myself - as though that were even remotely possible!

'But on the other hand,' I continued, 'neither can I accept that *everyone* should settle for philosophical familiarity. If everyone did that, there would be no philosophical progress and our civilisation would undoubtedly stultify. So there have to be people,' I suggested, 'who are prepared to "give it a go" and who are prepared to forego the usual guarantees of success. You guys are free agents,' I said, 'and, of course, you follow or stay, as you please.'

'So although I can't define that "unknown continent" towards which I feel these discussions are taking us nor even guarantee its *existence*, as a prelude to setting out - the very

suggestion of which is ridiculous when you think about it - I may still be able to provide at least some presentable justification for the undertaking.

'For instance, let's take a good look at those "difficulties" you speak of. The first one you mention is simply the standard difficulty of having to change one's habitual ways of thinking, from thinking of time as absolute to thinking of it as relative. But that isn't insurmountable. It is something to be conquered personally, like learning to operate a computer or ride a bike. Nor is the second difficulty any difficulty really, for there is no contradiction in things apart being also together. For instance, think of the words and letters in a written sentence, which are all separate in the length-dimension of the sentence but are all collapsed together when the sentence is seen endwise on. Since there is no contradiction in that, then why is there a contradiction in saying that those objects which are separated in the distance-time dimension which is spread out across one's field of vision are all collapsed together when viewed directly along the line of sight? That line-of-sight dimension in which the objects are "collapsed together" is the proper-space-proper-time dimension of the illumination itself, signified, as I say, by putting v equal to c in the relativistic formula, solving for t and then expressing the proper distance, s_p , of the signal as ct , which collapses everything down to nought. The other dimension, in which objects are separated, is the relativistic distance-dimension of that same illumination, signified, in the same way, by putting v equal to c in the relativistic equation, solving for t_R and expressing the observational distance s as ct_R , which gives us the ordinary observational distance-time separations of objects and events.'

'I'll take your word for that,' said my interrogator, 'But I still can't say I understand it.'

'Not the maths, no; but that is no more than mathematical corroboration of what you can actually see in front of you, with your own eyes. You look along a "light-ray", so to speak, and you can see that there's no distance nor time in it, just like those lights across the marsh. But in the way those lights are spread across your field of vision there *is* both distance and time, as experiments show. So there you see it, distance-and-time and no-distance-and-no-time, in the very same objects and without any contradiction whatsoever.

'A prime example of this,' I suggested, 'is Michelson's famous toothed-wheel method of determining the so-called "velocity of light". In that apparatus the lamp is at some position in my visual space and the screen is some distance s away from the lamp. The distances from me of the lamp and the screen can be ignored because they take no part in the experiment. So for that purpose, all that matters is that from some point on the screen the source-event is "seen" immediately, with no distance and no time in it, whereas from the point of view of the experimenter the source and the screen are separated by the known distance s . The ratio between that known length s and the measured time t_R between the emission-event at the source and the absorption-event at the screen is then the value of c which the experiment determines. To call this the "speed of light" is, as I say, logically unnecessary.'

'The experiment simply measures the constant c , not the "speed of light" . Right?'

'Precisely!'

To the group I explained that there is an interesting comparison between this new theory and Newtonian physics, which is that like the latter it provides an *absolute* determination of universal simultaneity. For instance, it is a tautology of relativity theory - both this intuitive one and Einstein's - that the proper distance-time s/c minus the proper time t is zero in every observational frame of reference.⁹ This fixes unambiguously (that is, absolutely or invariantly), the present moment everywhere; that is, a 'universal' time-zero for every seen event, precisely as in pre-relativistic physics. So if I observe a supernova I can subtract from my time of seeing it its distance from me divided by the constant c to allocate to that event a cosmical time-zero of some thousands of years ago, confident that all other observers of that same event, calculating their own different distance-times from it will concur. So for every event that I see there is a whole spherical distribution of events which everyone agrees were once 'now' at that point in history. And by the same token, associated with every event that occurs to me, here and now, there is a whole three-dimensional sphere of simultaneously occurring events which are all *now* in that same absolute sense. So, on the grounds of the conservation of energy, angular momentum and so on, if I were orbiting the earth in a space-suit, any adjustment I might make to the balance between my orbital angular momentum and that of the earth - by operating my rocket-pack, let's say - will be felt *immediately* throughout the whole solar system and beyond, as classical physics requires. That action-reaction 'jolt' is proper-time-instantaneous and reciprocal. So I can say without absurdity that in rising from my chair I am instantaneously shifting the balance of the earth and all other objects to some disappearing extent all over, which, by instantaneous reciprocal reaction is what makes it such an effort to rise and prevents my fourteen-odd stone from zipping about all over the place, as it undoubtedly would if the balance of momentum and so on between me and all those other bodies were not conserved.

This, however, is where all similarity with classical physics ends, because between any one such instant and the next, proper-time is not the same for all observers, as it is in classical theory. As we have seen, the proper-ageings of things which move relatively to one another may end-up 'scrambled' all on the same spot. So although the simultaneity, or now, of things is the same as in classical physics, the time-flow is different for different things. And that's where the essential difference lies between the relativistic way of thinking and the classical way: there is no chance of establishing an absolute or cosmical GMT by means of that absolute simultaneity, because any such synchronisation is completely destroyed between one instant and the next.

Another consequence of this new - what we may call 'discrete' - theory of relativity is that there is no need to think of the causal linkings of distance-separated bodies as mediated by 'waves' in any wave-conducting ether or field, far less any 'pure vacuum', or void. This, as we have seen, is because the emitter and absorber of quantum energy are in immediate proper-time-instantaneous contact. In double-slit 'wave-interference' experiments of the sort carried out by Thomas Young, the emitters at the source and the absorbers at the screen, in the line-of-sight dimension of the signal, are therefore sympathetically connected 'ahead', as it were, of the time it takes the signal to get there in the ordinary transverse dimensions. The paths for the signal to take or not to take (decided by the interferential 'go' and 'no-go' areas of the screen for the period of that particular quantum) are in that sense geometrically 'pre-ordained'. That is to say, if all routes from the slits to the screen (talking, now, in the non-line-of-sight, geometrical terms) are traced out in units equal to the so-called 'wavelength' of the source-energy, then the

⁹ That is to say, $s/c - t = s_1/c - t_1 = s_2/c - t_2 = \dots$

paths themselves, without anything 'travelling' in them interfere, constructively or destructively, with one another. That is, the paths from the slits, intersecting at the points on the screen, are themselves geometrically 'in phase' or 'out-of-phase' with each other, according to the units involved, thereby distinguishing those areas of the screen where the statistical probabilities of energetic interactions with the source are most and least. This solves the age-old mystery as to how photons (conceived in the classical way as travelling particles) seem to know at the start which routes to take so as to fulfil that preordained 'landing-pattern' because in proper-space and proper-time terms they are 'there' as soon as they 'start out'.

Besides, there is nothing in the 'wave-propagation' explanation of interference-phenomena that cannot be explained at least as adequately - and, of course, more economically - in terms of pure proper-space-proper-time geometry (that is, proper four-dimensional geometry, or *kinometry*, as we might call it). For instance, wave-propagation cannot explain that immediate and sympathetic, seemingly 'telepathic', connection between the sources and sinks of quantum energy which physicists call 'action at a distance'. In physics conferences and journals, nowadays, the mysteriousness of this phenomenon (due to the persistence of our classical precepts of 'wave-propagation') is a burning issue. The fact that light itself is intrinsically instantaneous therefore not only dispenses with any need for wave-theory in respect of light, or indeed any other form of quantum transaction. It also dispenses with any need for those proliferating explanations of action-at-a-distance which assume that there are 'spooky superluminal' influences connecting things before the theoretical 'waves' or 'wave-particles' can propagate between them. What remains is what might be called an overall-conserved *pure potential*.¹⁰ This is like classical absolute space except that instead of being continuous, like Euclidean geometry, it is quantised. That is to say, instead of bodies influencing one another continuously, as in classical physics and General Relativity, they do so only in discrete, immediate and reciprocal quantum jumps of action, angular momentum, 'gravitation' or whatever. So I cannot move or do anything without immediately affecting other things and they cannot move or do anything without immediately affecting me, all in discrete quantum amounts. That overall balance of action-at-a-distance, in all its forms, is no less conserved for being maintained in shuttle-like successions of proper-time-instantaneous quantum transactions than in the traditionally assumed 'continuous' way. But instead of thinking of those quanta (called 'photons', 'gravitons' or whatever) as little 'particles' travelling in a pre-existing space and time we now think of them simply as the ultimately irreducible informational bits into which observational space and time may be analysed, as in some super fine-grained video scenario. In that way, as a theory of nature based on observer-processed quantum-information relativity truly comes into its own.

¹⁰ This answers, in essence, to what David Bohm has named 'quantum potential', except that here we have no need of Bohm's recourse to neo-classical 'spooky superluminal' explanations of its occurrence.

Appendix: The Relativistic Clock Non-Paradox

There are still critics of Relativity who claim that there is a 'paradox' in the theory. If motion is relative, they say, then any motion of A relative to B is symmetrical with that of B relative to A, with the absurd consequence, according to Relativity, that each ends up older than the other. Here we examine this claim by looking specifically and in detail how motion appears to the participants.

Let P be a projectile and O an observer. P passes by O at a steady speed of, let us say, $v_{PO}/c = 0.6$, relative to O. As O and P pass each other, they synchronise their time-readings. On the way out from O, after one second according to his clocks, P passes another projectile, Q, approaching O from the opposite direction at the same speed relative to O of $v_{QO}/c = 0.6$.

As P and Q pass by each other they synchronise their time-readings, so that the time-reading of Q's clock, on arrival at O, will be the same as if P had gone all the way, with a magical turnaround at point PQ. There is thus no physical acceleration involved, with its concomitants in terms of force and energy. Let us now see how this exercise will be viewed by each of the participants in turn.

Q's view:

By standard Special Relativity, P's velocity v_{PO} on the way out from O gives a time-dilation of P relative to O of value:

$$t_{PO} = t_{OO} \sqrt{1 - (v_{PO}^2/c^2)} = 0.8t_{OO} \quad (1a)$$

A second of time on P ($t_{PP} = 1$ sec), relatively to O, will therefore be $t_{PO} = 1/0.8$ seconds, or 1.25 seconds, and in that time P will have travelled a distance $s_{PO} = vt_{PO} = 0.6c \times 1.25 \text{ sec} = 0.75c \text{ sec}$. The meeting of P and Q, which is witnessed by P after one second of his time from 'go' will therefore be witnessed by O after a time $t_{PO} + (s_{PO}/c) = (1.25 + 0.75)\text{sec} = 2 \text{ sec}$ (see Figure 2(a)). So here we have the first break in the symmetry: O and P do *not* witness that change-over event at the same time.

From that crossover event PQ, as seen by O at 2 seconds from 'go'. O sees Q travel towards him at speed $v_{QO} = 0.6c$ to arrive reading a time $t_{PP} + t_{QO} = 2 \text{ sec}$ in a time relative to O of $t_{PO} + t_{QO} = 1.25 \text{ sec} + 0.75 \text{ sec} = 2 \text{ sec}$ (see Figure 2(a)).

P's view:

As seen by P, after their meeting, O recedes from him at that same symmetrical speed of $v_{OP} = 0.6c$. (so far, and so far only, their motions are symmetrical.) After a time t_{PP} of one second he sees Q pass by him on the way towards O. The distance O has travelled relative to him in the meantime is $s_{OP} = 0.6ct_{PP} = 0.6 \text{ sec}$. At that same instant he witnesses clock O read $1/0.8 \times (1 - (s_{OP}/c))\text{sec} = 0.5 \text{ sec}$ (Figure 2(b)).

The distance from PQ to QO, relative to P, in Figure 2(b) is, of course, the same as the distance from PO to QO. This is the distance travelled by O in P's time of $1/0.8$ of O's time

$t_{PO} + t_{QO}$, which is $2.5/0.8 = 3.125$ sec. So the distance is that time multiplied by v_{OP} , which is $1.875c$ sec (Figure 2 (b)). Now Q travels that distance in a time which his clock registers as $t_{QQ} = 1$ sec. But according to the relativistic formula:

$$t_{QQ} = (3,125 - 1)\text{sec} \sqrt{1 - (v_{QP}^2/c^2)} \quad (1b)$$

where v_{QP} is Q's speed relative to P. Solving for v_{QP} in this equation gives $v_{QP} = 0.881c$. The time at which P witnesses the meeting of Q with O is therefore $(3.125 + 1.875)$ sec = 5 sec (see Figure 2(b), projected off-page).

Q's view:

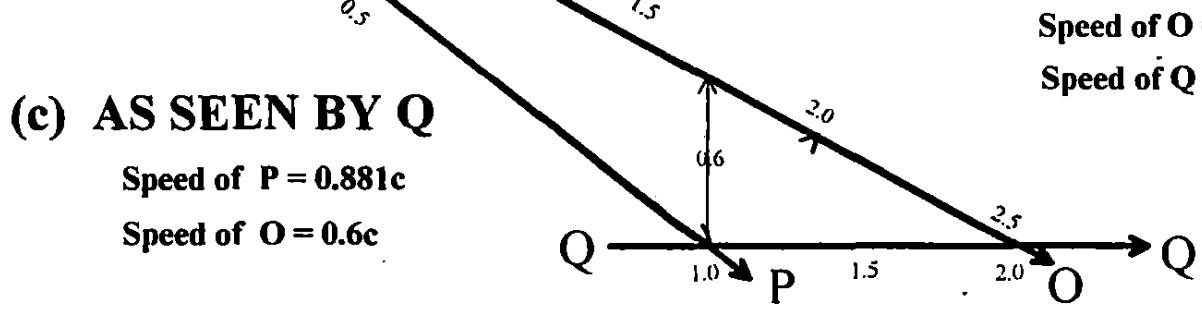
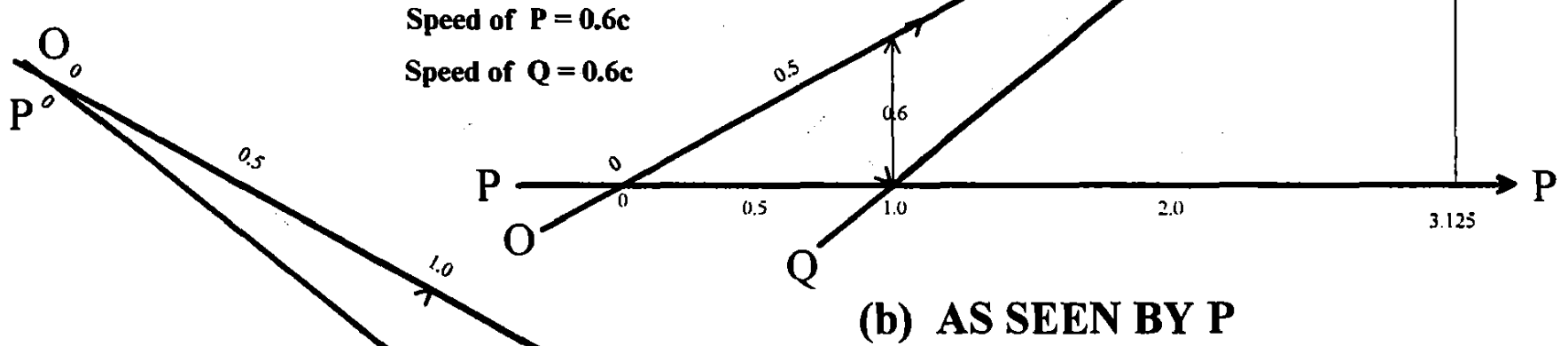
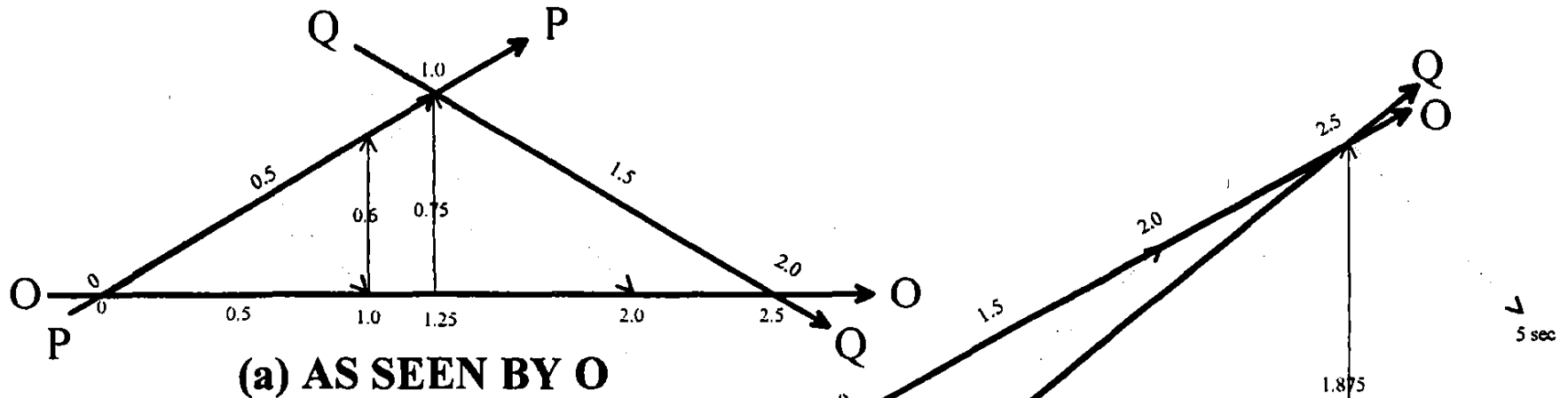
As seen by Q, the situation is the same as for P but in reverse. That is to say, as he starts out from the intersection PQ (see Figure 1(c)) he sees O's clock read 0.5 seconds (dotted diagonal) and as he reaches QO he sees O's clock read 0.5 seconds, as compared with his own clock-reading of 2 seconds. So both Q and O, at their meeting-point concur that as a result of the motion from OP to PQ and back to QO it is the distance-time-track which Q has relayed that is dilated (stretched), not O's.

The diagrams therefore describe the exercise as witnessed by each in turn of the three participants. Drawn to an exact scale of 1 vertical unit = c seconds = 3×10^8 metres = 1 horizontal unit = 1 second, these drawings are more or less self-explanatory. This constant ratio of 3×10^8 metres to the second in the witnessing of distant events, customarily called the 'speed of light', is projected in the diagrams by the 45° dotted lines (null-lines, as Relativists call them) connecting the main events to the various points of observation.

These detailed kinometrical projections make it plain that there is no symmetry between any two of the three viewpoints. So there is no suggestion of 'paradox' since all three participants clearly concur, at the end, that the ratio of the time-reading of Q to that of O will be 2.0/2.5, or 0.8, as given by the time-dilation formula. These results are the same if we make P go all the way without relaying his time via Q. In that case, we may think of P as a super-hard and super-elastic 'golf-ball' bouncing off a super-rigid 'wall' at PQ, so that the time taken for its acceleration-corner, or motion-reversal at that point would be negligible in comparison with the times overall.

So there is no 'Clock Paradox' in relativity. Q.E.D.

THE RELATIVISTIC CLOCK NON-PARADOX



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TWISTORS AND SUBSTANCE

On some metaphysical aspects of Science¹

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I

One main line of philosophical thought today² is based on two recent aspects which have been inspired by results of the theories of self-organisation and the formation of structure as well as chaos theory: the role of the observer within the world, and the visualising of evolution as a permanent, hierarchically structured self-differentiation of matter, the individual hierarchies satisfying common underlying principles and depending on some initial frame (a field of possibilities) the beginning itself being the outcome of some pre-worldly process. The observer then, as belonging strictly to this same world, being produced by its evolution at some later stage, acquires her knowledge about the world by the very means of her mode of being which is, actually, to acquire knowledge (for anthropological reasons³: basically, they can be thought of as the systematical defining properties of mankind).

On the other hand, in philosophy proper, metaphysics, particularly with respect to its actual task and scope, has been re-interpreted as an ultima philosophia rather than the prima philosophia as it was introduced in Aristotelian thought⁴. This simply means that metaphysics is not thought of as able to lay the grounds for any of the sciences: on the contrary, it is following up the scientific results in order to interrelate them and to project them onto a background frame of thought representing for man the worldly practical context of science and of life at the same time. To this extent the results of science produce meaning, a concept which is closely related to the anthropo-ontological conditions of acquiring knowledge of the world, and which always connects ontology with epistemology⁵.

Philosophically, these aspects imply that the world is a totality and that this totality is dialectically mediated. This means, according to a definition given by Kondylis⁶, that the ontologically real world is an objectively unfolding evolution within a unified being which re-establishes - by means of hierarchical steps and through a competitive procedure of resolving the world's immanent conflict structure⁷ - the original and non-conflicting unity of this being. In fact, seen in this perspective, the worldly process is somewhat deficient with respect to the original and later on achieved unity of being. In the strict idealistic sense, the concept of unity is used by Kondylis as a teleologically founded one in his text discussing the early philosophy of Hölderlin, Schelling and Hegel, usually referred to as the "Tübingen axiomatic". From the essentially materialistic approach of modern philosophy, however, one would prefer to give up this additional aspect: evolution is open and can fail to achieve the final unity, rather than teleological. The deficient process, falling off from the initial unity and systematically re-developing to a newly recovered unity, is called history. Obviously the problematic questions to be asked about history are: Is it necessary to have any history at all? Out of what kind of unity is it actually emerging? If there is a unity before there is a world, then what does "process" (eventually giving rise to the initial world) really mean? So, if "world" is visualised as a process itself, there is development. If there is development, there is a beginning. If there is a beginning, there should be a foundation for that beginning and some reason for it.⁸

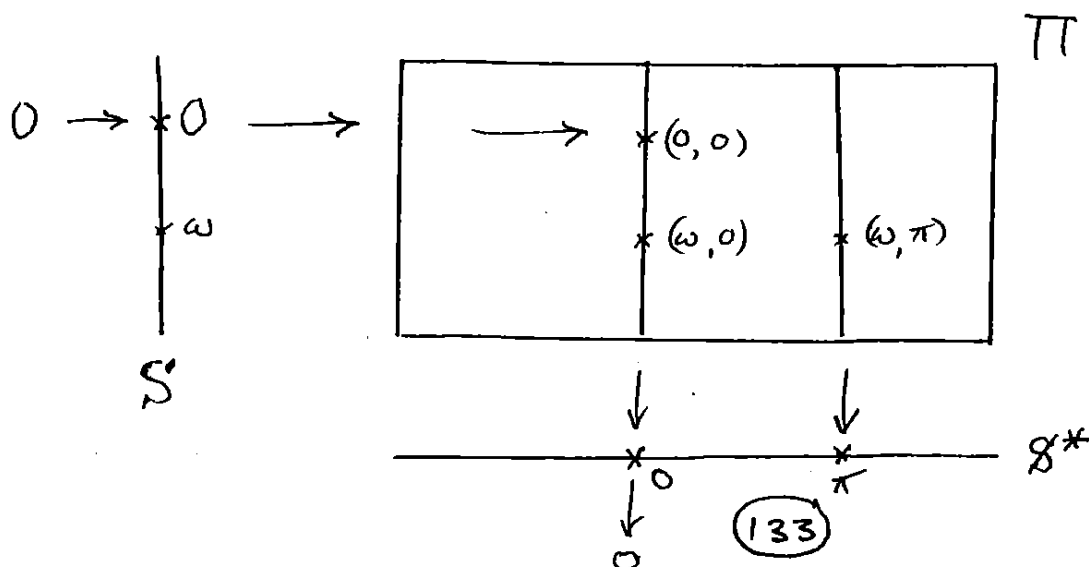
Now, as we explained earlier, metaphysical reflection is actually following up scientific research. First we have to look for the scientific picture which is valid today for this world, then we have to model its structure and cause in line with this. The material world in physical terms is the universe and the field of research dealing with the universe is physics. And because we are interested in global aspects of the world, we look for its material totality; hence we actually deal with cosmology first. Evolution of the world means basically evolution of the universe, and according to the standard picture

at present, this evolution starts with a Big Bang. So if we are looking for a foundation of that beginning, we have to ask for the pre-conditions necessary for a universe coming to life by means of a Big Bang. In physical terms, therefore, the problem is to think of the universe of space and time⁹ as something which has developed beforehand in order to come into being in the first place. Hence space and time appear as derived entities rather than as themselves fundamental. But the initializing process must be one which cannot be described in terms of space and time because it is (or "takes place"?) outside it and because it is the foundation from which space and time are derived as secondary entities.

What we have to do, then, is to discuss a physical theory which explicitly deals with pre-geometry or similar concepts within a philosophical frame in order to make it accessible to our basic metaphysical intention. For this purpose we have chosen the twistor theory of Penrose and we also assume the "closed standard picture" of the universe, the latter being cosmologically closed, that is, developing "forward" to some Big Crunch.¹⁰ We give a short summary of twistor theory next, and then discuss its philosophical implications.

II

According to Penrose¹¹, twistors are elements of a four-dimensional complex vector space, called twistor space \mathbb{T} , which can be defined as a double fibration over spin space S and its dual S^* . If there is such a spin space, then there is an exact sequence of the form $0 \rightarrow S \rightarrow \mathbb{T} \rightarrow S^* \rightarrow 0$, with the corresponding dual sequence.¹² In the sense of the following diagram there is thus a unique assignment of two spinors to one twistor:



The linear transformations of $\overline{\Pi}$, which conserve these sequences, give the restricted Poincaré group action on Minkowski space M. If in particular $x: \mathcal{S}^* \rightarrow \overline{\Pi}$ is a section of the fibration, then this defines a motion of \mathcal{S}^* on $\overline{\Pi}$.

However, in order to describe real physics and real motions in terms of $\overline{\Pi}$, it is necessary to deform twistor space so as to take space-time curvature into account. Hence if DM is this deformed space, we have the diagrams

$$\begin{array}{ccc} \text{DM} & \xrightarrow{\text{id}} & \text{DM} \\ \updownarrow x^* & & \updownarrow x \\ \mathcal{S}^* & \xrightarrow{\text{"L"}} & S \end{array},$$

which is equivalent to the scheme of the standard diagram of space-time of the form:

$$\begin{array}{ccc} T^*M & \xrightarrow{L} & TM \\ \updownarrow d & & \updownarrow v \\ \text{DM} & \xrightarrow{\text{id}} & \text{DM} \end{array},$$

where T, T* denote the tangent and cotangent bundle of deformed Minkowski space DM (space-time) and the d, v are the form and vector mappings expressed in terms of suitable sections. L is the Legendre mapping.

If now $\text{CDM}^* \subset C\Omega^+(DM)$ is anti-self-dual space-time, which is in fact a subset of the complexified future infinity of the conformally transformed space-time and CDM is self-dual space-time, respectively, then it can be shown that $x \in \text{CDM}^*$, $x^* \in \text{CDM}$. Hence a motion on S, say, defined by x produces a space-time point on CDM^* . The vice versa is not valid. The same can be shown for x^* .¹³ It can also be shown that CDM^* and CDM are Newman's H and H* spaces.¹⁴ Note in particular that the regularity conditions for x in order to be able to induce an adequate field structure on the associated space-time are such that the Hausdorff property on DM has to be given up.¹⁵

What we have here is, in a schematic form, an emergence mapping in the sense of Eisenhardt and Kurth.¹⁶ Indeed, what one would wish is eventually to achieve the commuting of the following diagram (up to Legendre transformations):

$$\begin{array}{ccc}
 \text{DM} & \xrightarrow{\phi^*} & \text{TM} \\
 \updownarrow x & & \updownarrow v \\
 \text{S} & \xrightarrow{\phi} & \text{DM} ,
 \end{array}$$

where ϕ is the concrete, real emergence mapping and ϕ^* is its differential.¹⁷

III

The prime concept of philosophy which takes explicitly into account all that we said of our general intention in the first section of this present paper, is the concept of substance. Basically, substance is both the foundation for a world and that which constitutes the world, at the same time. So what there is is substance only, but man can perceive only aspects of it, and this restricted impression is called world. Substance itself is non-worldly, it is outside the world, not in any locational sense, but rather in some conceptual sense, because the concept of location is undefined outside of space and time.

The concept of substance was introduced as early as Aristotelian philosophy, but has been modified subsequently in many ways. It has been rephrased in a more modern framework, originally by Spinoza. For him, substance is that which is in-itself, and which may be conceived out of itself, that is, it is that, the notion of which does not require the notion of another thing to be able to be formed.¹⁸ (Note that this is a truly onto-epistemological definition!) Substance is cause of itself (*causa sui*), the essence of which involves its own existence (*cujus essentia involvit existentiam*). What we perceive of it are only its attributes, of which there are infinitely many; but we can perceive only two of them which fall into our mode of existence: matter (*res extensa*) and mind (*res cogitans*).¹⁹ Though the basically infinite substance is indivisible, we perceive parts of its attributes, but these are different only in modal terms, not in real terms.²⁰ This concept of substance forms the basis of the various notions which we have mentioned in the first section, independent

of whether the actual approach chosen is idealistic or materialistic. The later development of the concept, chiefly undertaken by Schelling, and more recently by Bloch and Sartre²¹, does not really deviate from this modern line of substance philosophy, as initiated by Spinoza.

A suitable candidate for such a substance, though visualised now in terms of modern metaphysics, thinking of the world as a materialistic totality conceptualized in following the results of modern physics, is the spin network modelled by spin space, or rather: twistor space itself, as a sort of cross product of spin space and its dual. Note that forming this product is necessary for achieving results which are adequate for a realistic cosmology.

Hence substance is first of all a unifying background of being, as a projection pointing to realizations within a given field of possibilities, the two attributes of which (matter and mind) we can perceive empirically. Note also that according to the standard theory of space and time and with respect to our materialistic perspective, these two attributes are actually equivalent to each other. To this extent they constitute the material aspect of the world which emerges out of substance as a derivation. At the same time, we realize that a concept such as emergence is actually a concept for-us: without perception and interpretation of this perception by man it is a vacuous concept. This does not at all imply that the substance would have been obliged in one way or another to create perceiving beings, as followers of various forms of the anthropic principle would like to suggest. We merely state the fact as such; if there is no perception in a universe (which one could think of), this does not really matter, either for the universe or for substance.

Hence substance is foundation of being. Being came into existence by some initial emergence of the worldly, out of substance, which is therefore exteriorization of substance. And as such it is a deficient state of substance, because it can be perceived only in a restricted way, and thus only partially. Substance is the foundation of being, but is itself without any foundation. It is its own cause. Hence it is a non-local entity, something beyond space and

time, pre-geometry, outside the world which emerges out of it. The origin of the world is therefore self-referent. There is a "blind spot" at which emergence "took place" (represented by the initial singularity at the Big Bang). In the sense of Hogrebe²², this is the reason for a fundamental inconsistency in the world, an epistemic debt to be paid, which lies at the root of the structural relationship between metaphysics and art.²³ At the same time the worldly is constituted in a transcendental way, because there is an immanent tendency of the aforementioned falling off of the substance which causes a return of that which has been exteriorized, back to the original unity of substance. Hence the worldly is eventually re-interiorized again, which can be formally expressed in physical terms by the existence of a final singularity of space-time (the Big Crunch), which is structurally different in fact from the initial singularity.²⁴

Motion cannot be properly defined on substance itself. Nevertheless, substance is itself constituted as being in-motion, because it can be visualised as being in a permanently fluctuating state, that is, in being in intrinsic motion and potential for real motion (in space-time) at the same time. The term "intrinsic motion" means here a formal state of fluctuation which can be represented on the abstract space (twistor space) in which these things can be discussed at all. Note that chaos can be represented easily in a suitable phase space, and so can twistors. The question is, however, what real space-time phenomenon is actually expressed by phase space representations.²⁵

In a sense, intrinsic motion of substance, implying a potential for real motion - a field of possibilities - on the one hand, and a state of metastability on the other, expresses the freedom of substance, which means the freedom of being able eventually to create a world or not. Hence freedom in this sense is ontologically primary. In a genuinely Sartrean formulation one could say that substance, in being the foundation of being, has its own mode of being free.²⁶

Finally, we realize the origin of the conflict structure of the worldly: it is nothing but that component of the set of attributes which represents the intrinsic dual structure of substance itself (alternatively expressed by the

fact that twistor space is constituted by spin space and its dual). This introduces a first self-difference into substance itself, thus causing the actual motive for starting with a worldly process at all.

IV

The aspects discussed in this paper have a considerable number of consequences for most other fields of philosophy, in particular for social philosophy, because the deep interrelationship between ontology and epistemology mentioned earlier also implies a similar relationship between these two and ethics. This has been discussed in explicit detail elsewhere.²⁷ The important point is that the freedom underlying as a primary concept the construction outlined above is a necessary property of both substance and the world. It can be shown that a "correct" epistemology, that is, an adequate way of perceiving and interpreting the world, indicates a "correct" behaviour according to that which has been perceived and interpreted. This is a significant Stoic element in the thinking of modern substance philosophy and dialectics.²⁸ On the other hand, the discussion still remains somewhat unsatisfying, so long as the actual mechanism of emergence is not very clear. Further work is presently being undertaken²⁹, but this is also a call for more fundamental work in physics proper.

Note finally that ANPA's BNAK combinatorial hierarchy³⁰ enters this discussion exactly when looking for the explicit mechanism of spontaneously starting and performing emergence, subsequently producing the worldly frame in which further evolution can take place. It is interesting to realize that this is a period when ontology and epistemology are still unseparated.

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1. Alternative Natural Philosophy Association (ANPA) 15, Cambridge 1993.
2. For a general summary see my "Axiomatische Systemdialektik als Differenzphilosophie" in System und Struktur, Junghand, Cuxhaven, 1992, 31-64.
3. See my "Imagination und Katharsis: Zum poetischen Kontext der Subjektivität

bei Sartre" in: T. König (ed.), Sartre - eine Kongress, Rowlolt, Reinbek, 1988, 107-131.

4. M. Theunissen: Möglichkeiten des Philosophierens Heute. In: id: Negative Theologie der Zeit, Suhrkamp. Frankfurt a.M., 1991, 13-36.
5. H.J.Sandkühler: Onto-Epistemologie, in id.:Europäische Enzyklopädie zu Philosophie und Wissenschaften, Meiner, Hamburg, 1990, III 608-615.
6. Kondylis, P: Die Entstehung der Dialektik, Klett-Cotta, Stuttgart, 1979, 526.
7. ...which expresses in fact the competition between stability and instability as exhibited by the scheme given by Prigogine for the explicit procedure of the formation of structure.
8. The German word "Grund" means foundation and reason as well as that from which something may be derived at the same time. Also "cause" is a possible meaning for this.
9. We take here the strict view of Belinski and Khalatnikov when studying early Bianchi-type universes, holding that at the initial singularity the universe was actually "empty" and can be represented therefore by pure geometry. Hence it is thought that, from the beginning on, space and time are created as "res extensa", matter (in the sense of particles) being created out of geometry at a later stage. See L.Parker for this in "The Production of Elementary Particles by Strong Gravitational Fields" in F.P.Esposito, L.Witten (eds.) Asymptotic Structure of Space-Time, Plenum, New York & London, 1977, 107-226. See also the detailed exposition on this topic in Y.S.Zel'dovich, I.D.Novikov: "The Structure and Evolution of the Universe", University of Chicago Press, 1983.
10. Note that the American approaches on pre-geometry, initialized by Misner, Wheeler and Thorne in the early seventies, converge somehow with twistor theory. This can be seen clearly in the case of Newman's heaven theory.
11. See R.Penrose, W.Rindler: Spinors and Space-Time, Cambridge University Press, two volumes, 1984, 1986. Here: II, 89, 91.
12. See for details also my "Initiale Emergenz und kosmische Evolution. Zur Rekonstruktion der Substanz-Metaphysik" in System und Struktur, 1(1), 1993, 39-55.

13. R.Penrose: A Brief Outline on Twistor Theory, in: P.G.Bergmann, V. de Sabbata (eds.) Cosmology and Gravitation, Plenum, New York & London 1980, 287-316.
14. Ibid 315.
15. Ibid 301, 313sq.
16. P.L.Eisenhardt, D.Kurth: Aufriss einer Theorie der Emergenz, in: W.Saltzer (ed.) Zur Einheit der Naturwissenschaften in Geschichte und Gegenwart, Wissenschaftliche Buchgesellschaft, Darmstadt, 1990, 129-149.
17. See my paper mentioned in note 12 for details on the question of phase spaces and the genesis of the notion and concept in the works of Penrose and others.
18. Spinoza: Ethics, ordine geometrico demonstrata, Opera, Wissenschaftliche Buchgesellschaft Darmstadt, 1980.
19. See my work mentioned in note 2 for further details.
20. Spinoza, op.cit. pars prima, Prop.XV, scholium.
21. See my "Selbstreferenz und poetische Praxis", Junghans, Cuxhaven, 1991, for further details.
- 22. W.Hogrebe: Prädikation und Genesis. Metaphysik als Fundamentalheuristik im Ausgang von Schellings "Die Weltalter". Suhrkamp, Frankfurt a.M. 1989, 116.
23. This is an important concept which relates the philosophy of Sartre to more recent works of Hogrebe and Theunissen.
24. In terms of thermodynamics, because of the difference of entropy.
25. See note 12 for this.
26. Freedom in this sense is a central concept for the philosophy of Schelling, in particular as discussed by himself in the Munich lectures on positive philosophy.
27. See e.g. note 21.
28. ...which is still found in the philosophy of Ernst Bloch, see my "Naturproduktion und Innovation. Aktuelle Aspekte Blochscher Philosophie im Kontext materialistischer Dialektik" In: VorSchein, Ernst-Bloch-Association, in press.

29. See the results of the Frankfurt meeting on emergence, to be published in System und Struktur 1(2), autumn 1993, and the presently published "Emergenz und Dynamik" by P.L.Eisenhardt and D.Kurth, Junghans, Cuxhaven, 1993.
30. I remind you of my paper for ANPA 12 and the critique communicated to Clive Kilmister in a personal talk with respect to his "Space. Time , Discreteness" in: "Modern Perspectives on the Philosophy of Space and Time" (ed.J.P. Bendegem, Philosophica, 50, 1992, 2, 55-71) on which something more will be said shortly.

PART 3

New Alternatives - new fields.

CLINICAL ECOLOGY AND DIABETES MELLITUS

Faruq Abdullah and Patrick Kingsley

This paper addressed the concerns of the following article, extracted from an earlier ANPA newsletter. Fuller details may be obtained from Faruq Abdullah, The City University, Northampton Square, LONDON, EC1V 0HB.

Clinical Ecology and Diabetes Mellitus

The term Clinical Ecology refers to what is popularly known as food allergy. The importance of food allergy as being a major contributing factor in a wide range of illnesses was brought to the attention of the public by Richard Mackarness in a best selling paperback "Not All in the Mind" (Pan, 1976). Two years later a confirmatory article appeared in the Lancet (Food Allergy: Fact or Fiction, Lancet Vol. 1, Jan-June 1978, pp 426-428). Clinical Ecology came to embrace a wider view of allergy than used in traditional immunology to include "allergic-like" reactions involving radical shifts in blood sugar level and central nervous reactions. The importance of this area to medicine has been steadfastly ignored and ridiculed but now evidence has emerged that adult onset diabetes may be the end result of these maladaptive reactions and this is likely to bring about a Kuhnian[1] type revolutionary paradigm shift.

William Philpott is one of the pioneers in the Clinical Ecology area. Philpott was trained as a psychiatrist and neurologist in the 1950s at the time when antidepressants first appeared and as he says he prescribed them by the bushel. He also administered some seventy thousand electric shock treatments. He became disillusioned with the ability of these methods to deal with the problem and from the early 70s explored the area of clinical ecology carefully monitoring reactions to individual foods and chemicals. Many of his patients were found to be maladapting to a very large number of foods and chemicals, so he along with others explored the area of optimal nutrition to help reverse these reactions.

In recent years he has also explored magnetic energy healing based on separating the two poles of a magnet - a method that is also used in biomagnetic therapy reported on in previous ANPA newsletters - and one that goes back to Chinese traditions. Recently Philpott with his co-author Dwight Kalita has published a revised edition of their 1983 book entitled "Victory over Diabetes" [2] with a new preface entitled "A Breakthrough in Magnetic Energy Healing". The preface is reproduced below in full.

Central to non-insulin dependent diabetes (Type II diabetes) is insulin resistance. Over the past 20 years I have tested several thousand patients for disordered carbohydrate metabolism in relationship to single food test meals. Several hundred of these were also tested for insulin response to single food test meals which were correlated with the degree of carbohydrate disorder. The primary diagnoses of these patients were a wide

spectrum of physical and mental disorders including several hundred maturity-onset diabetics and a few insulin-dependent juvenile diabetics. From these studies solid evidence emerged that the insulin resistance of Type II non-insulin dependent diabetes mellitus is produced by maladaptive reactions largely to foods and, to a lesser extent, to common environmental chemicals such as car exhaust. These maladaptive reactions consisted of an assortment of IgG food allergies, food addictions, ill-defined food intolerances, hypersensitivity and toxic reactions to environmental chemicals.

There is a routine clearance of insulin resistance as well as the carbohydrate disorder with avoidance of the foods and substances evoking the maladaptive reactions. The reactions consist of an array of physical and emotional symptoms, as well as higher-than-normal blood sugar response. The carbohydrate disorder of brief duration and the chronic carbohydrate disorders justifying the diagnosis of diabetes mellitus Type II behave alike and therefore it is concluded that Type II diabetes is simply an extension of these lesser carbohydrate disorders. Both are readily reversed by avoidance of the maladaptive reactive substances, followed by carefully spaced exposure to them.

Unfortunately, there is a low level of awareness of the ecologic causes of insulin-resistant carbohydrate disorder. The stress of obesity has been highlighted since some 80 percent of diabetics at the time of their onset are obese. This obesity certainly is a significant stress that should be corrected. However, and surprisingly, the insulin resistance and the carbohydrate disorder were corrected immediately by avoidance and spacing before there was any time for weight reduction to have occurred. It is strange that in scientific medicine this is so little known, especially since a statistical verification has been published in the right place, that is, the journal Diabetes.

For years the presence and level of hormones and enzymes have been believed to be the producers of biological reactions without any consideration of an energy source which could make such reactions possible. This belief in spontaneously occurring biological responses is no longer tenable now that we understand the role of electromagnetics. Specifically, magnetism creates the energy which makes biological response possible.

For years it was customary to consider magnetism as one unit of energy. However, it has been conclusively demonstrated that magnetism is two energies that have opposite biological effects when these energies are separated. The balance between these two energies governs metabolism. Magnetism is a push and pull system. The clockwise spin

of a positive magnetic field pushes while the counter-clockwise spin of the negative magnetic field pulls [3].

Negative magnetic fields and positive magnetic fields are both magnetic energy, with 180-degrees opposite response in biological systems. Life energy is the balance between these two systems. An example is acid-base balance. The positive magnetic pole is acidifying and the negative magnetic pole is a alkalising in terms of biological response to single magnetic fields from a unipoled magnet. Biological life has a balance between acidity and alkalinity.

Another important issue is the demonstrated evidence that the positive magnetic pole evokes inflammation and the negative magnetic pole is anti-inflammatory and inflammatory resolving. Understanding the oppositeness of biological responses evoked by the separate magnetic fields is critically important. Exposing tissues to single magnetic poles can produce a predictable biological response in those tissues. I routinely correlate saliva pH with maladaptive reactions to foods and chemicals. These reactions are routinely acid and can be controlled by a negative magnetic field. Inflammation is characteristically an aspect of degenerative diseases and can be controlled by exposure to a negative magnetic field.

How is insulin resistance caused by maladaptive reactions to foods, chemicals and inhalants? The formulation is in this order: These maladaptive reactions - whether allergic, addictive, toxic or otherwise unexplainable inflammatory reactions - cause an inflammatory edema of cells and whole tissue groups. Insulin's assignment is to carry blood glucose through the cell wall into the cell. A cell with a swollen membrane cannot make proper use of insulin; thus the blood sugar remains in the blood and is not transferred into the cell. When these cells or tissues are placed in a negative magnetic field, the inflammatory edema is corrected and insulin works as it should. Therefore, not only should we use avoidance and spacing of maladaptive-reacting substances, but also tissue exposure to negative magnetic field energy to correct the insulin resistance of maturity-onset diabetes mellitus. Exposure to negative magnetic field energy ahead of a meal has been conclusively demonstrated effective in reducing the chances of a maladaptive reaction to foods. Maladaptive reactions to most environmental substances are essentially the same process as maladaptive reactions to foods.

The inflammatory reactions which occur due to the diabetes mellitus disease process

reduce oxygen to tissues, encourage invasion of micro-organisms (viruses, fungi and bacteria), produce inflammation of arteries with atheromatous build-up and many other tissue and nerve degenerative disorders. Great advances have been made in scientific medicine in understanding these degenerative disease processes. However, the most important thing we understand today is that this process exists because there is an imbalance between the positive and negative magnetic poles where positive magnetic energy has the ascendancy over the negative magnetic energy. Direct tissue exposure to negative magnetic energy can do much to correct this magnetic energy imbalance disorder.

In his book Philpott repeatedly draws attention to the studies of John Potts on the evidence for the reversibility of diabetes published in the journal Diabetes [4] To quote from the book: "John Potts, M.D. did a statistical study on bio-ecologic diagnosis and found that two thirds of insulin dependent adult onset diabetics did not need insulin after they had withdrawn from their maladaptive reactive substances. Those still using insulin required only one third the amount used before their work-up" Philpott has the following dedication in his book "To those chemical and clinical diabetics who wish to understand the multiple causes of, and through this, the reversal of the degenerative disease process" . He has also produced a more convincing case for the reversibility of diabetes in his 1992 publication "Diabetes Mellitus: A Reversible Disease" [5]. In this he explains how the reversibility of type II diabetes mellitus came as a surprise by product of a research project on the development of symptoms in mental patients in response to maladaptive reactions to foods and chemicals. Not many clinical ecologists have explored the diabetes field because, as Philpott points out, to examine a maturity onset diabetic takes a month of careful testing.

[1]Thomas S. Kuhn, "The Structure of Scientific Revolutions" University of Chicago Press, Chicago, 1970.

[2]William H. Philpott and Dwight K. Kalita, "Victory over Diabetes" 1991 paperback edition, Keats Publishing Inc., New Canaan, C.T. 068540, USA, ISBN 0-87983-548-6

[3]Philpott often uses flat ceramic magnets approximately 10cmx15cmx1cm in dimension and poled through their thickness. The negative and positive magnetic "energies" he talks of are then separated. The face of the magnet "radiating" a negative energy is uniquely defined as that which attracts the north seeking end of a compass needle and vice versa for positive

energy.

[4]The late John Potts published a series of papers in the American journal Diabetes the last of which is "Insulin Resistance Related to Specific Food Sensitivity", Diabetes, volume 35, Supplement 1, 1986.

[5]Available from Philpott Medical Services, 17171 S.E. 29th Street, Choctaw, OK 73020, U.S.A.

THE MODEL PROTON IN A NON-COMBINATORIAL HIERARCHY

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The proton, as the primary form of matter, is at the creative equilibrium interface between matter and vacuum energy. Just as there is electron-positron pair creation and annihilation activity in the vacuum field, so there may be an underlying 'heavy' lepton (muon) activity in the universal field environment. This paper explores the relationship between the muon and the proton on the simple assumption that Nature is constantly trying to create protons but is normally restrained by energy equilibrium criteria.

The author's theoretical model is of long standing record, as outlined in *Physics Today*, November 1984, p. 15, and as acknowledged for its remarkable 'classically-derived' prediction of the proton-electron mass ratio in the paper reporting its measurement by Van Dyck et al, *International Journal of Mass Spectrometry and Ion Processes*, 66 (1985) 327-337.

The advance reported in this ANPA-15 paper concerns recent developments of this model which focus upon aspects of the deuteron and the triton. In particular, the model will be tested by deriving theoretically the 12 year lifetime of tritium on the assumption that it decays owing to interaction with that same heavy lepton field environment that creates the proton. This approach then affords insight into the exposure of the deuteron to that heavy lepton field activity. The quantitative aspects of the energy transactions involved are too remarkable to be attributed to coincidence.

The advantage to humanity which such research affords is linked to the prospect of success now emerging from research on cold fusion, inasmuch as the theoretical processes envisaged explain why no neutrons result from what is deemed to be deuteron fusion. The consequences concern an alternative natural philosophy having bearing upon the forces of creation in the universe and are important in that by theorizing about the derivation of the proton mass in relation to the electron there is spin-off which can cause physicists to revise their views on nuclear theory.

1. The Triton in Focus

Tritium is the third isotope of hydrogen. It is radioactive but decays by releasing a minute amount of energy - about one thirtieth of what is needed to create an electron. Its nucleus, triton, is an enigma in physics. A portion of the energy it releases somehow vanishes without trace and this phenomenon has been the basis of the neutrino hypothesis. The fusion of hydrogen in the sun is believed to be the source of energy which powers our existence on Earth, but the supposed related neutrino emission from the sun is itself a problem. There is just not enough solar neutrino energy intercepted by our Earth to balance the energy books representing the solar hydrogen fusion hypothesis.

It is submitted that the triton is the guardian of the secrets which govern our understanding of the cold fusion process encountered when deuterium is loaded into a cathode in a Fleischmann-Pons experimental cell.

The triton has a lifetime of 12 years. That is a very important clue and it has caused this author to focus on the assumption that the triton incorporates a ground-state deuteron, which is the seat of the decay action. This means that the deuteron itself is subject to radioactive decay processes but, as will be shown, this decay action involves a proton creation followed by proton decay. What may then emerge as a cold fusion product is a tritium nucleus or the reestablishment of the deuteron in its original form. In other words, the deuteron appears stable, but it can develop into a triton by a natural lifetime process, albeit with very much higher probability if another deuteron in close proximity is available to sacrifice a proton.

This proposal is not hypothetical. It is based on a theme developed in the author's earlier work, published long before the Fleischmann-Pons cold fusion discovery was announced. See, for example, the American Institute of Physics journal 'Physics Today', 37, p. 15 (1984).

There the author drew attention to the P and Q scenario where a proton of energy P was attracted to an oppositely charged partner of energy Q. If each has a charge e bounded by a sphere of radius a determined by the J. J. Thomson formula ($E = 2e^2/3a$), the total energy of the P and Q charge in surface contact is:

$$P + Q - 3PQ/2(P+Q)$$

For the binding energy term to be a maximum, P and Q must have a certain relationship. This is when $1+Q/P$ is the square root of $3/2$. The reader may then verify that with P as 1836 the value of Q is 413, which is the combined energy of a pair of mu-mesons in electron units. Resulting from this discovery the author has advanced elsewhere a theory of proton creation

which explains how protons are built from the virtual muonic energy activity in the vacuum field. Note here that electron-positron creation and annihilation are ongoing activities in the vacuum field, the basis of quantum electrodynamics, and the mu-mesons are the 'heavy electrons' which hitherto have been seen in physics as having no role or function that could justify their existence in Nature. Their role is, of course, the most important of all, that of matter creation in the form of protons!

Now, we are, in the description which follows, to see how this same process of proton creation is at work within a deuteron or a triton.

The algorithm which the reader may keep in mind in the analysis which follows is the curious mathematical fact that $4Q$, meaning four mu-meson pairs, if combined with the energy released by creating two (P:Q) systems from two bare P components, will be exactly that needed to create a new proton or antiproton P.

To prove this write:

$$P = 4Q + 3PQ/(P+Q) - 2Q$$

Then rearrange algebraically as:

$$P(P+Q) = 2Q(P+Q) + 3PQ$$

or:
$$3P^2 = 2P^2 + 4PQ + 2Q^2 = 2(P+Q)^2$$

which is the above relationship between P and Q as calculated from minimization of energy potential.

It follows, therefore, that if a particle containing two P nucleons is bombarded by the mu-meson vacuum energy background there is a condition where 8 mu-mesons will create a third P. This is tantamount to a fusion process occurring at room temperature which adds a nucleon to a deuteron.

Note that the energy is 'borrowed' partially from the vacuum as a vacuum energy fluctuation and partly provided by the degeneration of two nucleons in creating the two Q dimuon components. The system will 'restore' by causing a proton elsewhere, as in a nearby deuteron, to decay, but for a transient period there will be a very active energy situation which can give basis for much that is observed in cold fusion phenomena.

The remainder of this paper will develop the above theme by reference to the triton, and the verifying key which confirms what is said above is the resulting calculation of the 12 year mean lifetime for the transmutation just mentioned. This gives insight into the energy generation rate that can be

expected in the cold fusion deuteron reaction. A deuteron will experience the mu-meson transmutation described on an average that is set by the triton 12 year lifetime. Since the deuteron is in the required ground state condition 2 parts in 7 of any period of time¹ the probable deuteron transmutation lifetime by this process is 42 years. However, one cannot exclude secondary nuclear reactions triggered by the excess energy transients of the above process.

Note that the deuteron ground state is one in which the deuteron structure has two antiprotons sitting amongst three beta-plus particles, represented by $(e^+ : P^- : e^+ : P^- : e^+)$, and the process we are to consider is one where attack by 8 mu-mesons causes the outer beta-plus particles to become dimuon Q charges as a newly created P charge is nucleated from a nearby vacuum lattice charge. The latter will be understood from the following detailed description.

The Constant Vacuum

In the Winter 1992 issue of 21st Century one reads of an interview with Martin Fleischmann and his Italian theoretician colleague Giuliano Preparata on the eve of the Third Annual Cold Fusion Conference.

This was an interview which revealed that we could expect a backlash from the criticism levied at the pioneer work on cold fusion. It has aroused retaliation which will take the form of an attack on the weaknesses of much that has become accepted in theoretical physics. The following two quotations from that interview will serve to set the scene for the subject developed in this paper:

'There is something seriously adrift with modern theory. There is a lot of work to be done, lots more to be discovered.'

'Preparata pointed to the hyperfine structure constant, alpha, which relates the electrostatic and electro-magnetic fields and is crucial in physics. "I often ask myself," he said, not really joking, "What if the fine structure constant were like the Dow-Jones index and constantly shifted up and down? Then there could be no science and no rationality If it were not for constants such as the fine structure constant and the speed of light, then our universe would not exist.'

Here then is a statement that should cause physicists to wonder and reason as to why the textbooks of science do not discuss the way in which Nature determines that fine structure constant and thereby is able to build our universe. The derivation of the value 137.0359 which is α^{-1} , where α is

¹ See 'The Theoretical Nature of the Neutron and the Deuteron', *Hadronic Journal*, 9, 129-136 (1986).

$2\pi e^2/hc$, e being the electron electrostatic charge, h Planck's constant and c the speed of light, is crucial to everything that is fundamental in physics. Next, in order of fundamental importance, there is the understanding which can come from the theoretical derivation of β , the proton-electron mass ratio, as 1836.152.

In a 1985 book entitled 'The Fundamental Physical Constants and the Frontier of Measurement' published under the auspices of the Institute of Physics in U.K. B. W. Petley of the National Physical Laboratory describes the theoretical attempts to derive these dimensionless constants and states at page 161:

'No doubt the theoretical attempts to calculate α and β will continue - possibly with a Nobel prize winning success.'

Now, the reader may wonder how this concerns the triton and cold fusion. Well, perhaps Martin Fleischmann and Giuliano Preparata are unaware of the connection via this author's work, but the very essence a vacuum medium that can bombard us with action and events that trigger fusion is the way in which it determines α and β , as is shown in this author's published work. The Physics Letters, 41A, pp. 423-424 derivation of α was published in 1972 and the theoretical derivation of β was published by the Italian Institute of Physics under the title: 'Calculation of the Proton Mass in a Lattice Model for the Aether', in Il Nuovo Cimento, 30A, pp. 235-238 (1975).

The first paper derived α in terms of a resonance in a fluid crystal structure of the vacuum and the analysis involved knowledge of the lattice cell dimensions. The underlying research had already at that time solved the problem of gravitation and revealed that a virtual pair of mu-mesons had association with each cell and were the building blocks for hadronic matter including protons. Of particular relevance to the calculation of the proton-electron mass ratio in free space is the way in which, as a rare occasion governed by statistical chance, nine mu-mesons come together at the seat of a vacuum lattice charge to create a proton.

Here then is Nature's arsenal by which it can act, even from within our bodies, to bombard matter with mu-mesons. These are energy quanta which act in concert to strike the body blow which converts a tritium atom into helium 3 and a deuterium atom into tritium, in the process creating a new nucleon in an act seen as fusion but by promoting the decay of one elsewhere. Indeed, we confront a scenario where Nature is constantly trying to create protons throughout space but it only succeeds where the energy equilibrium as between the sub-quantum vacuum underworld and matter has become unbalanced. Generally speaking, if a new proton is created an old one somewhere nearby must decay. Therefore, if the nuclear chemistry suggests that an intruder proton moves to fuse with the deuteron so creating a tritium

nucleus, the real event is probably one where the mu-meson attack on the deuteron has caused a proton to appear as a nucleon whereupon the energy equilibrium bookkeeper has 'ordered' the demise of that intruder proton.

This may seem fantasy speculation, but the reader should be mindful of the power of the author's published research by which those α and β constants were derived. The calculations matched the part-per-million precision of the measured values and were in exact accord.

We can, therefore, proceed to study the triton with confidence and our objective, as with corresponding published work on the neutron, for example, is no less than the aim to confirm the theory by simultaneously deriving values for the magnetic moment, the mass and the lifetime of the triton.

The reader can share in the author's pleasure of discovery by working through this exercise, because the triton, rather curiously, lends itself to straightforward analysis.

It is necessary to engage in some preamble to explain the factors involved but to keep the focus on the objective the argument will advance directly to the calculation of these three values and the reader is asked to keep in mind that the ultimate objective is the calculation of the triton lifetime. The deuteron component of the triton stands as the target and so much of what is discussed is addressed at the deuteron transmutation as if it has the same lifetime in its ground state.

The Triton's Vital Statistics

The triton has a structure supporting three units of nucleon mass presenting an overall unit of positive charge e . Its mass is slightly less than that of three protons. Indeed, we should begin by working out precisely how much the measured mass differs from that of three protons as that provides the value we need to compare with the one derived theoretically.

We will work in terms of mass expressed in terms of electron rest mass as a number ratio.

The author's data reference is the 2nd Edition of the McGraw-Hill, Condon and Odishaw Handbook of Physics (page 9.65).

Atomic mass of proton plus electron:	1.00782519
Atomic mass of triton plus electron:	3.01604971
Unit atomic mass in electron units:	1822.888

This latter value was found by dividing the first atomic mass into 1837.152..., which is the proton mass incremented by one electron unit.

If we now multiply the first-listed atomic mass by 3 and subtract the second-listed atomic mass, the result is 0.007426 and multiplication by the unit atomic mass in electron units gives 13.54. This, therefore, is the measured mass difference as between 3 protons plus two electrons and the triton.

It follows that the triton has a mass that is 11.54 electron mass units below the combined mass of three protons. Our task is to find the model form of the triton which allows us to calculate this mass discrepancy.

The other items of data we need to extract from the same data source (page 9.93) is (a) the triton lifetime of 12 years, (b) the half-spin unit of angular momentum (presumed to be same as the proton) and (c) the magnetic moment stated in nuclear magnetons to be 2.9789.

It is, however, better for us to avoid reliance on data that is based on indirect measurement and take note of the direct measure of the triton nuclear magnetic moment presented as a ratio in terms of the proton magnetic moment effective in the same reacting environment. This ratio, as quoted from the Dover 1966 text of 'Atomic Physics' by Harnwell & Stevens, is:

1.06666

The task ahead is then to guide the reader through the analysis by which the three measured numerical dimensionless values just presented as the triton's credentials are duly derived by pure theory.

The Magnetic Moment of the Triton

It is appropriate here to refer to the author's paper entitled 'The Theory of the Proton Constants', Hadronic Journal, 11, pp. 169-176, 1988.

On page 174 of this paper the gyromagnetic ratio of the proton is deduced theoretically as being 2.792847367, which compares with the measured value of 2.792847386(63) and so is quite precise, it being computed from a proton modelled on a structured resonant state.

This, in effect, is the proton's own magnetic moment expressed in terms of nuclear magnetons and so one can see that the 2.9789 triton magnetic moment above is derived from the measure 1.06666 and the independent measure of the proton's gyromagnetic properties.

Now, when we have regard to the fact that the triton's magnetic moment is measured as a frequency ratio as between the reaction of a triton and a proton

in the same magnetic field, there is the curious feature that the two frequencies have what appears to be a perfect integer ratio, namely 16:15, which is the near-unity ratio factor 1.06666.

This causes one to wonder whether the interfering wave modulation which would develop harmonic interactions somehow locks the response of the triton onto a condition that is exactly set by this 16/15 ratio, even though the true triton magnetic moment with no proton reaction present is virtually that of three nuclear magnetons.

With this doubt, there is little purpose in trying to derive the precise quantity 2.9789 and it suffices for our purposes to justify, if only as an approximation, the triton magnetic moment as being 3 nuclear magnetons.

The interesting point to then take into account is that amongst all atomic nuclei the triton is unique as having by far the largest magnetic moment in relation to its nuclear angular momentum. The ratio is 6:1, whereas Ag^{108} , which sits between the two stable isotopes of silver, has a half-life of 2.4 minutes and comes closest with an exceptionally high ratio factor of magnetic moment to angular momentum of 4.2.

What is it, therefore, that gives the triton the magnetic moment of 3 nuclear magnetons based on a single half-spin unit of angular momentum?

The simple answer which is now suggested is that the triton comprises three nucleons two of which are protons and one of which is an antiproton. They all react magnetically in opposition to a magnetic field and so the two protons 'spin' one way and the antiproton spins the opposite way. The magnetic moments add to 3 units and the 'spins' add to a single half-spin unit of angular momentum.

This then explains the magnetic moment property and, further, we have now an insight into the structure of the triton.

The Structure of the Triton

Once the structure of the triton has been pictured in our minds then we can proceed with the confirming analysis by calculating the triton's mass discrepancy and its lifetime.

The interesting feature seen already is that we have not pictured the triton as comprising one proton plus two neutrons. Keep in mind the no-neutron syndrome of cold fusion! Three protons will not hold together even in a quasi-stable aggregation. This is why physicists have taken the easy course and assumed that it consists on two neutrons plus one proton with some kind of glue that introduces a negative mass binding energy.

Such assumption has led them down a blind alley. We need to add something such as beta-minus or beta-plus particles or be bold enough to imagine a stable entity including antiprotons. The truth can only be found by discovering the structure which gives the right answers for the three measured parameters presented above.

Discovery in this pursuit needs inspiration and intuitive analysis and it is here that the author must lead the reader directly to the solution and then show how the calculated properties prove that it has to be the correct structure of the triton.

The triton does, in fact, comprise two protons plus one antiproton, and our only concern now is to understand the 'binding' that holds the three nucleons together but keep the proton and antiproton far enough apart so that they do not fuse and mutually annihilate one another.

Now, here we are guided by the fact that independent analysis of the nature of the deuteron has shown that in its prevalent state it comprises two protons bound together by an intermediate beta-minus particle, otherwise termed a positron. This is fully explained in the previous footnote reference, the author's paper 'The Theoretical Nature of the Neutron and the Deuteron', *Hadronic Journal*, **9**, pp. 129-136 (1986). The less prevalent ground state comprises an in-line configuration of three positive beta particles separated by two antiprotons.

We may be further guided by earlier work reported by the author in his book 'Physics without Einstein', published in 1969 by the author under the trade name Sabberton Publications, from the above-stated address. On pages 147-152 of that work there is a description of nuclear bonds, which the author termed chains, which took the form of an alternating sequence of beta-plus and beta-minus particles and which linked adjacent hole-cum-charge sites in the vacuum lattice which locked onto the atomic nucleus and caused it to form a shell structure. Indeed, this theme was further elaborated in the author's paper entitled 'The Chain Structure of the Nucleus', published in 1974, also by same publisher.

The data there presented show that a charged meson can attach itself to a charged nucleon to release sufficient energy to account for its own mass-energy and further the total energy of a chain spanning between two vacuum lattice hole-cum-charge sites. Furthermore, there is a balance of mass-energy or mass deficit which one calculates as being some 12 electron mass units.

In these circumstances, and having regard to the fact that we are trying to account for a triton mass deficit of 11.54 electron units, the author sees no point in going further than the assertion that the triton has a single beta

particle chain linking the antiproton and the proton pair, the latter regarded as being seated at an adjacent lattice site in the vacuum lattice system.

The beta particle chains are deemed to be very much a part of the structure of large atomic nuclei. Each chain has up to 170 such particles corresponding to the fact that the vacuum lattice spacing is 108π times the beta particle radius. There are two of the author's papers of easy reference as background to this subject. They are one already mentioned, namely: 'Aether Theory and the Fine Structure Constant, Physics Letters, 41A, pp. 423-424, (1972) and 'Theoretical Evaluation of the Fine Structure Constant', 110A, pp. 113-115 (1985).

As will be seen from those papers there is a factor 1843 derived from a resonance closest to a zero potential condition and representing the volume of a vacuum lattice charge in relation to a beta particle. Indeed, the derived value of the fine structure constant was given in the form:

$$\alpha^{-1} = 108\pi(8/1843)^{1/6} = 137.0359$$

The fact that the space occupied by the vacuum lattice charge can, given enough energy input, develop into 1843 beta particles from which a proton form can condense is crucial to the creation of the nuclear chains, but the action of creation of a proton depends primarily upon the mu-mesons that do the work.

The concept of space conservation in charge particle transmutations is consistent with energy conservation, bearing mind that the pressure or energy density within the charge of the vacuum lattice particle is in equilibrium with the 'gas-type' pressure set up by the mu-meson pairs that, on average, populate each cubic lattice cell of side dimension 108π beta-particle radii. Thus the number of beta particle charge volumes that equals this cube volume is a measure of a factor N which is relevant to the inverse chance of a 'hit' as the annihilation and random position recreation of a mu-meson recycles at the standard (Compton electron) frequency associated with vacuum energy charge pair creation activity.

To evaluate some numbers, note that the lattice charge has a Thomson radius that is larger than the beta particle charge radius by a factor 12.26, which is the cube root of 1843. The energy of the lattice charge is therefore $1/(12.26)$ or 0.08156 electron units. The number of electron charge volumes in the unit cubic cell of the vacuum is $(108\pi)^3$ divided by $4\pi/3$ and so is 9,324,644. Dividing this by 1843 we find that there are 5059.49 lattice charge volumes of energy 0.08156 electron units in each cubic cell of the vacuum, which is 412.666 electron mass units of energy. This is double a mass energy a little below 207, thereby representing the combined mass energy of a virtual mu-meson pair that is the energy in each cell.

The fundamental derivation of the 108π cell dimension parameter and the 1843 factor, the subject of the author's primary analysis of vacuum energy discussed in the above-referenced 1972 Physics Letters paper, therefore leads to the theoretical derivation of the mu-meson energy quantum. It tells us the energy content of the vacuum state.

The triton, when created, lives amongst this activity and its rather special structure makes it vulnerable to decay owing to the bombardment by those mu-mesons. The core target for that bombardment is not the antiproton or the two proton nucleons in its composition. The target is the vacuum lattice charge to which the triton is attached. The deuteron, however, is also subject to such attack and here, too, the real target is a lattice particle in the its near vicinity.

An isolated proton or a deuteron does not need to develop a fixed association with a lattice charge because its mass has not exceeded a critical level above which the dynamic quantum 'Zitterbewegung' behaviour needs a collective balance by a graviton system. The phenomenon of gravitation is dependent upon the inertial reaction of vacuum particles in the form of gravitons which have a mass-energy of 2.587 GeV, an energy value having an effective mass between two and three proton masses. This is fully explained in the author's works. See, for example, 'The Theory of the Gravitation Constant', Physics Essays, 2, pp. 360-367 (1989).

However, when the proton or deuteron is part of a water molecule the nuclear chain structure of the oxygen atoms will provide the lattice location in the vacuum field system. This is why the cold fusion events we see with free deuterons in a palladium host metal are not, so far as we can judge, occurring in water.

When atomic nuclei exceed the mass of two protons they do, of necessity, share in a collective action requiring dynamic balance by a multiple graviton system and that action requires that their combination as a structured nuclear entity spreads itself over a multiplicity of vacuum lattice sites. The triton, therefore, has to have a nuclear beta particle chain able to bridge two lattice sites and it probably has two protons in close proximity that straddle the lattice charge of one site whereas the antiproton nucleon constituent is seated at the other lattice charge site. Tritium is, of course, radioactive whether in the molecular structure of water or not and so it warrants respect and caution from a health viewpoint.

The Triton Lifetime

This structure already discussed now leads us to the calculation of the decay property of the triton. To proceed we restate part of the commentary in the introduction.

In order to set up the nuclear bond in the form of a chain of beta particles a meson charge has to develop as a charge attracted to the proton. This meson charge is termed a Q charge and its energy is that of the unit cell energy, approximately 413 electrons as already explained. Two opposite polarity charges e, having energy E in electron units represented by P and Q and conforming with the J. J. Thomson formula:

$$E = 2e^2/3a,$$

where a is charge radius, will, when attracted so as to be in surface contact at their charge radii, have a combined energy E' which is given by:

$$E' = P + Q - 3PQ/2(P+Q)$$

This formula is basic to proton creation and was mentioned by the author in *Physics Today*, 37, p. 15 (1984), so we are not introducing something new at this stage in developing the theory of the triton.

In fact P and Q are in equilibrium as an optimum energy condition for which the negative term is a maximum when P is 1836 and Q is 413.

The point of interest is that E' can be calculated to be 92.7 electron mass units below the value of P.

In other words, given that there are two protons well separated by the diameter of the vacuum lattice charge (or a beta particle in the case of a deuteron), we can see how such a system, which features in the triton composition, can deploy twice the energy of 92.7 electron mass units to assist in a nuclear transmutation. This sums to 185.4 electron mass units.

We then note that the stimulus of 4 pairs of virtual mu-mesons, each of 412.7 electron mass units will suffice with the 185.4 electron mass units to create a proton of 1836 electron mass units. In fact, the energy equation is rigorous in providing exactly the amount of energy needed, which is why the decay of a triton yields so little energy that the result has remained a puzzle to scientists.

The scenario of interest is then the action by which the triton can be the seat of a process by which a proton is created within the triton itself so as to force a transmutation.

The condition we are considering is a coincidence event when 8 mu-mesons hit the lattice charge in the same vacuum cycle. If the result is the creation of a proton then the recovery of the equilibrium of the vacuum/matter interaction will involve the demise of a proton in matter nearby.

The task in determining triton lifetime is simply that of determining proton creation probability in a vacuum lattice site charge within matter.

Proton Creation Probability

As already shown, it takes 8 virtual muons to trigger the action leading to the creation of a proton. The question is how to bring 8 muons together for this purpose. There is an active virtual muon pair in each cell of the vacuum medium, that is for each lattice charge (-e), the latter being neutralized, so far as we can sense in our matter frame, by a positive continuum background.

If the positive virtual muon μ^+ enters the lattice charge it will momentarily, in the relevant action cycle, render that charge neutral by converting it to some neutral paired charge form. Therefore, to get 8 muon energy quanta to combine in some way, we need to have 8 lattice charges in close proximity in a state in which either all are transiently neutral or, alternatively, 7 are neutral and one is charged to a double unit level, as by being transiently primed by the addition of μ^- .

Now, the chances of one lattice charge being primed by either muon in its cell are 2 in 5059. There are 256 combinations of chance simultaneous priming of 8 such lattice charges in each action cycle. Table I shows the virtual muon polarity combinations as distributed amongst the various mixed states.

TABLE I

States	μ^+	μ^-
1	8	0
8	7	1
28	6	2
56	5	3
70	4	4
56	3	5
28	2	6
8	1	7
1	0	8

Only the first two entries in this table represent states that can satisfy the merger requirements by creating neutral energy quanta with a single nucleating charge. Thus there are 9 chances in the 256 for the conditions to meet the proton creation trigger requirement. In other words, in every action cycle at the Compton electron frequency we have 9 chances in (5059)⁸ of proton creation referenced on a particular lattice charge.

This gives us a 'lifetime' in the sense that the attempt to create a proton can influence a decay process which sheds a proton, as already explained.

That lifetime is:

$$(5059)^8 / 9(1.235 \times 10^{20}) \text{ seconds or } 12.2 \text{ years}$$

The mean lifetime reported for the triton is 12 years and so this result is a quite remarkable application of the author's theory.

Discussion

Given the above solution to the mysteries of triton decay, it needs little imagination to probe the possibility that a deuteron, in its prevalent state, as two protons sitting on diametrically opposed sides of a central beta-minus particle, could become subject to the stability of a nearby vacuum lattice charge and experience similar proton infusion. In this case, the deuteron would become a triton, whereas in the triton the proton infusion into the two-proton component destroys the beta particle nuclear chain and severs the link with the antiproton component, which thereby becomes involved in a decay which replenishes the virtual mu-meson population of the vacuum.

The deuteron proton infusion process would be accompanied by the demise of a proton elsewhere, but what we would see with two deuterons in close proximity would appear to be one deuteron shedding a proton and a beta minus particle and the other deuteron acquiring a proton and shedding a beta plus particle, which overall amounts to an act of fusion. Two deuterons merge to create a proton and a triton by shedding energy as the two beta particles annihilate one another.

To account for the nucleation of the Q charge forms the less prevalent deuteron ground state composition having five component charges is the best basis for the transmutation under discussion. The central beta particle binds the two proton forms whilst the outer beta particles transform into Q charges to release the extra energy needed to convert the 8 mu-mesons entering the lattice charge target into a proton.

One can develop this theme by investigating the expected excess heat generation rate that could come from the 12 year decay rate for the deuteron ground state and one may further wonder how that process might be accelerated.

However, the main conclusion reached in this work is that there is basis for understanding the cold fusion reaction and the focal issue here is the interpretation of the process by which the triton is naturally radioactive at room temperatures. It is believed that the account presented here will help with that understanding.

The relationships between various physical constants, and the relationships between such constants and the properties of the universe.

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1 Introduction.

This paper describes an investigation that is preliminary in nature. The findings should be judged in that light, for some stem from assumptions that require further study before being accepted as 'safe'.

The purpose of the paper is to outline themes that might merit examination, perhaps during a period of post-graduate study, and to enable advice to be sought on whether such a study might be worthwhile.

2 The concept of 'maximum time'.

It is probable that the universe had a beginning. Many heavenly bodies are observed to be active or in motion. It seems likely that the universe is not static and that it is still evolving from some form of creation at what might be designated as a 'point'. The 'big-bang' theory is a popular hypothesis that describes such an evolution.

It can be argued, therefore, that the age of the universe to date is the maximum period of time that can have existed. The existence of a longer period would imply either that the universe existed before its beginning (which would be absurd) or that we were already in the future (which everyday experience tells us is not so).

This period will be referred to as 'To' and will be used in all cases where a period of time has previously been assumed by others to be infinite.

3 The concept of 'maximum distance'.

It follows from 2 above that the maximum distance that can (at present) exist in the universe is $c \cdot T_o$, where c is the speed of light. This distance is equal to the radius of the universe. (If the universe had a beginning, it seems likely that some light would by now have travelled a distance $c \cdot T_o$ from the point at which the universe began. The universe, therefore, has a radius which is probably now not less than $c \cdot T_o$. Since the speed of light cannot be exceeded, the radius of the universe cannot now be greater than this distance).

Since c is a universal constant, the radius of the universe is proportional to the age of its existence. Its boundary expands at the speed of light.

It may be wondered whether the 'maximum distance' might be the diameter, or even the perimeter, of the universe rather than the radius. However, it is thought that the radius is the correct distance in this context. As pointed out in para 22, we cannot 'see' more than half way to the boundary of the universe, thus implying that the maximum distance we can perceive is $2 \times c \cdot T_0 / 2$.

4 • The concept of 'minimum energy'.

Assuming that Planck's Law and the expression for minimum time referred to above are correct, the minimum energy that can exist in the universe in a measurable form must be of the order of ' h/T_0 ', where h is Planck's Constant and $1/T_0$ represents the minimum frequency that is possible in the universe. (This deduction matches up fairly well with the finding of the Uncertainty Principle that the maximum uncertainty of measuring energy multiplied by the minimum uncertainty of measuring time should be roughly equal to \hbar (h divided by 2π). It is not clear whether the minimum

energy value should be regarded as h/To in all cases or whether it should be modified by factors such as $\frac{1}{2}$, $1/2\pi$, or $1/4\pi$. The value h/To is taken throughout this paper, but comment is made where a different value might make better sense. The energy h/To is roughly 10^{-44} ergs).

5 The concept of 'minimum mass'.

Using the relationship $E = m \cdot c^2$, it follows from the expression for minimum energy derived above that the minimum mass in the universe is $h/To \cdot c^2$.

6 The rest mass of a photon.

It is widely believed that a photon is a massless particle. Certainly, if the photon has mass, this mass must be very small. The speed of light seems to be almost constant over a wide range of frequencies - see Appendix 1 - and, therefore, over a wide range of photon energies. The present accuracy in measuring this speed at almost any frequency is now considerable. Any attempt to account for an increase of photon energy by measuring a small change in the speed of light (thereby enabling an appropriately large

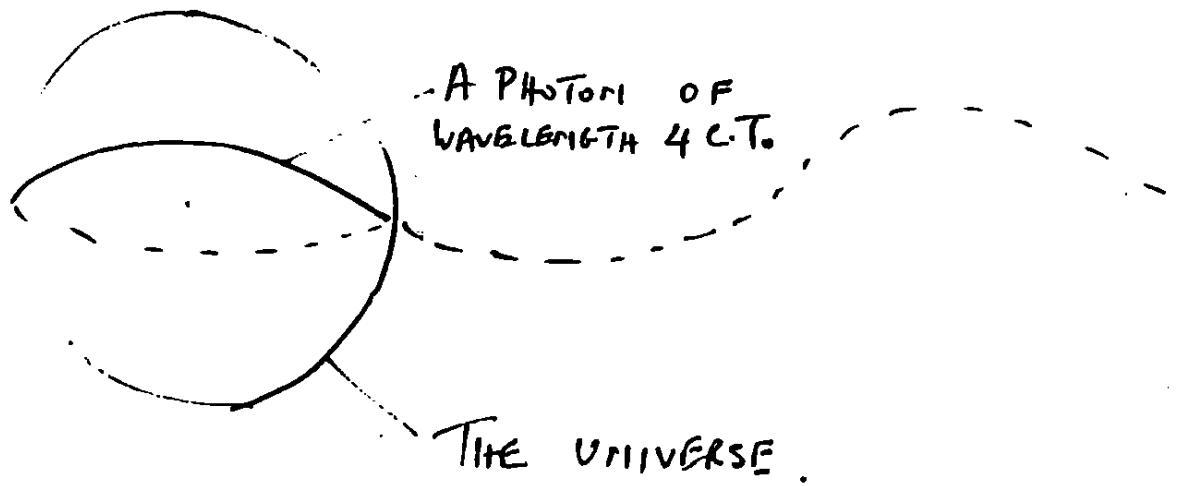


FIG I.

relativistic increase in photon kinetic energy to be predicted in step with increase of photon frequency) will require any rest mass of a photon to be very small indeed. (See Introduction to Quantum Physics - French and Taylor - p 56).

However, a photon of energy h/τ_0 would have a frequency of $\frac{1}{\tau_0}$ and thus a wavelength of $c\tau_0$, equal to the radius of the universe. If this wavelength were increased to $4 \times c\tau_0$, such a photon would be stationary with respect to an observer at the centre of the universe - see fig 1. It is proposed, therefore, that $h/\tau_0 \cdot c^2$ should be regarded as the approximate rest mass of the photon and should be referred to as M_p .

M_p is very small - approximately 10^{-66} grammes. This is far too small to be revealed by any variations that are currently measurable in the velocity of light. Indeed, it has been calculated that, in view of the accuracy of contemporary measurements, any rest mass of the photon would have to be less than 10^{-44} grammes (see French and Taylor), so a rest mass of the size of M_p is not precluded.

7 The concept of 'maximum mass'

The maximum mass that is now possible is the present mass of the universe. It is obvious that this maximum cannot be smaller than the mass of the universe and it is equally obvious that it cannot be greater.

The size of this mass can be deduced as follows. Another route to determining minimum energy is to consider the gravitational energy of a particle of minimum mass M_p located at the boundary of the universe. This minimum energy is given by $M_p \times G \cdot \mu / R_o$ where G is the Gravitational Constant, μ is the mass of the universe, and R_o is the radius of the universe (which is equal to $T_o \cdot c$).

• That the gravitational energy of such a particle is equal to the minimum energy is probable. It is not possible to obtain a smaller energy by reducing the mass of the particle, for this mass is already as small as it can be. It is not possible to reduce the mass of the universe (including the particle) for this mass grows with time, and it is not possible to increase the separation of the particle from the centre of the universe beyond its deduced size of $c \cdot T_o$. Any attempt to reduce this gravitational energy by moving the particle towards the centre of the universe would cause the particle to gain mass to offset the change in gravitational energy.

It can be deduced, therefore, that

$$h/To = h/To.c^2 \times G.Mu/c.To.$$

This yields the relationship

$$Mu = C^3 .To/G,$$

a finding that indicates a mass of approximately 19×10^{55} grammes, assuming an age of the universe of 4.7×10^{17} seconds (15 billion years). This agrees quite well with current predictions (eg that the universe has 10^{80} particles) - see 'The Meaning of Time' by Professor Stephen Hawking. It is interesting that Sir Arthur Eddington in 'The Expanding Universe' predicted that the Mu should be given by the expression $\frac{1}{2} Ro.c^2 / 2G$, but suggested that Ro was only a tenth or so of the value given by $c.To$.

Another method of obtaining the predicted mass of the universe is as follows. Consider a minimum mass at the boundary of the universe rotating with minimum angular velocity $1/To$ about a central mass equivalent to Mu. Assume the gravitational force on the particle balances the centrifugal force.

$$h/To.c^2 \times 1/To^2 \times To.c = h/To.c^2 \times Mu \times G / c^2 .To^2 ., \text{ from}$$

which Mu is again $c^3 .To/G$.

8 The existence of 'maximum/minimum pairs'

In para 7 a maximum value μ for mass was predicted. This can be compared with the minimum value M_p calculated in para 5. The quotient μ/M_p is equal to $c^5 \cdot T_o^2 / Gh$ - an outcome that appears to be common with respect to all quotients arising from such pairs.

For example, minimum length can be calculated by moving a minimum mass very close (i.e. minimum distance) to the maximum mass in order to yield the maximum energy in gravitational terms. This leads to the equation

$$c^5 \cdot T_o / G \text{ (maximum energy)} = h / T_o \cdot c^2 \times c^3 \cdot T_o / G \times G / L_m,$$

where L_m is the minimum distance that is possible.

This yields the expression for L_m of

$$G \cdot h / c^4 \cdot T_o.$$

The maximum length, R_o , is equal to $c \cdot T_o$, which again leads to the quotient $c^5 \cdot T_o^2 / G \cdot h$. A table of max/min pairs is given in Appendix II.

9 The meaning of infinity.

The quotient $c^5 \cdot T_0^2 / G \cdot h$ is a very large number - roughly 10^{120} ! It is also dimensionless. Since it represents the maximum mass (the universe) divided by the mass of the smallest particle that can exist, this quotient represents the maximum number of particles that could theoretically exist in the universe. (The actual number of particles in the universe may be quite different as many are very massive compared with the minimum mass that is being considered - see Eddington).

It is difficult to imagine a larger number than this - not only because this number is very large but also because it is hard to see how a larger number could be derived that would have any physical meaning. It is proposed, therefore, that this quotient be regarded as 'infinity'.

10 The meaning of 'In the Limit'.

It is often necessary, for example in differential calculus, to reduce a variable 'x' to a limiting value 'dx'. It is normally assumed that this value tends to zero. This assumption, however, may not be true. If the variable in question is dimensionless, its minimum value will be the reciprocal of the value of infinity given above. If

the variable has dimensions, it seems that its limiting value will correspond to the appropriate minimum as given in Appendix 2. The consequences of such a proposal could be far-reaching. For example, the validity of the Dirac Delta Function (see 'The principles of Quantum Mechanics - P A M Dirac) would have to be questioned. Further study in this area might, therefore, be productive.

11 The continuous creation of matter.

Such a process has been proposed before (Hoyle) but did not predict a distribution of matter in the universe that was compatible with observation (see The Meaning of Time - Hawking).

The model of the universe described in para 7 has a gravitational potential at its extremity of $-G \times \frac{3}{c^3} \cdot T_o / G \times 1/c \cdot T_o = -\frac{3}{c^2}$. Thus a particle of mass M at this point would have a mass energy of $M \cdot c^2$, but a gravitational energy of $-M \cdot c^2$. The creation of such a particle would thus introduce no net energy gain or loss into the universe. It is suggested that, under these circumstances, particles will appear 'out of the blue'. It is also suggested that they are likely to have the minimum permitted mass, $h/c^2 \cdot T_o$. If particles can exist with such

a mass, why would any particle emerge from a process of spontaneous creation with a greater mass?

12 An expanding universe.

The general theory of relativity requires that the universe should expand. The universe described by the model in this paper will also expand. In fact, because its radius is $c \cdot t$, the boundary of this universe expands at the speed of light.

However, it is proposed that new matter is being continuously created at this boundary (see para 11). Consequently, the original universe at its beginning would have been small. Such a process of growth could account for the very uniform appearance of the universe as perceived by the observer as his view sweeps across the sky. Whether it could also account for the observed distribution of matter as a function of distance from the observer is a question that needs investigation.

13 The beginning of the universe.

The mass of the universe M_u increases with time. Consequently, this mass must have been less when the universe was younger - a deduction that conflicts with the Big Bang theory. Depending on when its beginning took place, the universe may have started its life very small indeed.

We also know that the smallest possible particle of mass M_p becomes smaller with the passage of time. Consequently, the mass of such a particle must have been much larger in the early years of the universe. It seems reasonable to deduce that at some point these two values would have been equal and that this conjunction would have marked the beginning of the universe.

Suppose, then, that the universe at its beginning was a single particle. Such a particle would still have to have a mass of $c^3 \cdot T_0/G$, although T_0 would be very small and would, in fact, be equivalent to the frequency of a photon of this mass equivalent as given by Planck's Law. The particle would also have to comply with the law of minimum mass. Thus its mass would also be given by the expression $h/c^2 \cdot T_0$.

This leads to the equation $h/c^2 \cdot T_0 = c^3 \cdot T_0 / G$, from which it follows that, under these circumstances, T_0^2 is equal to $G \cdot h / c^5$. This value of T_0 is the so-called 'Planck Time'. It is obtained by deriving absolute values for mass, length and time from the dimensions of 'c', 'h' and 'G' - see attached note.

Substituting for T_0 in either the expression for minimum mass or the expression for maximum mass indicates that the universe at this point had the Planck Mass and, similarly, the Planck Length. According to this model, therefore, the universe began with a particle described by the Planck mass, length and time - ie a 'Planck Particle'. This is welcome news in that it provides, perhaps for the first time, a consistent set of meanings for these three parameters and also because it avoids the huge energies associated with the 'Big Bang' model. Whether a 'Planck Particle' as described above could spontaneously appear - as might be permitted by the Uncertainty Principle - for long enough to initiate the creation of the universe is a matter that requires further study.

A mass equivalent to the Planck Particle described above would be a small 'primordial' Black Hole (Hawking). What bearing this has on the process described above also requires study. However, it has been shown theoretically that Black Holes should radiate, and that the smaller the

Black Hole, the more vigorous the radiation should be (Hawking). Thus, being a Black Hole may not in this regard prevent the Planck Particle from performing the role of 'universe creator'.

Note - it is interesting that the Swarzschild radius (the critical radius to which matter must be compressed in order to form a Black Hole) is given by $2GM/c^2$, where M is the mass concerned. (See Penguin Dictionary of Physics).

Putting this radius equal to $c \cdot T_0$ gives $Mu = c^3 \cdot T_0 / 2G$, very similar to the finding of para 7.

This leads to the interesting deduction that the universe is, itself, a large Black Hole. In other words, it is proposed that the universe began as a very small Black Hole, which grew in size as it consumed the matter created spontaneously at its boundary, and thereby reached its current enormous size.

- 14 The relationship between gravitational potential and frequency.

It was shown by Einstein that the frequency of radiation is modified by change in gravitational potential.

Such modification was described by the relationship:

$$\nu = \nu_0 \left(1 + \phi/c^2 \right)$$

where ν_0 is the initial frequency of the radiation, ν is the final frequency, and ϕ is the difference in gravitational potential.

It was stated by Einstein that this relationship is an approximation. If this approximation is resolved - see Appendix 3 - the relationship becomes:

$$\nu = \nu_0 \sqrt{1 + 2\phi/c^2}$$

Note - this expression is probably not exact due to the second approximation used by Einstein in his paper. It should, however, be a good approximation where ϕ is small compared with c - see Appendix 3. Its form is similar to that of the equivalent transformations derived for the Special Theory of Relativity, and it is suspected it may, therefore, be of some relevance.

Present observers report that the spectra of distant objects are shifted towards the 'red'. It has been assumed that this shift is caused by the Doppler effect and, thus, that all such bodies are receding from us. Hubble's Law states that the magnitude of this recession is proportional to the distance between the body and the observer - a law that is based upon observation and is now the main basis for the Big Bang theory.

However, the model of the universe described in this paper could account for this red shift in terms of the effect described in para 14. The gravitational potential at the boundary of the universe is $-C^2$ (see para 11), sufficient (using Einstein's relationship) to reduce the frequency of any radiation reaching the centre of the universe from its boundary to zero! However, Hubble's Law requires that this potential should vary linearly with distance (over the distances for which observation is possible) - a requirement that has implications for the model of the universe to be selected.

- 16 A universe with total mass M_u proportional to its radius R_o .

The prediction that the mass of the universe is $c^3 \cdot T_o/G$ suggests such a universe. However, the gravitational

potential within such a universe (except at the very centre) is everywhere the same and is equal to $-c^2$. The observed linear shift of frequency with distance is not compatible with such a model.

- 17 A universe with total mass Mu proportional to the square of its radius Ro .

Such a universe would have a mass proportional to the square of To . The gravitational potential would vary linearly from a 'maximum' value at the boundary to zero at the centre, and would be compatible in this regard with Hubble's Law. However, this model is not compatible with the prediction that $Mu = c^3 \cdot To/G$, unless G is a function of To (c being constant) and, in fact, is equal to A/To , where A is a constant. The precise value of To is not known but, according to current estimates, A would have a numerical value similar to that of the speed of light, but would have to have different units.

- 18 A universe with total mass Mu proportional to the cube of its radius Ro .

This is the sort of universe that conventional geometry might suggest. Extending the argument outlined in para 17, the existence of such a universe would imply that G varies as the inverse square of T_0 . However, gravitational potential would then vary according to the square of distance and would not be in keeping with Hubble's Law.

19 The selection of universe model.

The type of universe described in para 17 is selected as the most probable model for it is the only one that is consistent with experimental observation - Hubble's Law. (It is assumed that the Big Bang theory is not the correct explanation for the red shift phenomenon due to the conflict between this theory and the deduction that the mass of the universe increases with time).

This selection requires that the gravitational constant ' G ' should vary inversely with the age of the universe. This is an innovation but may not have been noticed so far due to the very small rate of change in the value of ' G ' thereby required.

Whether the selected model is consistent with the observed distribution of matter in the universe (i.e. density of

matter as a function of distance from the observer) requires investigation.

It is necessary to explain why the selected model does not cause the universe to collapse into its centre, due to gravitational forces. The explanation is that, arising from the max/min theory explained earlier in this paper, angular velocity and angular momentum cannot fall below certain minimum values. Consequently, a spontaneously created particle will rotate about the centre of the universe with an angular velocity of $1/T_0$ and will experience a centrifugal force of $M_p \times c \cdot T_0 \times 1/T_0^2$. The gravitational force in the other direction will be $c^3 \cdot T_0 / G \times M_p \times G \times 1/c^2 \cdot T_0^2$. These forces are equal and opposite. The angular momentum of the particle is $M_p \times c \cdot T_0 \times 1/T_0$. Putting M_p equal to $h/c^2 \cdot T_0$ shows that the angular momentum of a spontaneously created particle is h - the value that is to be expected.

20 Predicting the age of the Universe

The mass of a thin shell of radius r located symmetrically about the centre of the universe is

$$4\pi r^2 \cdot dr \cdot N \times \frac{h}{c^2 t}$$

where N is the no. of minimum-mass spontaneously-created particles per unit volume,
 t is the age of the universe when these particles were created, and
 $h/c^2 \cdot t$ is the mass of each particle.

As $r = c \cdot t$, the mass of the shell is

$$\frac{4\pi r^2 N h dt}{c}$$

The mass M_u of the whole universe is, therefore,

$$\int_0^{cT_0} \frac{4\pi r^2 N h dr}{c} = 2\pi N h c T_0^2$$

This must equal $c^3 \cdot T_0 / G$, the expression for M_u derived in para 7.

Consequently,
$$N = \frac{c^2}{2\pi h T_0 G}$$

However, it seems probable that $G = A/T_0$ (para 17), so

$N = c^2 / 2\pi h A$. In other words, $N \cdot h$ is a constant.

This expression for N can be substituted back into the expression for the mass of the universe.

$$\begin{aligned}
 M_u &= \int_0^{cT_0} \frac{4\pi r^2 h}{c} \cdot \frac{c^2}{2\pi h A} \cdot dr \\
 &= \int_0^{cT_0} \frac{2c r dr}{A} = c^2 T_0^2 \frac{c}{A} = R_0^2 \frac{c}{A}
 \end{aligned}$$

Note - if c is numerically equal to A, $M_u = R_0^2$.

Correspondingly, the mass of an 'inner sphere' of the universe will be given by the expression $R^2 c/A$, where R is the radius of such a sphere.

The gravitational potential at the surface of this sphere will be $-G.R^2.c/A.R$, the outer shells beyond the surface of the sphere contributing zero to this potential. This reduces to $-R.c/To$ or $-R.c^2/R_0$.

It was shown in para 14 that the frequency of radiation varies with gravitational potential ϕ according to the relationship

$$V = V_0 \sqrt{1 + 2\phi/c^2}$$

Substituting $\phi = -\frac{Rc^2}{R_0}$ yields the expression

$$V = V_0 \sqrt{1 - 2R/R_0}$$

For values of R that are small compared with R_0 , this reduces to

$$V = V_0 \left(1 - R/R_0\right)$$

This is in accordance with Hubble's Law.

In Appendix 4 the graph shows how 'velocity' is observed to vary with distance. The galaxy 'Hydra' is 2.0×10^9 light years away and appears to have a speed of recession of 6×10^9 cm/sec.

Using this fact and the simplified 'linear' relationship above indicates a value of T_0 of 10×10^{10} years.

However, using the revised version shows that the frequency of observed radiation will have declined to zero when $R = R_0/2$, thus indicating a value of T_0 of 20×10^{10} years. These values agree well with the spread of estimates given in the current literature.

21 The possibility that h may also be a function of the age of the universe.

It was shown in para 20 that $N.h$ is a constant, where N is the number of particles per unit volume that it is proposed are spontaneously created at the boundary of the universe. It is possible that both N and h are constants. However, other solutions are also possible. In particular, it may be that $N = K.T_0$ while $h = B/T_0$, where K and B are dimensioned constants. Is there any evidence for such a suggestion?

Frequency is observed to decrease with distance. The perceived energy of a distant event - as expressed by Plank's Law - might be expected also to decrease with distance. If it is assumed that energy does not transform with distance, it becomes necessary to deduce that h increases as we look at distant bodies (i.e. as we look backwards in time) in a manner that will enable the product $h.v$ to remain constant. This argument suggests that h varies inversly with T_0 as the event being observed becomes more distant.

The only other evidence for proposing that h varies in this manner - and it is slight - is that there appears to be an exact numerical relationship (in cgs units) between G and h of the form

$$G = \frac{h \times c^2}{16 \sqrt{\pi} \cdot \pi}$$

thus implying that both G and h are inversely proportional to T_0 . This numerical relationship may be no more than coincidence. On the other hand, it is possible to imagine that the factor $\sqrt{\pi}$ might arise from statistical considerations - e.g. normalised Gaussian Distributions - and that the factor 4π might come from the Uncertainty Principle in its form $\Delta E \cdot \Delta t = \frac{h}{4\pi}$. Dimensional difficulties associated with this proposal would have to be dealt with by introducing an appropriate dimensioned constant,

At present, therefore, there is some basis for proposing that h might be a function of T_0 . However, if true, such a proposal would cause all fundamental physical constants to depend upon just two factors: one the speed of light (a true constant) and the other the age of the universe (a quasi-constant).

22 The motion of the galaxies.

The implication of the arguments put in this paper is that, although the universe expands through the continuous creation of matter at its (expanding) boundary, the galaxies etc that have been formed by the subsequent coalescing of such matter have little or no radial motion.

23 The transformation of time and distance with distance and time.

The implication of deducing that red shift is caused by the gradient in gravitational potential is that frequency and, therefore, time transform with distance.

The expression $V = V_0 \sqrt{1 - 2R/R_0}$ was derived in Appendix 3.

This can be written as $\lambda = \lambda_0 / \sqrt{1 - 2R/R_0}$ treating

the speed of light as being constant throughout the universe.

If we write λ_0 as dR , we can integrate as follows to yield the perceived distance of separation R' as a function of the true distance R .

$$R' = \int_0^R \frac{dR}{\sqrt{1 - 2R/R_0}} = \left[-R_0 \sqrt{1 - 2R/R_0} \right]_0^R$$

$$= -R_0 + \sqrt{1 - 2R/R_0}$$

if $R = R_0$, $R' = R_0 [1 - 1]$

This implies that the radius of the universe (and consequently T_0 as well) are part real/part imaginary. Note, however, that this calculation needs to be reworked to take account of the second approximation referred to in para 14.

24 Imaginary time and distance.

It was suggested above in para 23 that distance (and, consequently, time) have real and imaginary components. This is not surprising. The model of the universe described above does not permit the observer to 'see' more than halfway to its boundary. Radiation commencing at the point of the creation of the universe can only, in the maximum time T_0 , travel half the distance to the present boundary and then back to the observer - assumed to be near the centre. Distances beyond halfway may, therefore, contain an imaginary component. As the radius of the universe is $c.T_0$, half of this distance could be regarded as imaginary. However, the product $c.T_0$ has had many different values during the life of the universe and has ranged from the

minimum possible distance to the maximum possible distance. It follows, therefore, that $c \cdot T_0$ may be part real/part imaginary for all values of distance and thus for time.

25 The minimum electric charge.

A system consisting of a minimum electric charge at the boundary of the universe acting upon a similar charge at the centre of the universe should, due to electrostatic forces, possess the minimum energy, h/T_0 . (It is hard to imagine how a smaller amount of energy could be generated by electrostatic means).

This leads to the equation:

$$e^2 / c \cdot T_0 = h / T_0, \text{ or } e^2 = h \cdot c,$$

where e is the minimum charge that is possible and, by this equation, is equal to 1.409×10^{-8} esu.

The electron might be considered to have an angular momentum of $\hbar/2$. This can be equated with $M_e \cdot r^2 \cdot \omega$, or $\frac{1}{2} M_e \cdot r_0^2 \cdot \omega$, where M_e is the mass of the electron, r is its radius of gyration, r_0 is its physical radius, and ω is its angular velocity.

The electron is unlikely to have a surface velocity of more than c at its equator. This means that we can try the relationship $\hbar/2 = \frac{1}{2}Me.ro.c.$

Putting $e^2/ro = Me.c^2$ gives $ro = e^2/Me.c^2$ and eliminating ro yields $e^2 = \hbar.c^2$, similar to the expression above, which supports the concept being proposed.

However, the charge of the electron is measured in the laboratory to be 4.803×10^{-10} esu, smaller than the charge calculated above by a factor of 29.34. Why? If the minimum energy were $h/4\pi.To$, rather than h/To , this ratio would be reduced (8.27), but would not be eliminated.

This subject is not new. It has surfaced before but as a debate about the nature of the fine structure constant. This constant ($h.c/2\pi e^2$) is dimensionless and is roughly equal to 137. An attempt to explain this fact was made by Sir Arthur Eddington assuming that the value of this constant is an exact integer. It is now doubted that this is so.

Is it possible that the perceived charge of the electron is smaller than its true charge? Is it possible that, consequently, the radius of the electron is considerably larger ($\times 860$) than the figure of 2.8×10^{-13} cm, as quoted in all the text books?

Such findings might be attributable in part to relativistic effects associated with the spinning motion of the electron. This possibility deserves investigation, though it may not yield an effect that is sufficient to account for the discrepancy referred to above.

Alternatively, charge may transform with distance, which would require modification to the model used for determining the value of the minimum charge. For example, it was assumed above that energy does not transform with distance. If the energy of the electron is given by the expression e^2/r , the deduction that incremental length dilates with distance implies that charge may also vary with distance, but as the square root of the distance concerned.

This reasoning means that the value of minimum charge deduced above should be modified by a factor. This factor depends upon the radius of the universe and also upon the distance of The Earth from the centre of the universe. It is assumed that the centre of our own galaxy is this centre (or is even a centre) and that the distance of the Earth from this centre is approximately 30,000 light years. As perceived by an observer on Earth, a minimum charge at the boundary will be inflated by a factor of $\sqrt{15 \times 10^9}$ but a similar charge at the centre of the universe will be reduced by a factor of $\sqrt{30,000}$.

The model for calculating the value of the minimum charge is now different and the minimum charge is given by the expression

$$\frac{e}{\sqrt{30,000}} \times e \sqrt{15 \times 10^9} = \frac{h}{T_0}$$

This causes the predicted value of the minimum charge to be reduced by a factor of 26.6 - fairly close to the difference of 29.3 quoted above.

26 Summary

Starting from the assumption that the universe had a beginning, minimum and maximum values are deduced for many parameters. The predicted values for the mass of the universe, the age of the universe, and the Hubble red shift agree roughly with current estimates. The predicted value for minimum charge is considerably larger than the measured charge of the electron - a finding that may open the way for a further assessment of true (as compared with perceived) electronic charge and radius.

A mechanism for the creation of the universe is proposed which involves deducing that the Gravitational Constant varies as the inverse of the age of the universe. It is shown that Planck's Constant may also vary in this way which leads to the suggestion that the only two fundamental 'constants' in the universe are the age of the universe and the speed of light.

As was pointed out in the Introduction, this paper is preliminary in nature. Should any of the ideas have value, guidance on how they might be developed - perhaps during an appropriate period of post-graduate study - would be received with much gratitude.

THE ABOVE PAPER WAS READ AT AN EARLIER MEETING OF ANPA, BUT WAS INADVERTENTLY OMITTED FROM THE PROCEEDINGS. THE WORK IS CARRIED A STEP FARTHER IN THE FOLLOWING PAPER:

ABSTRACT

The quantisation of gravitational potential and its consequences upon galactic redshifts.

This paper is the third of a sequence of papers that develop a theory of quantised variables. It is argued that gravitational potential should possess levels at the following values: $c^2/2$, $c^2/3$, $c^2/4$ and at fractional values such as $2c^2/5$, $3c^2/7$ Estimates are made of the quantisation of redshift of distant galaxies (and quasars) that should result from such a prediction.

A literature search reveals that many observers have reported 'bunching' or 'clustering' of galactic redshifts (although no theoretical cause for such an effect has gained acceptance). The analysis given in this paper of the observed quantised redshifts of 'nearby' galaxies suggests that the Solar System is in a region where the potential difference with respect to the centre of the universe is $c^2/67$. This finding is used to predict the quantisation of redshifts of distant galaxies and quasars ($z > 0.06$). It is discovered that the resulting predictions match the reported observations as yielded by the literature search. It is deduced that the upper limit of observable galactic redshift is 4.79.

THE QUANTISATION OF GRAVITATIONAL POTENTIAL AND ITS CONSEQUENCES UPON GALACTIC REDSHIFTS

1 INTRODUCTION

This paper is the third in a sequence of papers presented to ANPA in order to develop a theory of quantised variables.

In the first paper (presented at ANPA 13 and referred to as Paper 1) it was argued that the maximum detectable period of time is the age of the universe and that, hence, all fundamental variables are quantised, having both maximum and minimum values.

In the second paper (presented at ANPA 14 and referred to as Paper 2) it was shown that producing a derived variable by dividing one fundamental (quantised) variable by another leads to a quantisation of the derived variable such as is seen in the quantised Hall Effect, where Hall resistance values of $h/2e^2$, $h/3e^2$, $h/4e^2$ are observed, and as in the Fractional Quantised Hall Effect, where Hall resistance values of $4h/3e^2$, $3h/5e^2$, $3h/7e^2$ etc are observed.

2 THE QUANTISATION OF GRAVITATIONAL POTENTIAL

Gravitational potential (ϕ) is typically of the form

$$\phi = -G.M/R, \quad (1)$$

where G is the gravitational constant, M is a mass and R is a distance. Assuming that G remains constant in all circumstances, ϕ is the result of dividing one fundamental variable (M) by another (R). We expect, therefore, that in appropriate circumstances ϕ should display quantisation similar in form to that shown in the Quantised Hall Effects.

It was shown in Paper 1 that the minimum quantum of mass is given by

$$M_{\min} = \hbar/c^2 \cdot T_0,$$

where T_0 is the age of the universe (in seconds), and c is the speed of light.

It was also shown that the minimum quantum of length (R) is given by

$$R_{\min} = \hbar \cdot G / T_0 \cdot c^4.$$

If we put $\phi = -G \cdot M_{\min} / R_{\min}$,

we find that $\phi = -c^2$.

If two or more quanta of mass and/or length are inserted into equation (1), ϕ will have a series of values such as:

$$-c^2/2, -c^2/3, -c^2/4, -2c^2/5, -3c^2/8\dots\dots,$$

and so on. Such values are equivalent to the values (fractional and otherwise) observed in the Hall Effects referred to above.

The purpose of this paper is to explore the consequences that might arise from such quantisation of potential in order to find out whether they are confirmed by observation.

3 THE THEORETICAL CONSEQUENCES OF THE QUANTISATION OF GRAVITATIONAL POTENTIAL.

When light flows across a difference of (gravitational) potential it is well known that, according to the General Theory of Relativity, its frequency is modified. That such modification takes place has been confirmed by experiment.

If the potential difference is small in comparison with c^2 , such modification is in accordance with the expression:

$$\delta v/v \approx \delta\phi/c^2, \quad (2)$$

where v is the frequency of the radiation, δv is the observed frequency shift and $\delta\phi$ is the difference in potential.

If the potential difference is significant in comparison with c^2 , the relationship can be written

$$v' = v_0 / (1 - 2\delta\phi/c^2) \quad (3)$$

where v' is the observed frequency and v_0 is the initial (emitted) frequency.

(Note: equation 3 is often quoted in the form

$$v' = v_0 / (1 - \phi_1/c^2) / (1 - \phi_2/c^2), \quad (4)$$

where ϕ_1 is the potential at the point of emission and ϕ_2 is the potential at the point of observation. These equations give similar results except at very high redshifts (or blueshifts).

It is believed that equation 4, which is derived from the external solution of the Schwarzschild metric, may be incompatible with the situation that obtains inside a 'dust-filled' universe, particularly when values of ϕ approach

$c^2/2$. Equation 3, which can be derived from the fundamental considerations of Einstein in this field, may in such circumstances be more appropriate).

Hence, if reddening of radiation is observed, ie if radiation has 'climbed' out of a 'potential well', $\delta\phi$ must be less than $c^2/2$.

That all points in the universe might be at the same potential seems inherently unlikely. If the universe has a boundary, which is the case for the model being considered in Paper 1, it seems probable that potential will vary between periphery and centre and, further, that such variation might be substantial.

A major cause of variation in potential throughout the universe arises from the argument - developed in Paper 1 - that the minimum linear acceleration is $-c/To$. This finding can be justified simply as follows. The minimum angular velocity is $1/To$. Thus the minimum radial acceleration, ie that experienced at the periphery of the universe, is $-1/To^2 \times c.To$, which gives the result stated above. The minus sign indicates that the minimum acceleration is retarding in nature as one travels from periphery to centre. In travelling thus, the energy lost is $c/To \times c.To$, or c^2 . Light taking this path would thus be appropriately reddened.

Another cause of variation in potential throughout the universe arises from gravitational attraction. It was proposed in Paper 1 that the mass of the universe (the maximum mass that is possible) is $c^3.To/G$, a prediction that agrees reasonably well with current estimates. On Newtonian arguments the potential difference between the surface and centre of a massive sphere is $-GM/2R$, which yields a potential difference in the case of the universe of $-c^2/2$.

Light travelling from periphery to centre would, due to gravity, descend a potential hill and would thus be blue-rather than red-shifted. Hence, the combination of both effects would be a reddening of light, equivalent to a net potential difference of $c^2/2$ between periphery and centre.

The use of Newtonian principles in this context needs some justification. It is widely believed that the universe is best described by the so-called Robertson-Walker metric, an equation derived by assuming that the universe is isotropic and is effectively 'dust-filled', with no internal pressure gradient such as might be encountered inside a star.

This metric leads to the Friedman Equation for the energy balance inside such a universe:

$$\dot{R}^2 - G.4/3.\pi.R^2p = \text{Constant},$$

a straightforward Newtonian balance between potential and kinetic energy that would seem to support the Newtonian approach taken above.

If such a net potential difference exists, it might be possible to confirm its presence by detecting effects that arise from the quantisation of potential referred to above. For example, the predicted levels in potential should, if they exist, cause the redshifts of distant bodies to be bunched into regular, predictable and observable patterns.

It will be assumed that the Solar System is not at the centre of the universe and that, consequently, we are located within a particular quantised level of potential. It is assumed further that we are not at a point where any fractional effect obtains and, hence, that we are located at the n th level where ' n ' is an integer.

As we explore space towards the periphery of the universe, we shall at some point encounter a different level of potential and will thus experience a step change in potential of magnitude

$$c^2\{1/(n - 1) - 1/n\}$$

and then a series of further steps given by the general expression

$$c^2\{1/(n - x - 1) - 1/(n - x)\}, \quad (5)$$

where x is another integer such that $n > x > 0$.

The existence of such steps should cause marked quantisation of galactic redshifts. Whether such quantisation can be observed is, therefore, an important test for the theory.

4 THE OBSERVED QUANTISATION OF GALACTIC REDSHIFTS

A literature search reveals that a surprising number of academic papers have been published during the last twenty years or so reporting that the redshifts of distant bodies are in some way 'bunched' or 'clustered'. Such papers can be grouped under two broad heads: those that claim a periodic quantisation (typically equivalent to steps of 70 - 75 km/sec in recessional velocity) of the redshifts of relatively nearby galaxies; and those that claim a logarithmic quantisation in the redshifts of very distant galaxies, such quantisation being equivalent to large increments (eg 0.1c) in 'recessional velocity'.

No link between these two effects has been proposed nor has any theoretical explanation for either gained acceptance. Indeed, some of the papers in this field have been received

with scepticism, particularly as other workers, who have sought to confirm the alleged periodicities of redshift by analysing samples of galaxies of widely varying redshifts, have failed to provide conclusive evidence that periodicity occurs. (It should be noted, however, that the theory proposed in this paper does not predict a straightforward periodicity of redshift).

On the other hand, the validity of the experimental evidence that was relied on for proposing the existence of such effects has survived criticism and has, therefore, to be accepted as valid. This enables us to proceed by examining this evidence to see whether it confirms the predictions that flow from the theory being proposed.

4.1 THE QUANTISATION OF REDSHIFTS OF 'NEARBY' GALAXIES

The published material in this field includes the following papers, which are here summarised as follows.

TIFFT 1976

This paper contains an investigation of differential redshifts of separate bodies within individual nearby galaxies.

Having applied corrections for the Doppler shifts that arise from the known rotations (and hence local radial velocities) of some galaxies, there is clear evidence that some separate bodies within such galaxies have redshifts that are quantised into levels corresponding to increments of 70 - 75 km/s of recessional velocity.

For example, Fig 1 shows the bodies observed in the Galaxy M51 and reveals that such bodies are grouped into distinct sets. Fig 2 is a histogram of the redshift data of M51 (corrected for rotation) clearly showing peaks separated by 70 - 75 km/sec.

Such observations are repeated for other nearby galaxies including NGC 2903, M 31 (several sets of data) and the Magellanic Clouds, a mean quantisation of red-shift of 70 - 75 km/sec being observed in all cases.

ARP AND SULENTIC - 1985

Using data of better accuracy than was available to Tifft, these authors examine groups of galaxies and establish that small galaxies in galaxy groups are sometimes redshifted with respect to the largest galaxy within in the group.

Furthermore, such redshift differentials are quantised, nearby galaxy groups (M81 and M31) showing discrete levels of redshift broadly in accordance with the findings of Tifft.

Fig 3 shows a histogram of the redshifts of small galaxies surrounding M81 and M31, peaks being clearly visible.

M81 has a redshift with respect to our own galaxy of 99km/sec and M31 has a redshift of -58 km/sec (both values having been corrected for solar velocities caused by the rotation of our own galaxy). The authors note that a careful measurement of the redshift peaks suggest quantisation at 68 km/sec, not 70 - 75km/sec as indicated by Tifft as the result of measurements on somewhat more distant galaxies (eg M51) that display somewhat larger intrinsic redshifts.

If 68 km/sec is taken as the appropriate redshift quantisation that obtains for the part of the universe occupied by the Solar System, the number (n) of the local potential level can be calculated using equations 2 and 5 as follows.

$$\delta v/v = \delta\phi/c^2 = 1/(n - 1) - 1/n = 1/n(n-1)$$

But $\delta v/v = V/c$, where V is the recessional velocity

$$\text{Hence, } n^2 - n - c/V = 0 \quad (6)$$

or $n^2 - n - 4411 = 0$ (using $V = 68$ km/sec), giving $n = + 67$

In view of the inaccuracies in determining local redshift quantisations, it is estimated that $n = 67 \pm 2$, such an error range being equivalent to a spread of V of 64 - 72 km/sec.

Table 1 shows the quantisation levels of redshifts that are to be expected at redshifts in the range 0 - 1000km/sec. These levels increase with distance/redshift and are not periodic. It is of interest that within M51 - a galaxy with a mean (but uncorrected for rotation of our own galaxy) recessional velocity 480 km/sec - a quantisation level of 82 km/sec can be predicted - which is similar in scale to the redshift quantisation observed in this location by Tifft.

TIFFT 1977

In this paper Tifft examines the redshifts of galaxies in the Coma cluster. The redshifts of such galaxies are in the range 6,500 - 8,000 km/sec. There is evidence of quantisation of differential redshifts between such galaxies - see Fig 4.

The observed level of redshift quantisation in this case is 222 km/sec, not 70 - 75 km/sec as measured with much closer galaxies. The author noted that 222 km/sec is almost exactly three times larger than the redshift measured for much closer galaxies and suggested that, for some reason, the 'missing' peaks had not been detected.

There may, however, be another explanation. Using equation (6), we can determine the number of the potential level that corresponds to a redshift quantisation of 222 km/sec.

$$n^2 - n - 300,000/222 = 0$$

which solves to give $n = 37$.

The potential difference between this level and that occupied by the Solar System is

$$c^2(1/37 - 1/67).$$

The redshift that would be observed resulting from such a potential difference is 3,600 km/sec. This is of the same order as that actually observed, but differs from it by a factor of approximately two.

It is possible that the balance of redshift - ca 3,600 km/sec - arises from an actual but random recessional velocity (of such a size) between the Coma group of galaxies and the Solar System. Throughout the universe random velocities of such a size are far from uncommon.

On the other hand, it is possible that a significant and systematic contribution to observed redshifts (say 50%) is produced by true recessional velocity (in accordance with expanding universe theories) upon which additional (quantised) redshift due to gravitational potential is superimposed. Whether this is so might be resolved by observing the constituent bodies in other distant groups of galaxies to see whether both the mean redshift of the group and differential redshifts between individual galaxies can be fully accounted for by the theory of quantised potentials being proposed, or whether there is a substantial and systematic redshift component of the entire group that remains unaccounted for.

GUTHRIE AND NAPIER 1988.

In order to test the findings of Tifft, Guthrie and Napier examined two samples of galaxies from the Virgo cluster. The first sample consisted of 112 spiral galaxies with accurately measured redshifts in the range $0 < z < 3,000$ kms/sec, and the second consisted of 77 dwarf irregular galaxies in the same range.

The redshifts for galaxies in both groups were corrected for solar motion, and the technique of power spectrum analysis was used to test for periodicity in the distribution of redshifts.

Although there were some faint indications of periodicity in the range 70 - 75 km/sec, these were too slight to be considered as conclusive.

GUTHRIE AND NAPIER 1990

As a further test of the Tifft findings, Guthrie and Napier selected a sample of 89 spiral galaxies with accurately known redshifts, this time within the narrower range of $0 < z < 1,000$ km/sec. Such shifts were again corrected for solar motion and were also tested for periodicity using power spectrum analysis.

A strong periodicity of 37.2 km/sec emerged against a white noise background, the probability of such a periodicity occurring by chance being calculated as being less than one in 30,000.

Fig 5 shows a histogram of the combined samples (up to 1,000 km/sec) as studied by Guthrie and Napier. The vertical lines show the positions of the (aperiodic) peaks predicted by the theory being proposed - see Table 1.

The smallest quantum of redshift predicted is 68 km/sec while the largest (towards 1000 km/sec) is some 100 km/sec.

It is noted that the largest quantum is greater than the smallest by a factor of approximately $3/2$, and that the smallest is approximately twice as large as the periodicity detected by Guthrie and Napier. This fortuitous state of affairs may account for the periodicity revealed by the power spectrum analysis technique. In general, however, such a technique does not reveal aperiodic peaks such as are predicted.

Whether an examination of redshifts from a wide spread of nearby galaxies could ever provide conclusive evidence of redshift quantisation is open to doubt. Unlike the examination of redshift differentials within individual

galaxies or groups of galaxies (where the mean velocity can reasonably be assumed to be constant), the Guthrie and Napier approach requires that corrections be made for solar, galactic and inter-galactic motion. The errors in such corrections may mask the quantisation effect being sought.

However, examining the redshifts of very distant galaxies is likely to be more fruitful. Although the errors associated with such measurements are larger than those associated with the redshift measurements of nearby galaxies, the predicted redshift quanta are much larger than those predicted for nearby galaxies - and as observed by Tifft and Arp.

4.2 THE QUANTISATION OF REDSHIFTS OF DISTANT OBJECTS

As we approach the boundary of the visible universe, the theory (coupled with observations as reported above) predicts that there should be levels of potential at $c^2/3$, $c^2/4$, $c^2/5$ etc and at various fractional levels. The predicted redshifts that separate such levels are large and should be clearly detectable when observing quasars and other very distant objects.

Using equations 3 and 5, and the conclusion developed above that the Solar System is at a potential of $-c^2/67$ with respect to the centre of the universe, the predicted positions of redshift peaks in the redshift distributions of quasars and other distant objects can be calculated. Such predictions are summarised in Table 2.

A search of the technical literature reveals a surprisingly large raft of publications reporting observed quantisation of quasar redshifts. Thus previous workers have already provided a ready means of comparing prediction with observation. However, no explanation of such quantisation has so far been proposed.

Papers that report redshifts in this area include the following.

KARLSSON 1971

Having analysed the redshift distribution of 159 quasars and other bodies in the range $0 < z < 3.0$, Karlsson noted a series of well-defined peaks at $z = 1.96, 1.41, 0.96, 0.60$ and 0.30 . This distribution is illustrated in histogram form in Fig 6.

Note: redshift 'z' is defined by the expression

$$1 + z = v_0/v'$$

Using empirical means Karlsson determined that successive peaks fitted the series

$$(1 + z_1)/(1 + z_2) = 1.227.$$

However, as is clear from Fig 6, the peaks predicted in Table 2 also provide a good fit to this distribution, on the assumption (supported later) that some of the peaks are unresolved double peaks.

KARLSSON 1977

The histogram shown in Fig 7 resulted from the analysis of observations of 574 quasars (published in catalogue form by Burbidge in 1976) and shows the distribution of numbers of quasars as a function of redshift grouped according to bins of size $z = 0.1$.

As can be seen, this distribution displays a sequence of peaks and troughs. These were noted by Karlsson, who repeated his empirical proposal that the peaks were located according to a geometric series, expressed this time in the form

$$x = \log(1 + z).$$

The positions thus predicted are marked by arrows on fig 7. As can be seen, a reasonable fit results.

However, the vertical lines drawn on Fig 7 mark the predicted peaks as listed in Table 2. The fit is, once again, good (within the resolution of the histogram).

It is interesting to plot the peaks that would be predicted if the correction of $c^2/67$ were removed from the calculation of peaks. Such peaks are given in Table 2 in the column marked z' , and are shown on the Karlsson histogram in Fig 8. The fit is not as good, thereby providing some confirmation that such a correction is needed and that the one used is of the right size - ie that the Solar System is indeed located near to the 67th level of potential.

WILLS AND RICKLEFS 1976

Using a different sample of (427) radio-quasars to that used by Karlsson, these authors compiled the redshift distribution shown in Fig 9. When compared with the Karlsson peaks, it was concluded (with the assistance of power spectrum analysis) that there was little evidence of periodic peaks and none for those observed by Karlsson.

The peaks listed in Table 2 have been marked on Fig 9 and - as can be seen - there seems by visual inspection to be a good fit between these and the profile of the distribution. However, as the predicted peaks are aperiodic, it is difficult to assign a probability to this finding through the application of one of the established statistical techniques.

DEPAQUIT AND PECKER 1984

These authors examined in detail possible spurious causes of periodicity in redshift distributions and concluded that no such causes could account for the peaks reported by Karlsson. They then examined a sample of 715 radio quasars, some of which had featured in the original Karlsson study, and found that the presence of the Karlsson peaks was confirmed.

The 'smoothed' histogram of the redshifts of this quasar sample is shown in Fig 10 - line 'a'. The smoothing process employed may have caused the tips of the peaks to be located with false precision. Nevertheless there is a clear correlation with the Karlsson peaks (shown by arrows) and with the peaks from Table 2 (shown by vertical lines).

WILLS AND LYNDS 1978

A 'complete sample' of radio quasars (172 in all) - see Fig 10 line 'b' - was constructed by these authors who, having conducted a power spectrum analysis test, obtained a negative result for any periodicity.

The validity of such a test was disputed by Depaquit but, in any case, the aperiodic peaks listed in Table 2 would not have been revealed by such a test.

The marked similarity between the two lines in Fig 10 and, furthermore, the coincidence between many of the Table 2 peaks and those shown by line 'b' give reassurance that the theory being proposed is compatible with the Wills and Lynds sample.

HEWITT AND BURBIDGE 1991

Fig 11 shows a histogram of some 700 distant galaxies that possess $z < 0.2$. The authors comment on the marked peak at $z = 0.06$ but not on other peaks that appear to be present.

Fig 11 has been marked to show the peaks (in this range of z) listed in Table 2. As can be seen, there is a clear correlation between the profile of the histogram and the predicted peaks.

One possible explanation for the presence of the strong peak in the histogram at $z = 0.06$ is that this is the point in the distribution where the interval between the predicted peaks becomes equal to the bin size. Thus quasars from two peaks can at this point be gathered in a single bin, leading perhaps to the high reading recorded. (In order to test for the form of aperiodicity being proposed, histograms may have to be organised in bins of size proportional to redshift).

PEACOCK AND NICHOLSON 1991

An all-sky sample of 320 radio quasars in the range $0 < z < 0.2$ was examined by these authors, who produced the histogram shown in Fig 12. The data was used to refute claims by others of strong periodic 'clustering' of quasars on scales of 100 Mpc. However, when the peaks listed in Table 2 are plotted on this histogram, it is clear that there is some correlation, particularly in the region $0.06 < z < 0.15$.

The strong peak in the histogram at $z = 0.055$ may be due to the reason given above.

Longair 1989

The broad distribution distant radio sources was illustrated by this author as shown in Fig 13. As can be seen, this distribution peaks at an epoch equivalent to the universe being only 25% of its current age, and falls to a low value at an epoch that is even more remote. (In fact the most distant quasar yet discovered has a redshift of $z = 4.41$, equivalent to a 'look-back time' of 90% of the age of the universe. Despite considerable efforts subsequently, this is the most distant object that has been found so far).

Under the terms of the theory being proposed, we would expect the surface defined by $\delta\phi = c^2/2$ to mark the periphery of the visible universe. It would not be

surprising, therefore, if such a surface enclosed all 'visible' objects.

Due to the location of the Solar System at the 67th level of potential quantisation this surface may, in fact, be visible to us, but with difficulty.

Using equation 2 we can write

$$v_0 = v' / \{1 - 2(\frac{1}{2} - 1/67)\}$$

The resulting redshift would be 4.79 - suggesting that there is a maximum observable redshift and that current observers have almost attained it.

ARP 1982

One possible outcome of the theory being proposed is that the current 'big bang' explanation for galactic redshift may require revision. That such a revision may be needed is supported by evidence provided by Arp, who examined the differential redshifts of elements within various 'peculiar' galaxies.

The galaxy NGC 1232 is a 'peculiar' galaxy in that one of its spiral arms shows a distinct 'kink'. The redshift of the galaxy as a whole is measured as

1,729 +/- 73 km/sec.

However, the redshift of a smaller daughter galaxy, obviously associated with the main galaxy, is

6,496 +/- 58 km/sec.

Even stranger, the redshift of an object located within the parent galaxy precisely at the kink referred to above is

28,000 km/sec, or almost 0.1 c.

Such variation is well beyond that which can be explained in terms of Doppler effects arising from local rotation within the galaxy and, in conjunction with similar sets of data from observations of other 'peculiar galaxies', may be a further indication that the big/bang theory is insufficient to explain all redshifts.

5 SUMMARY AND COMMENTS

There is correlation between the theory being proposed and current observations. The theory of quantised variables would thus seem to provide a plausible explanation for the

observed quantisation of redshifts of both nearby and distant galaxies and, as such, is worthy of further consideration.

However, to claim more might at this stage be premature. For instance, comparisons between predicted and observed peaks need to be carried out in a more rigorous manner, even though the technique of comparison by visual means may in this context possess more value than is normally credited.

Furthermore, the proposed variation of gravitational potential throughout the universe needs to be confirmed (by theory or by experiment). The existence of a minimum level (quantum) of linear acceleration (c/T_0), as predicted in Paper 2 and as taken in this paper to contribute to such potential, also needs to be confirmed - preferably by direct experiment.

The assumption that redshift is caused predominantly by potential difference without contributions arising from expansion of the universe or from other causes (of which there may be many) also needs to be tested. As pointed out in 4.1, further observation of differential redshifts within distant clusters of galaxies may provide evidence that is decisive on this point.

Further investigation is also needed to establish whether observed peaks are constant or whether values vary slightly with direction of observation. Any such perturbation might also indicate the presence of redshift due to universal expansion as well as that attributable to quantised potentials.

Irrespective of such matters, the concept that the observed quantisation of galactic redshift is caused at least in part by the quantisation of potential is hereby introduced. If confirmed, such a finding would be a further underpinning of the basic tenet of ANPA that the universe is fundamentally digital in nature.

Geoffrey Constable

9 August 1993

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Table 1

Predicted quantisation peaks in the redshifts of 'nearby' galaxies.

Level of potential plateau (ϕ/c^2)	Predicted redshift peak (km/sec)
1/67	0
1/66	67.84
1/65	137.8
1/64	209.9
1/63	284.3
1/62	361.0
1/61	440.3
1/60	522.4
1/59	607.1
1/58	694.9
1/57	785.5
1/56	879.7
1/55	977.1

Table 2

Predicted peaks in the redshift distributions of 'distant' bodies.

Level of potential plateau (ϕ/c^2)	Redshift peak (z)	Uncorrected redshift peak (z')	Log(1 + z)
1/15	.0562	.0742	
1/14	.0618	.0801	
1/13	.0683	.0871	
1/12	.0763	.0954	
1/11	.0859	.1056	
1/10	.0977	.1180	
1/9	.1127	.1339	
1/8	.1324	.1547	
1/7	.1592	.1832	
1/6	.1982	.2247	
1/5	.2600	.2909	
1/4	.3739	.4142	.140
1/3	.6595	.7319	.222
3/8	.8903	1.0	.278
2/5	1.086	1.236	.322
3/7	1.406	1.646	.388
4/9	1.663	2.000	.427
5/11	1.877	2.316	.461
5/12	1.256	1.449	.355
6/13	2.059	2.606	.488

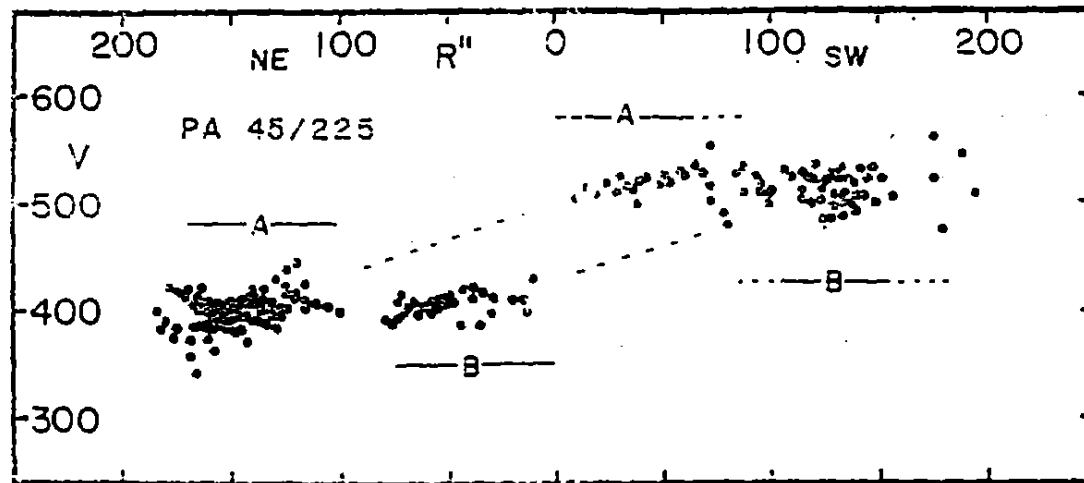


FIG 1

-The rotation curve for M5 in position angle $45^\circ/225^\circ \pm 15^\circ$ from Tully (1974a). The four crossings of the major arms are easily seen, and the two arms are designated A and B. Dashed lines show the dual redshift model suggested with the A arm $70-75 \text{ km s}^{-1}$ higher than arm B.

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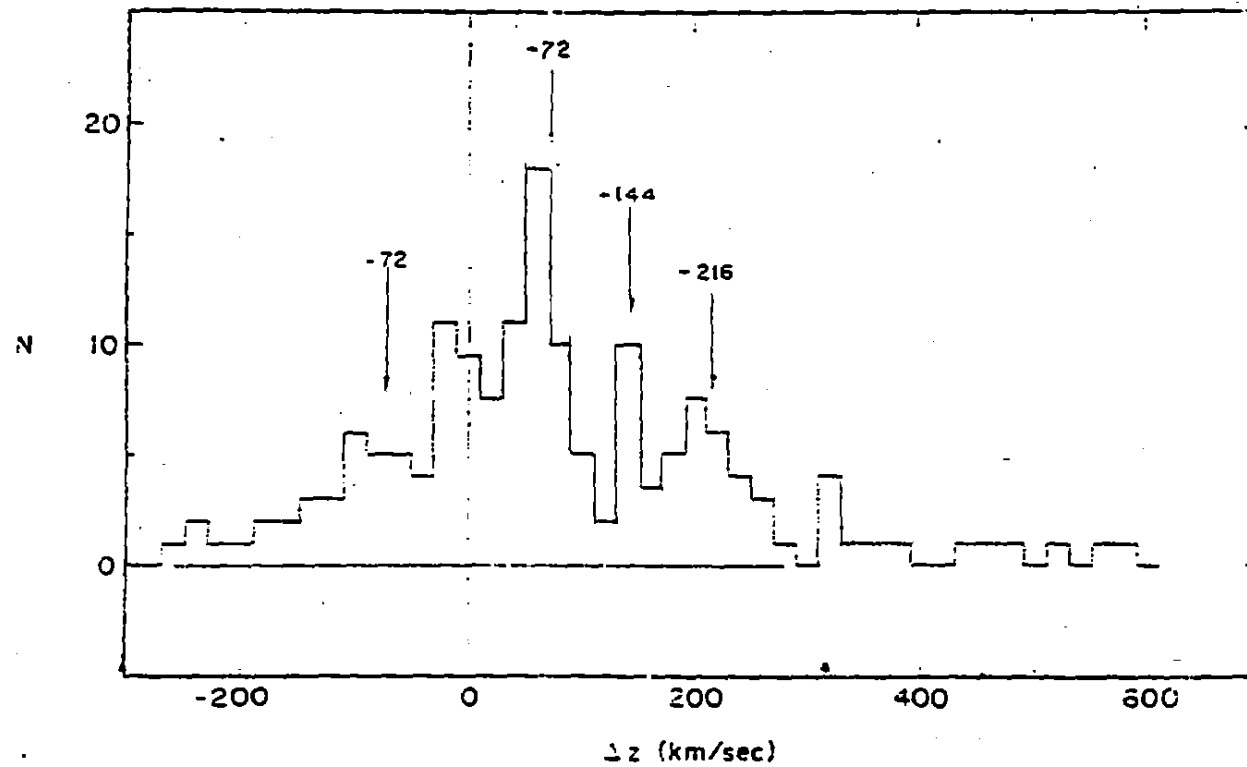


FIG 2

--Same Δz 's as plotted in Fig. 1 binned in 20 km s^{-1} intervals. Arrows indicate multiples of 72 km s^{-1} at exactly these points.

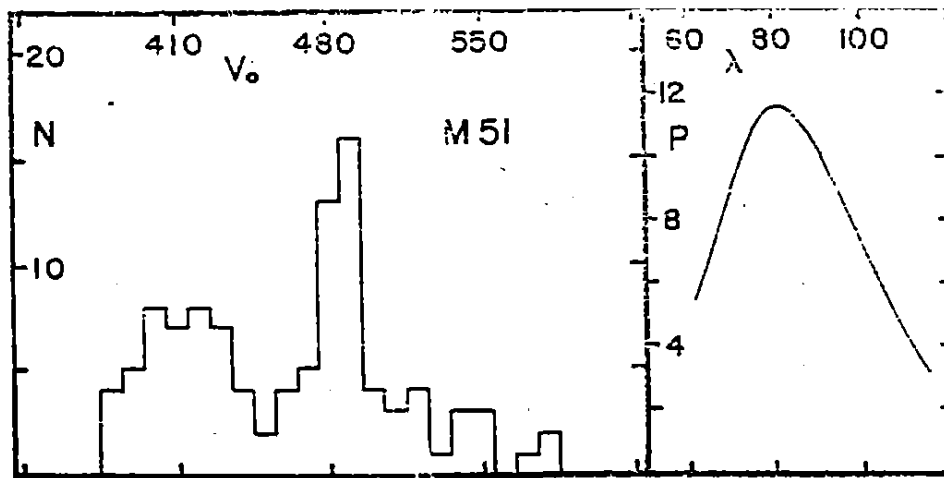


FIG 3

—The left (a) diagram is a histogram of the redshift data for M51 shown in Figs. 1, 2, after correction for rotation. Two well-defined peaks demonstrate that the data contain two well-defined redshifts. The right (b) diagram is the power spectrum of the redshift distribution in Fig. 3.

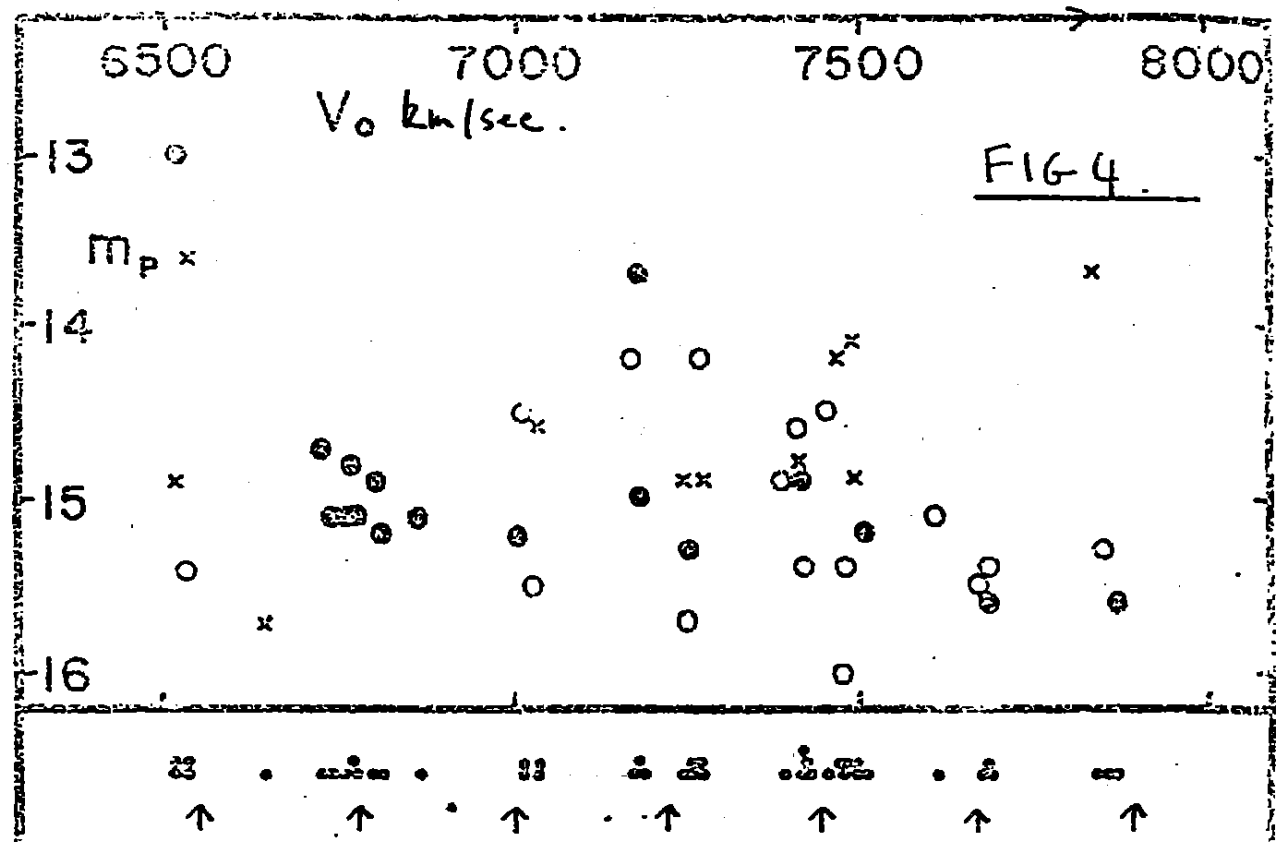


FIG 4

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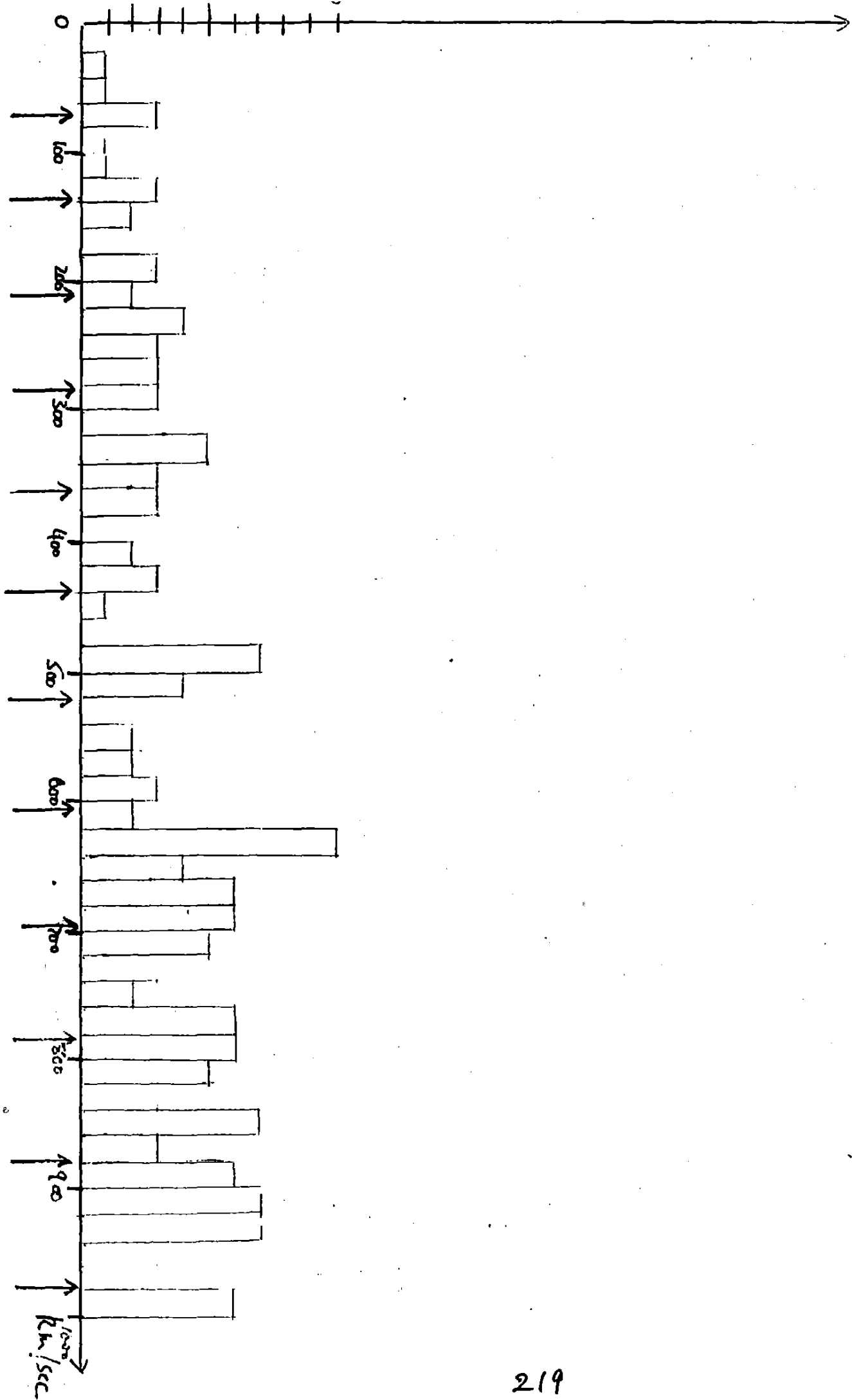
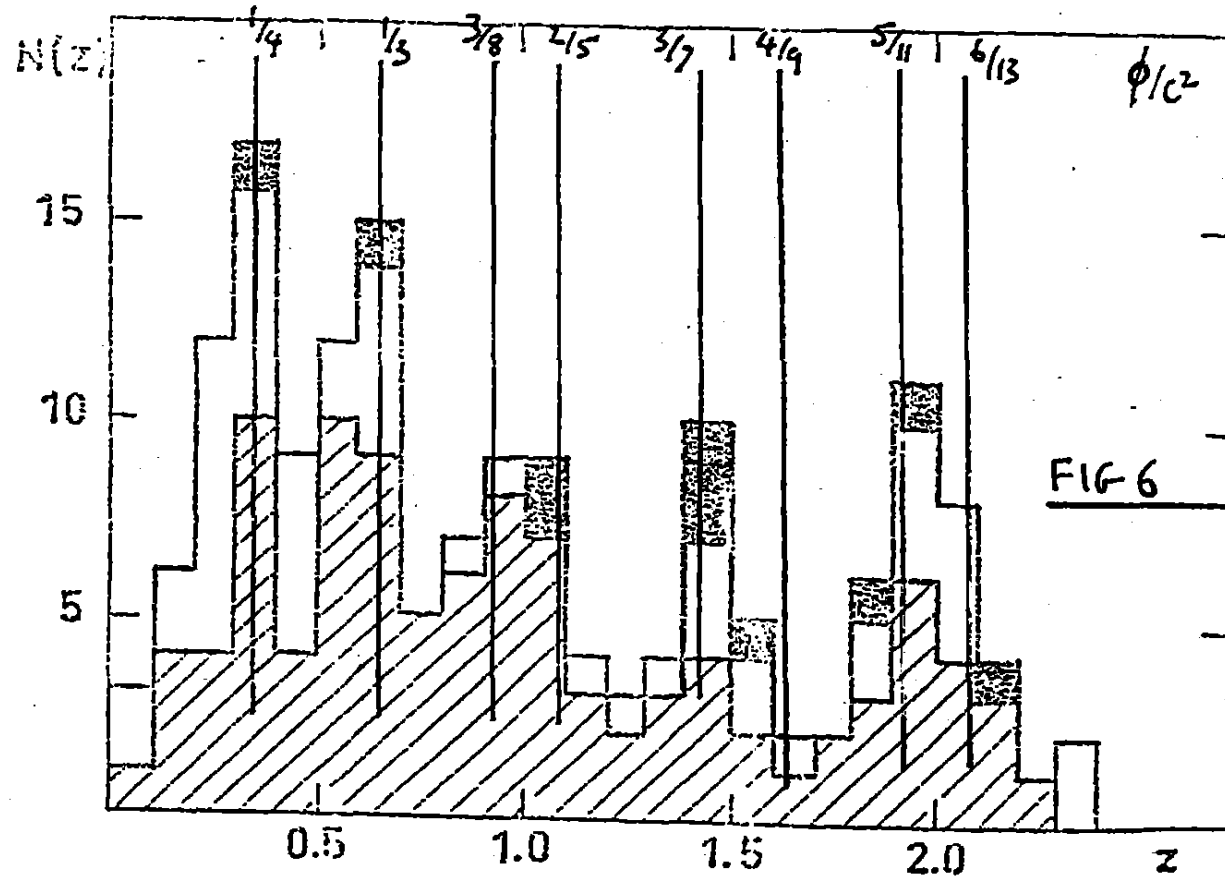


FIG 5



Histogram of the distribution of quasar redshifts. A bin-size of 0.1 z has been used. The shaded area represents the redshifts known in 1967, and the solid areas represent eleven determinations from 1970

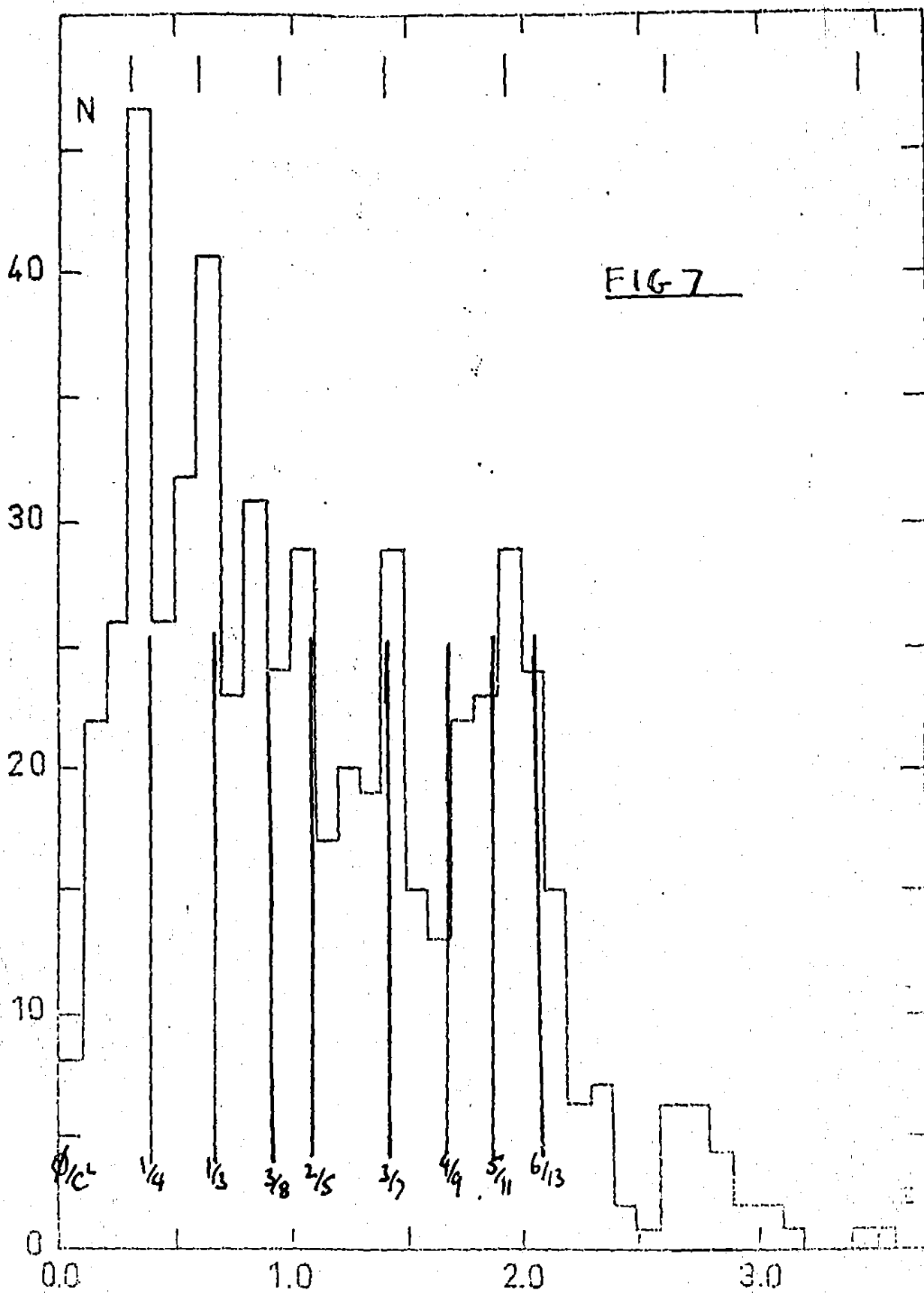


Fig. 1. The distribution of 574 QSO emission line redshifts. Peaks derived from a previously established relation are indicated by bars.

FIG 8.

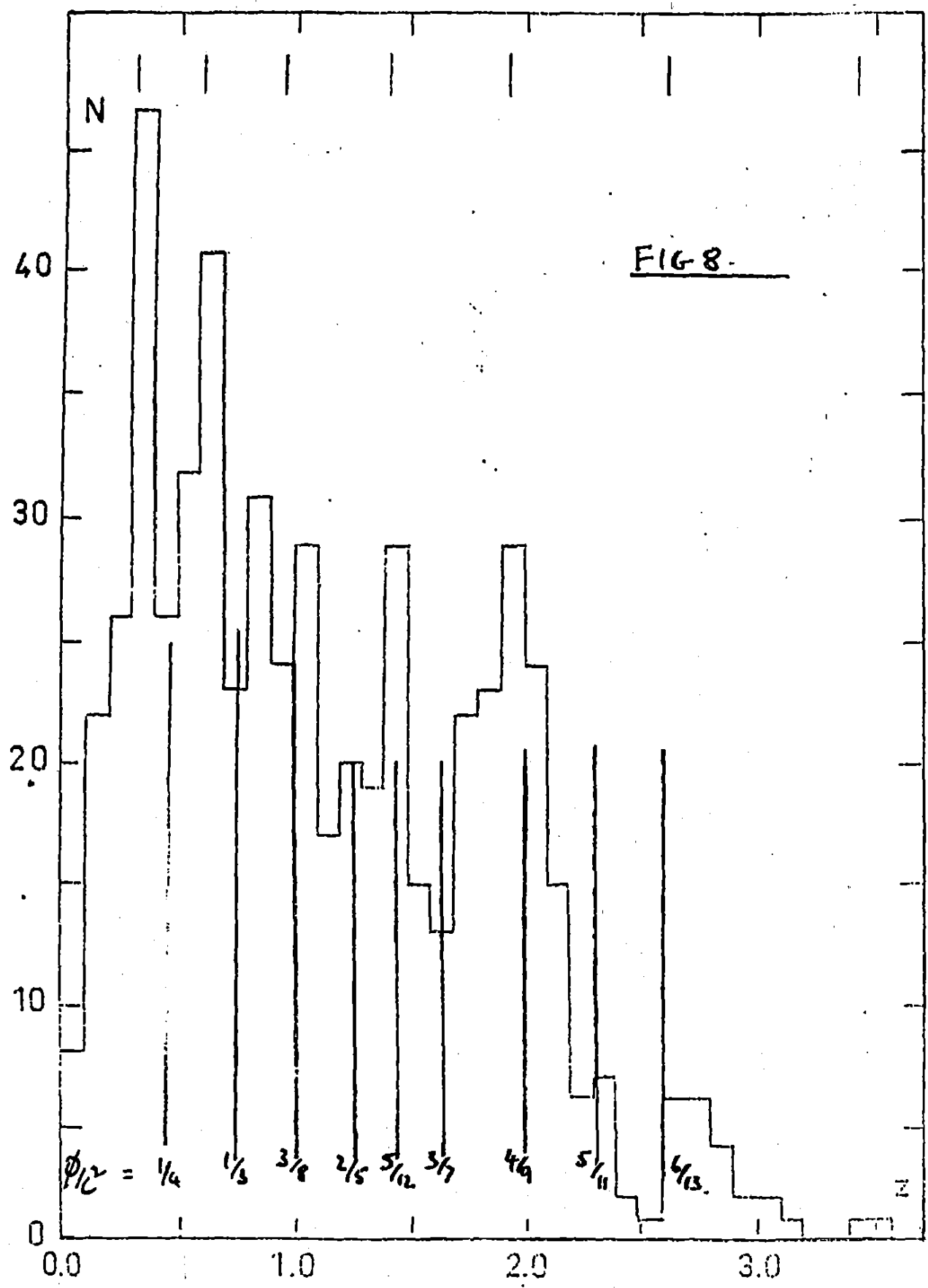


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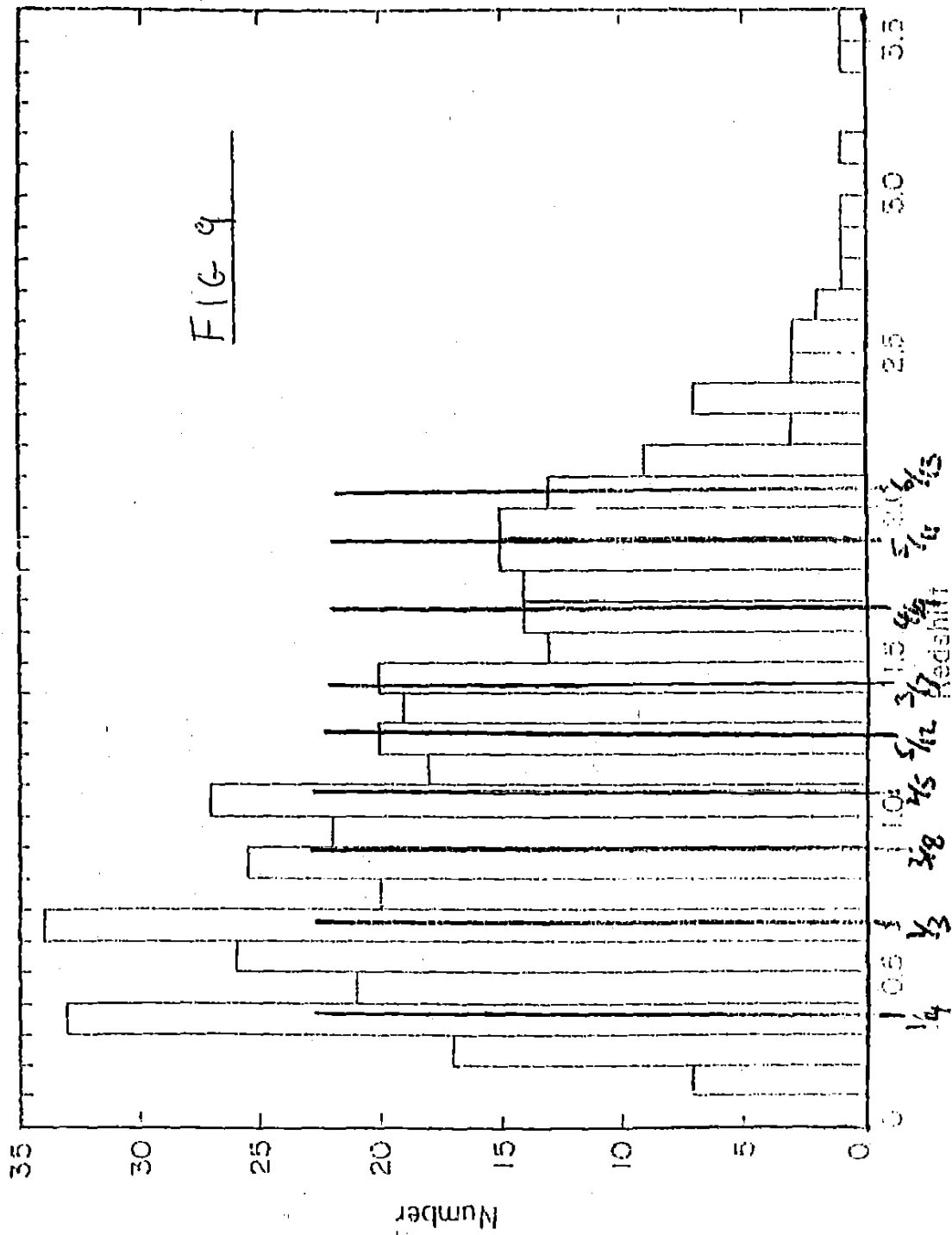
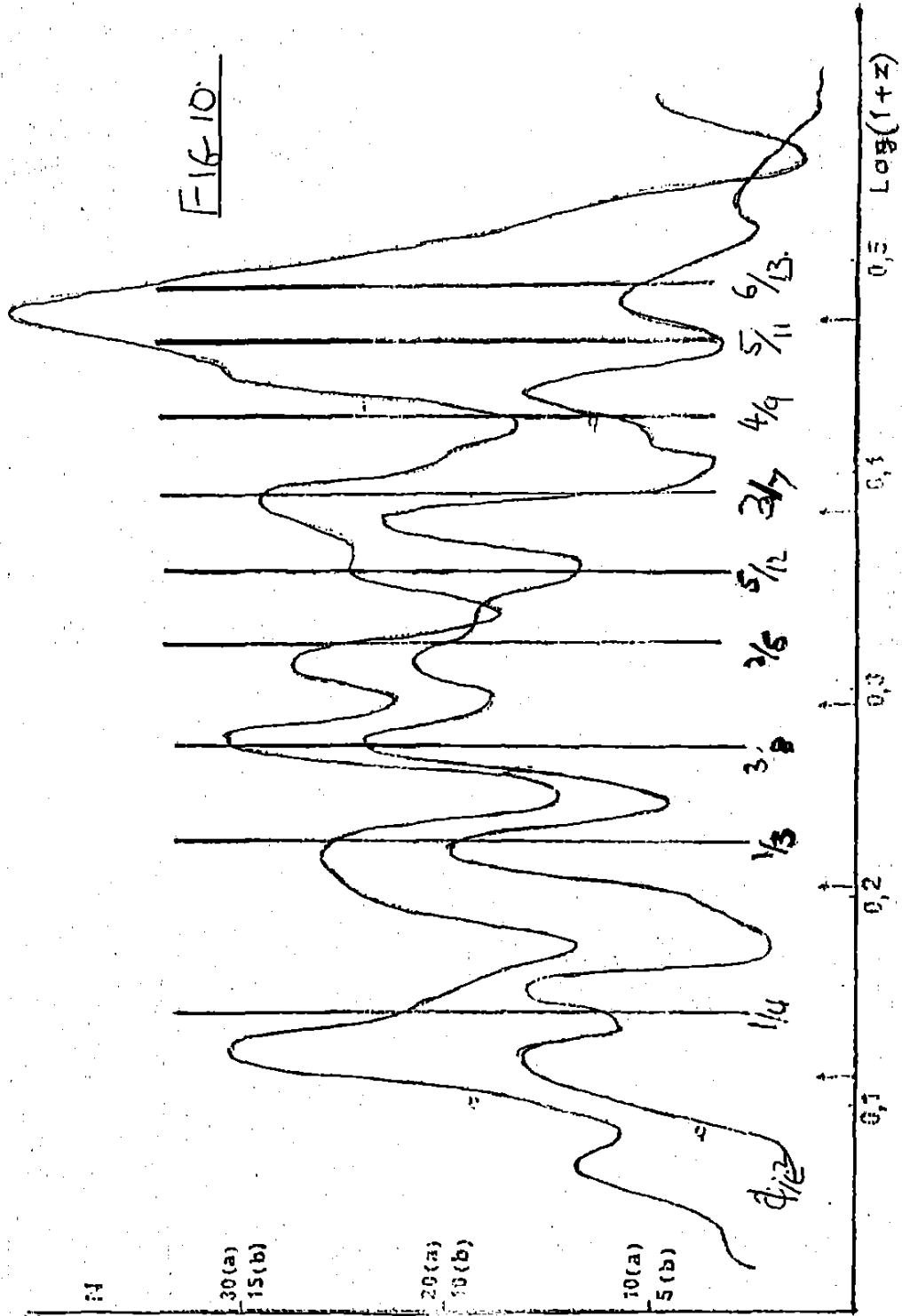
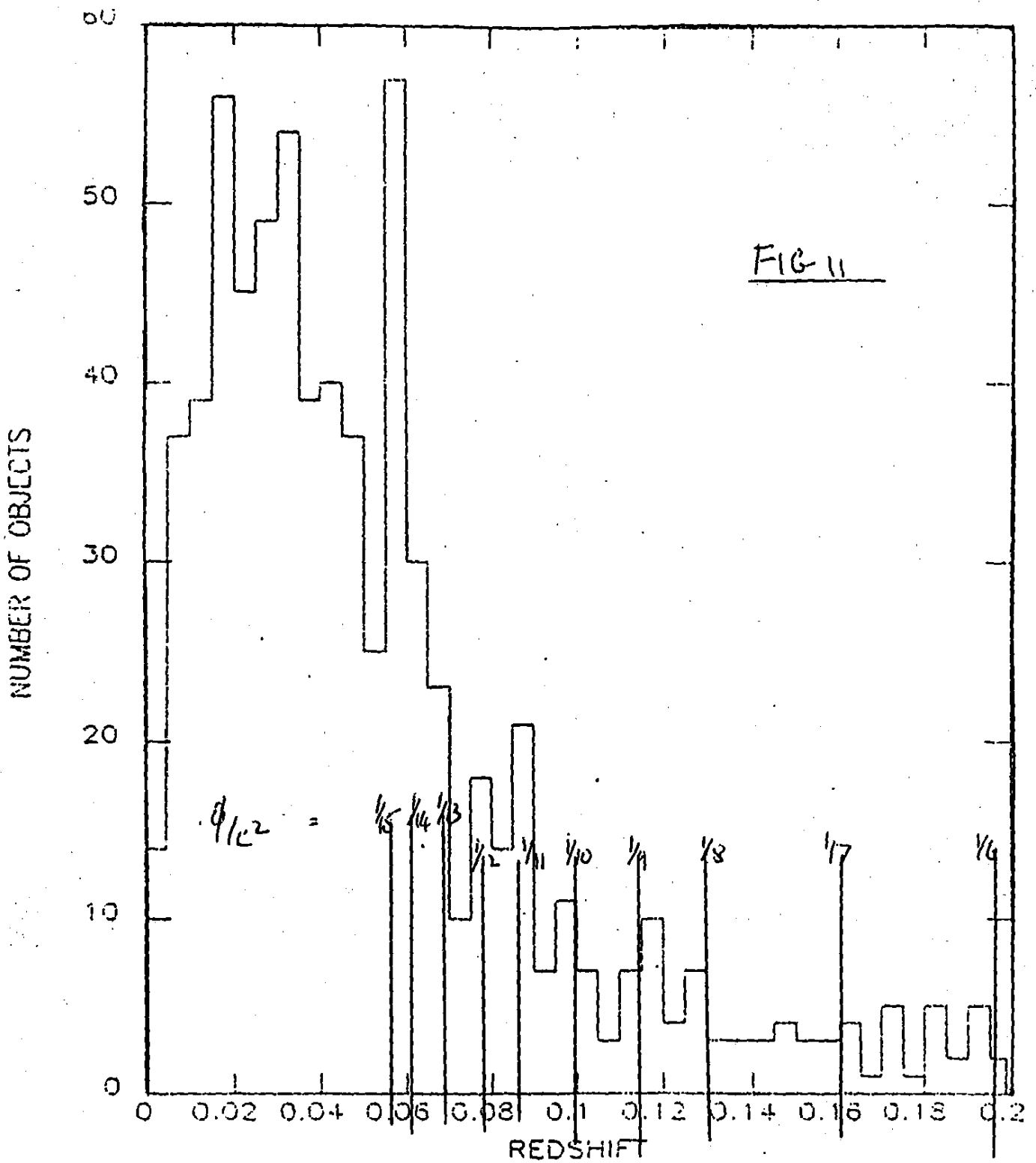


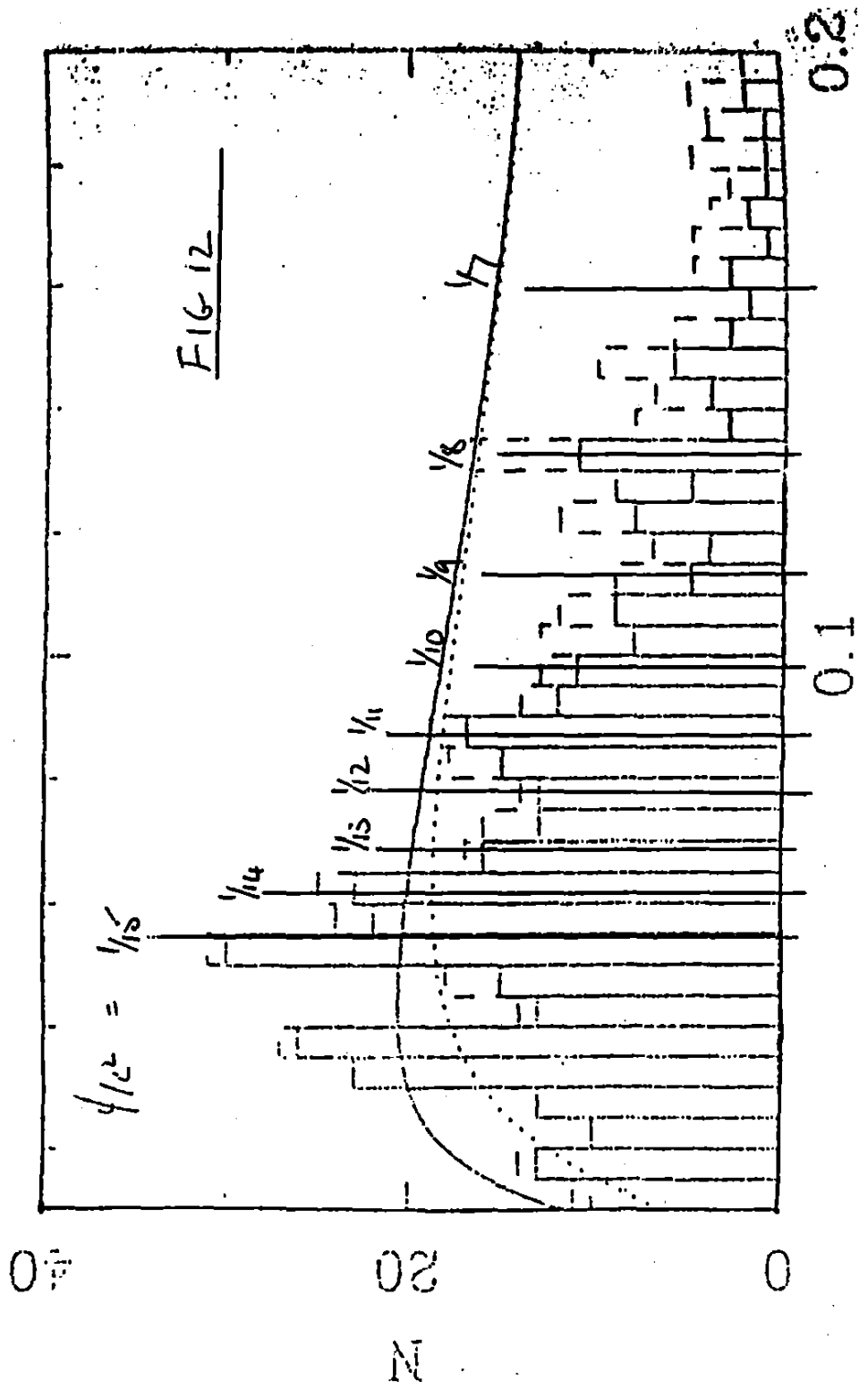
FIG. 9. Redshift distribution, in intervals of 0.1, for the 427 radio-detected QSOs.

FIG. 10.





—Here we show a histogram of the redshift distribution for $z \leq 0.2$. The interval $\Delta z = 0.005$ is used. The major peak beyond the maximum at $z = 0.06$ is clearly visible.



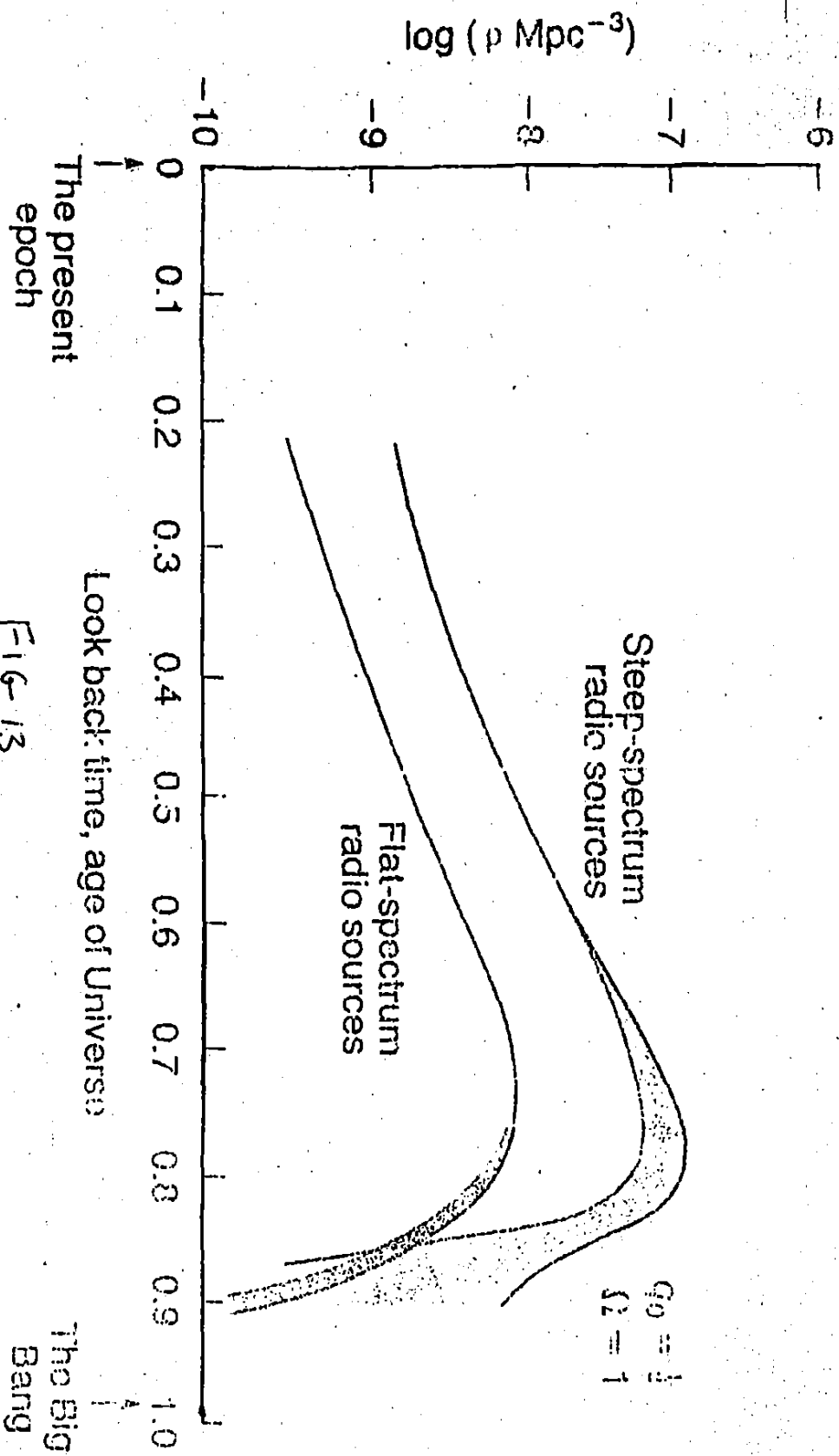


FIG-13

ALTERNATIVE MATHEMATICS AND ALTERNATIVE THEORETICAL PHYSICS: THE METHOD FOR LINKING THEM TOGETHER IN PAST CENTURIES

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1. Introduction

I am a teacher of History of Physics since 20 years. My research field is History of the foundations of both Physics and Mathematics around French Revolution's period. By studying this subject I collected evidence for an alternative to dominant science; actually, it started since two centuries ago. In other words, I suggest an historical substantiation of that word "alternative" which characterizes ANPA. The following analysis concerns classical physics only; in what way it may be extended to our Century's theoretical physics is a question to be solved by a specific work to be done as yet; at present I have only some conjectures that however are not presented here.

2. The alternative to classical mathematics: Constructive mathematics

My starting point is to consider as a decisive event in the history of mathematics, the birth of E. Bishop's constructive mathematics (CoM)[1].

In the 17th Century the beginnings of theoretical physics resulted very impressive because at the same time Newton built the first systematic theory and an advanced, marvellous calculus. This marriage seemed so unavoidable that it never was controversial except when, two centuries after, the entire world resulted quantized, the light too.

However, the subsequent theory, i.e. quantum mechanics, was built again by means of the differential equations - i.e. the continuum's notion. Any suggestion by physicists for introducing a finitist mathematics[2] was considered as a naive effort doomed to the failure. Rather than physicists, the mathematicians took more seriously their specific crisis which occurred in the beginnings of this Century. While the dominant group attempted to restore firm bases to traditional mathematics, some minority groups started a long march for revisiting the whole body of mathematics by appealing to potential infinity (PI) only, i.e. by rejecting Zermelo's axiom, Zorn's lemma and even the unrestricted use of the ϵ - δ technique, which defines both real numbers and the limit. Indeed the ϵ - δ technique deals always with intervals (ϵ -intervals and δ -intervals); but the limit is required to be one point, although in no way an ϵ -interval may be reduced to a single point, if not by appealing to an actually infinite accuracy.

The long march of intuitionists, recursivists, Russian constructivists, computability theorists allowed at last Bishop to present almost any part of modern mathematics by rejecting actual infinity (AI). The difference with traditional mathematics resulted to be very little in quantity but very great in quality, that matters mainly foundational notions and techniques.

The relevance of CoM was emphasized by the contemporary birth of more mathematics which radically differ from the traditional one, i.e. the Cauchy-Dedekind-Weierstrass' ϵ - δ

mathematics, otherwise called the "rigorous" mathematics: in 1958 Robinson^[3] showed that one can consistently extend the real number field by dropping out the Archimedean axiom and so to obtain what Leibniz and Newton called the "infinitesimals", i.e. the mathematical beings that in the 19th Century rigorous mathematics repudiated.

Moreover, H. Weyl's suggestion for a new mathematics such to be more adequate to the needs of physical theories was accomplished in the 80's^[4]. This mathematics resulted to be more powerful than the constructive one but less powerful than the rigorous one. In sum, since the 60's we entered - actually, again - in a pluralistic era of the foundations of mathematics. Today, we have to choose the kind of mathematics, mainly by choosing to reject AI or not.

It is easy to recognize that non-standard analysis is more powerful than what physical theories ask; never a physicist will do something involving AI, and he would have to reject any Platonist notions either, because never experimental results can support this kind of notions. Rigorous mathematics by including AI in an essential way, is overdimensioned w. r. to physical needs. Here it is enough to remember the legion of pathological functions it includes; never a Dirichelet's function, say, will represent a physical phenomenon. As a naive reaction to this discovery, theoretical physicists bounded the set of their functions to be continuous with their first and even second derivative - really an unadequate set of functions because it is an open set under differential operations.

In particular, CoM, without rejecting what today constitute the irreversible achievements of mathematical theories, represents a radically divergent attitude w. r. to classical mathematics. Hence, in my opinion, today it may be well qualified as the alternative mathematics.

The natural problem is now the following one: What is the relation between CoM and theoretical physics (TP)?

3. Alternative mathematics and physical theories

Being consistently free of AI, CoM does not represent some common, physical notions which directly appeal to AI. But, being disputable what is the structure as well as the ingredients of a physical theory, one may doubt whether what CoM is unable to represent constitutes an essential element of physicists' theoretical activity.

Let us remark that apparently that the different kinds of mathematics shape in radically different ways the basic notions of a physical theory. For ex., a point is represented by an infinitesimal dx in non-standard analysis, by the classical real point in rigorous mathematics, by an ever more reducible interval in length in CoM (well-known real numbers like e are all included). This variety of representations matters TP. For ex. Newton's version of inertia principle requires that we are able to test when $f=0$ (let us remark that here is required an exact equality, because being the notion of force defined by the second principle, now we cannot exclude that the relationship force-effects will be a non-linear one); such an accuracy is not allowed by a mathematics which appeals to PI only - surely by experimental physics either.

Moreover, it is clear that the set of non-standard functions includes as a particular case the set of rigorous functions; whereas the order of infinity of the set of constructive functions is properly lesser than the order of the previous sets. Then, no wonder that absolute space and absolute time are conceivable in the first two kinds of mathematics and not in the last one. Likely, when in thermodynamics the reversible processes are defined as quasi-static processes, they have to be represented by functions whose single value is an infinitesimal since it only can represent a state which at the same time is a point and a not null part of a trajectory.

Differential equations too give different solutions in the different kinds of mathematics. For ex. in CoM mechanics' equation $m d^2x/dt^2 = f(dx/dt, x, t)$ results to be undecidable when f is discontinuous or unlimited - as e.g., the force in the central point of a central field of forces^[5].

In other words, the application of CoM to a physical theory allows us to decide by means of mathematical techniques what in the past were considered as questions of philosophical nature only. Hence, today we have a certain method for investigating any past physical theory about the possible introduction of AI in its notions and techniques. Being some physical notions actually Platonist in nature - as in the above, the notion of Newton's inertia was shown to be -, it may be a natural consequence that CoM does not represent some physical theories - say, Newton's mechanics. The very problem is whether CoM is unavoidably too weak for representing a meaningful part of TP or not. If it is sufficiently strong, then one can re-visit past constructive theories in order to recognize a new historical development of the not-Platonist TP.

Till to 1967 so hard was the effort by the constructivistic mathematicians for building their theory that they directed no attention to apply CoM to physical theories. And also in the subsequent time - till now - computer science seemed to them a more easy application than the gigantic body of physical theories, which moreover suffered in past times great crises of philosophical nature too^[6]. Furthermore, the few attempts in this direction gave undecidable results, - i.e. the lack of a general algorithm for solving the problem at issue - as if CoM would be a too weak mathematics^[7]. Thus, this point deserves a careful analysis.

In 1982 I applied CoM to several formulations of thermodynamics^[8]. For ex. Carathéodory's formulation is rejected because his main axiom results to be undecidable (in introducing it, even Carathéodory actually remarked that it cannot be tested by operative means). The mathematics of traditional formulation is so simple to be easily recognized in agreement with CoM; whereas almost all the different formulations - except for Broensted's one - resulted to include undecidable principles; hence, they cannot be represented by CoM.

My conclusion was that thermodynamic theory may be represented by CoM; but when one qualifies such a theory by a suitable formulation - either the traditional one or the Broensted's one. Hence, far to be unadequate to TP, CoM selects the suitable formulations of a theory; it rejects some formulations of thermodynamics because it requires to a physical theory to make a consistent use of PI only. That does not means at all that TP cannot be represented by CoM provided that for any main physical theory one either suggests a not-Platonist formulation of it, or he finds out it among the already known formulations.

In last years, my work was to investigate the history of physics in order to find some more formulations in agreement with CoM. It is a very remarkable fact that two decades ago one of the most authoritative historians of physics, C.C. Gillispie, devoted a book in order to re-evaluate the scientific work of the almost forgotten Lazare Carnot (1753 - 1823)^[9]. His mechanics deliberately avoids differential equations by introducing first in TP conservation laws as the invariants of symmetry groups ^[10]. Its basic phenomenon is not a continuous phenomenon - like in Newton's mechanics -, but the shock of bodies. The problem of shock is solved in the velocities, hence the conservations laws give rise to algebraic equations - not the differential ones-. It is apparent that such simple formulae of this theory are in agreement with CoM.

Let us remark that this mechanics dates 1782, while Lagrange's *Mécanique Analytique* dates 1788. Moreover, Lagrange never minded symmetries or groups. Only 130 years after L. Carnot's book, in 1918 E. Noether developed the well-known technique for obtaining conservation laws from the Lagrangian - an alternative approach to symmetry than L. Carnot's one, although the source of both is the same principle of virtual works^[11].

Remarkably, L. Carnot's mechanics results to be a better alternative to Newton's mechanics than Mach's mechanics. Both agree in putting the Newton's third principle as the basic one, i.e. in stating the entire mechanics as a theory of interaction. However, by lacking of symmetry's

technique the latter one makes use of the same differential equations of Newton's one, although Mach stresses that $f=ma$ has to be meant as an identity. This last criticism was actually started by D'Alembert and it was expressed at best by L. Carnot. Furthermore, a comparison of the several versions of the first principle gives evidence that Mach's version of it constitutes an echo of L. Carnot's one, which results to be the best one^[12].

From all the above I conclude that to choose CoM led us to recognize a very alternative not only in thermodynamics but also in mechanics, i.e. the theory that through Newton's formulation monopolized TP. Thus, one may stress that even the most authoritative physical theory may be formulated in an alternative way. The subsequent historical development of TP confirms that L. Carnot's mechanics was a real alternative; only it - and not Newton's mechanics - was capable to originate thermodynamic theory. As Gillispie remarked, the parentage relationship between Lazare and Sadi actually worked as a very scientific parentage. In sum, by CoM we obtained an entire historical tradition of alternative theories to the dominant ones.

When one takes in account classical chemistry - whose mathematics being the most elementary one agrees with CoM - L. Carnot's mechanics, S. Carnot's thermodynamics all together, then he realizes that, by lacking of idealizations, those constructive theories have been in the past underevaluated as immature, or merely phenomenological, or engineer's theories, i.e. incomparable with the highly theoretical Newton's mechanics - actually a theory relying essentially on AI. In other words, idealization till to AI worked as a blocking prejudicen w.r. to a substantial part of TP. Instead, today we can consider by means of CoM all the above theories on the same foot of Newton's one, and moreover as constituting the alternative theories to it - at least at their times; today L. Carnot's mechanics results as insufficiently developed because it includes the action at distance in an analogical way only -.

4. A method for examining a physical theory by the alternative mathematics

From the above instances of constructive physical theories I induced the following method for examining by CoM a particular physical theory^[11].

Here a physical theory is characterized by means of a particular formulation. This one is considered as organized in a deductive way, as in ancient times Aristotle required and as at the same time Euclides organized its Elements; after two millennia, Newton's Principia extended this kind of organization as the correct organization of a physical theory too. Then any physical theory may be considered as composed by four elements: physical magnitudes, laws on magnitudes, principles and differential equations. The following four rules specifies the method.

"i) Any physical magnitude may be represented by a variable ranging on constructive real numbers; any functional relationship among physical magnitudes may be represented by a constructive real-valued function."

In fact, any measurement gives a truncated number; a traditional physicist idealizes it in a classical real number but for the only reason of facilitating the theoretical computations. Rather, in CoM any real numbers represents a process of an ever more accurate approximation, just as the result of a measurement of a physical magnitude may be evermore improved by more sophisticated apparatuses. Hence, not only CoM can well represent physical magnitudes but also it is more adequate to their values than classical mathematics.

"ii) Any experimental law may be represented in CoM by means of the same formula holding true in classical mathematics provided that the equality's symbol is substituted by that of approximate equality."

In fact, any experimental law constitutes an approximate equality between approximate experimental values. Hence, CoM represents correctly it by an approximate equality and not - as classical mathematics does - by an exact equality, which in CoM results to be undecidable.

"iii) It is necessary to scrutinize whether a principle includes AI by means of either its main notions or the statement itself. In the case the principle is represented by a mathematical formula one has to test whether the formula results to be undecidable or not - i.e. whether there exists no algorithm for deciding when the formula is true or false. In the affirmative case, the Platonist formula cannot represent a principle and, as a consequence, CoM cannot represent the formulation to which this principle belongs."

This rule evidentiates that a principle, being a synthetic statement of a great variety of phenomena, often idealizes the reality, so that its testability constitutes an unsolvable problem; hence, it cannot represent a physical theory by CoM. This rule is more easy to be applied when the statement of the principle is equivalent to a mathematical formula because it may be easily analyzed by means of CoM. Otherwise, the principle requires an analysis from a philosophical view point. For example, Hanson^[13] offered a decisive analysis of the many ways Newton's inertia principle includes AI. The task is more difficult when the verbal version of the principle did not attract the attention of a philosopher. In this sense the examination by CoM of a whole theory is not a mechanical procedure but a work of interpretation too. Indeed, CoM concerns several foundational aspects of the theory.

"iv) A differential equation constitutes an idealization of a series approximating, finite difference equations. CoM can solve it by means of the last ones. When in a theory a differential equation plays the role of a principle, then possible undecidable problems concerning solutions of physical interest bar this role and at last they deny the representation by CoM of the formulation, including such differential equation as a principle".

Since Newton, the use in TP of infinitesimals - and hence differential equations - was so impressively productive that they suggested as natural notions some idealistic notions. No wonder if Newton's followers (Euler, Laplace, Lagrange) idealized a technique, i.e. a differential equation (for ex. $f=ma$) to an universal principle. Instead, CoM rejects the essential use of IA in its specific techniques; so that a differential equation in CoM may result to be undecidable for some physical cases and hence it cannot represent an universalistic principle of TP.

5. Alternative mathematics and the whole body of theoretical physics

In the two past decades ever more authors found out undecidable results when they applied CoM to some physical theories; they include statistical mechanics, thermodynamics, Hamiltonian mechanics, quantum mechanics, chaos theory^[14]. Being unaware of L. Carnot's mechanics, all they concluded by guessing that their results prove CoM to be inadequate to TP. In particular, Pour-El and Richards directed the attention on counter-examples of non-computable solutions of the wave equation, as if they stated the incapability of CoM to exhibit counterparts of those mathematical theorems TP needs^[15].

Actually, all counter-examples by Pour-El and Richards belong to the set of weak solutions of a wave equation. Bishop's CoM is unable to represent them^[16], whereas by essentially adding Markoff's principle $\{(P(a) \vee \neg P(a)) \wedge \forall a \neg P(a) \rightarrow \exists a P(a)\}$, Aberth's CoM^[17] states them as undecidable - essentially by his Th. 6. 1; i.e. someones may be obtained by means of more specific hypotheses, some others cannot be obtained at all, just as numerical analysis does. However, all weak solutions are obtained when one adds to CoM a non constructive hypothesis, i.e. the extended Church's Thesis^[18].

By generalizing to any differential equation of TP, we can say that almost all solutions which are relevant to TP - the regular ones - are represented by CoM. However, since some singular solutions too may be relevant to TP, the correct mathematical conclusion to draw is that we cannot obtain all physical solutions of a differential equation by a general algorithm of a CoM. Hence, the correct philosophical conclusion w. r. to a deductive physical theory of TP is that CoM does not allow to consider any differential equation to work as an universalistic principle. That denies Laplace's dream in mechanics and Hertz's thesis ("electromagnetism is just Maxwell equations"). In other words, according to CoM, TP cannot be reduced to a mere mathematical technique; or, evenly, mathematical-physics is essentially more restricted than TP. It is well known that the same conclusion was reached in TP by different, yet cumbersome ways.

All this is relevant to the general method for introducing CoM in a deductive physical theory, as it is illustrated in the above. There CoM is meant as Aberth's version of it. I justify this choice by the following argument.

In the history of TP the authors of some theories rejected the deductive kind of organization (Aristotelian organization = AO). Their original texts stated by a double negated statement the crucial problem of the theory. L. Carnot's classical mechanics (1782), classical chemistry, S. Carnot's thermodynamics, Lobachevsky's non-Euclidean geometry were centered respectively on the following problems: "A body cannot change its state of motion if not by other bodies"; "It is not possible that matter is divisible at infinity"; "It is not true that heat is not work"; "It is not absurd the hypothesis of two parallel lines" (emphasis added).

In classical logic one is allowed to cancel the two negations; one obtains as affirmative statements just the principles of the corresponding, deductive formulations of the same theories: "Any body perseveres in its state of motion"; "There are atoms"; "Heat is equivalent at work"; "There exists two parallel lines". Aberth's CoM, by including - through Markoff's principle - a typical formula for cancelling double negations, results to be adequate to the above affirmative statements of the principles of deductive formulations. On the contrary, the founders of the above theories rejected the affirmative statements for lack of experimental evidence. By accepting "- - A is not equivalent to A", i.e. the characteristic law of non-classical logic^[19], anyone of them puts a crucial problem ("why - - A is not equivalent to A?") which directed him to invent a new method for solving it. Hence, they organized their formulations in a non deductive way which I call a problem-based organization (PO). Then, Bishop's CoM whose logic - being without Markoff's principle - is a non-classical one, results to be adequate to those theories. In the case the theory includes wave equation, only the regular solutions may be considered for building that new scientific method which constitutes the core of the theory; undecidable results merely confine the certain part of the suitable mathematics for building this method. In sum, the radical variations of meaning suffered by principles when the kind of organization is changed, requires a choice on the suitable version of CoM to be introduced in a physical theory.

Let us remark that in order to interpret the several undecidability results in TP, Da Costa and Doria invoked a deeper insight on the foundations of science than the common view on Goedel's theorem^[14]. Actually, this theorem receives a new interpretation by means of the above category, i.e. the option on the kind of organization^[20].

6. The symmetry as the alternative mathematical technique for an alternative physical theory

Few years ago the authoritative theoretical physicist A. O. Barut wrote a very remarkable paper^[21]. He re-visited all past physical theories by starting from Kepler's version of gravitation theory. In this theory Barut sees a first hint for a symmetry technique in TP; in the subsequent

times this technique - according to Barut - played a role which is sometimes complementary, sometime cooperative to the "dynamic" technique, i.e. the differential equations. Unfortunately, Barut is not aware of L. Carnot's mechanics; i.e. its first introduction of symmetry in TP as well as its formulation of the traditional mechanics by symmetry. Moreover, he ignores that classical thermodynamics also may be based upon symmetry^[22]. These facts straightens decisively his thesis.

Moreover, it is remarkable that in Lazare Carnot's mechanics symmetry is not a fortuite event. In his geometry he deliberately improves the old synthetic method in order to achieve all results already obtained by the analytical method and moreover to obtain new results. L. Carnot was able to extend this method to mechanics and calculus. This new method is illustrated at length in his last book on calculus^[23]: when we look for the solution of a problem concerning a system of mathematical equations, we add ("ajoinde") auxiliary quantities for generating new auxiliary systems in which one can more easily find out the desired solution ("to generalize is the same than to simplify") and then we come back to the original system with the solution lacking of the auxiliary variables.

The auxiliary quantities are easily recognized as the infinitesimals of calculus as well as the geometric motions of mechanics. The latter ones are defined as the motions of the bodies such that they can move in the opposite direction without interacting with other bodies. Let us remark that this property of invertibility assures that the set of geometrical motions constitutes a group - being a priori given the inverse of every element - upon which one can operate without the typical difficulties of the algebra of CoM^[24].

One can see that this same method originated Galois' theory and Klein's Erlangen program^[25]. Hence, it represents a philosophical tradition of long duration as well as of great effectiveness.

By inspecting more accurately the original works of all the above authors, evidence results that in any theory this method is associated to a PO, whose crucial problem is stated by a double negated statement (then the theory is developed either by just the mathematical technique of symmetry - in L. Carnot's mechanics or by means of some materialized forms of a symmetry - the periodic table of elements in chemistry, S. Carnot's cycle in thermodynamics). Actually, already D. Birkhoff^[26] emphasized the link between symmetry and the principle of sufficient reason - itself a double negated statement (for ex. "No event without cause") - i.e. the regulative principle informing a theory starting by a double negation statement.

By means of the above facts I qualify Barut's thesis as follows: "dynamics", i.e. differential equations, constitutes the typical mathematical technique in the case the formulation of a physical theory is based upon AO and AI; whereas "symmetry" is the technique in the case the formulation is based upon PO and PI. I tested such thesis in all theories of classical physics. The following table summarizes the results (Let us note that classical thermodynamics is a PO theory inasmuch as the Lagrangian theory of symmetry used by Callen is so. About the characterization of the statistical mechanics, truly Boltzmann wanted to use a PI mathematics and he liked "empirical" organization of a theory; but in fact he was unable to recognize AI in his mathematics^[27] and moreover he chose an AO by putting classical mechanics' equations as his principles).

TABLE: The Relationship between Symmetry's Technique and the Basic Choices of a Classical Physical Theory

PHYSICAL THEORY	SYMMETRY	BASIC CHOICES
GRAVITATION (Kepler)	yes (Barut)	PI & PO
MECHANICS (Newton)	no	AI & AO
MECHANICS (L. Carnot)	yes (Drago)	PI & PO
CRYSTALLOGRAPHY	yes (Bravais)	PI & PO
THERMODYNAMICS	yes (Callen)	PI & PO
CLASSICAL CHEMISTRY	yes (Barut)	PI & PO
ELECTROMAGNETISM (Maxwell)	no	AI & AO
STATISTICAL MECHANICS (Boltzmann)	no	AI & AO

That completes the alternative in TP; beyond the kind of mathematics, the kind of the organization and at the same time the kind of logic, we achieved a characterization of the alternative in TP by means of the kind of the basic theoretical technique. I think that symmetry, being a traditionally algebraic technique - contrarely to differential equations, which essentially are continuous techniques - fits well the basic assumptions of an alternative Natural Philosophy commonly based upon discreteness.

By the present paper I think to add to such a Philosophy more qualifications, i.e. a typical use of non-classical logic together with a particular organization of a theory (the PO, otherwise called empirical, or genetical, or instrumental organization). There is a last point to be added; it requires one more choice - may be an unpleasant choice. I will develop this point in the next section.

7. Space and Geometry in alternative Physics

By the above analysis we obtained an alternative to dominant physics in the objective physics, i.e. in the realm of experiments, mathematical techniques and logical arguments which are commonly presented by textbooks. The two basic options - on the kind of mathematics and on the kind of organization - pertain instead to the effective physics, i.e. they effectively shape the theory as a whole. However, there exist the subjective physics also, i.e. the physics as it is presented inside the scientific community or inside the community of physics teachers; i.e. it is presented by common language, basic notions, intuitive ideas, feelings, stereotypes.

To the last realm pertains the notion of space (as well as that of time). We well know that philosophers pondered upon it a long time. It may be considered at last either as a container (Newton's version) or as a relational space (Leibniz).

Accordingly, the notion of geometry changes from the analytical geometry to the synthetic geometry (in particular, intrinsic geometry). It is highly remarkable that some physical theories -

i.e. thermodynamics and chemistry - lack of geometry; hence, their notion of space is highly dubious. Instead to see in this lack one more evidence for their immature stage of development - as a Newtonian philosopher does - let us consider this historical event as a problem to be investigated.

Let us come back to the section 2, where we mentioned Weyl's mathematics. This mathematics enjoys some more properties than CoM. In particular, it is capable to represent the geometric intuition (i.e. crossing points, existence of points in continuity, etc.). Then, the following hypothesis can be suggested^[28]. Although at the beginnings of TP Galilei's experimental methodology contrasted the idealistic notions, the first physical theories - i.e. geometrical optics and then celestial mechanics - where the points at infinity appeared as "natural" additions in order to take in account the geometrical intuition, then introduced in a natural way the AI (just for the same reason Weyl's mathematics includes them^[29]). Subsequently, AI entered in mechanic theory in an overt way by means of Newton's infinitesimals, which since then on dominated science one century and half. When, in the turn of 1800, new theories born as alternative sciences - chemistry, L. Carnot's mechanics and S. Carnot's thermodynamics - all they referred to a relational space instead of a space as a container. In fact, they rejected AI and, as a natural consequence, even geometry, which had first introduced it in TP.

However, let us remark that both chemistry and thermodynamics lack of geometry at all, while L. Carnot's mechanics starts a new kind of geometry in TP - i.e. symmetry - via geometrical motions. It is not a chance, in my opinion, that some decades after L. Carnot, geometry - and hence the notions of space, sphere, line too - was founded anew by Lobachevsky. Actually, the Russian geometer founded anew calculus on PI as an Algebra of Finites, in particular he introduced first the modern notion of function^[30] The event was so radical in nature that after two millennia since Euclides and in opposition to him, Lobachevsky's non-Euclidean geometry started a process for founding in a new way the whole mathematics.

As a conclusion, the price to be paid by choosing PI - or finiteness or discreteness -, is to renounce to the geometrical intuition and, as a consequence, to renounce to produce physical arguments relying upon geometrical continuity of the objects at issue. These features may present so radical variations - as the notions of a non-Euclidean geometry do w. r. to Euclidean geometry's ones - to include contradictory intuitive aspects, just as ether, vacuum, wave and corpuscle did in past times. Rather, one has to choose a definite mathematics and then to follow its specific intuition, if any.

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**TECHNOLOGICAL INNOVATION AS AN EVOLUTIONARY PROCESS : A
THEORETICAL EXTENSION IN DISCONTINUOUS INNOVATION**

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ABSTRACT

The paper explores how products and associated organisations might evolve in conditions of environmental uncertainty.

The paper proposes a search path, of the type specified by Simon, which might be used by managers to create new viable solutions to business problems.

The argument of viability is based upon analogy with successful strategies adopted by species other than humans, and in particular references the evidence of Peters to suggest that such alternatives are already emerging.

TECHNOLOGICAL INNOVATION AS AN EVOLUTIONARY PROCESS : A THEORETICAL EXTENSION

Introduction

Management of any activity involves the selection and implementation of courses of action. Selection, if it is to be other than purely random in nature, must be based upon some form insight as to what the consequences of those selection decisions might be. It is difficult to select without a vision of whether any worthwhile objectives can be achieved. Simon, in his book "The Sciences of the Artificial" suggested that there are two kinds of selectivity. One is where various paths are tried out, the consequences of following them are noted, and this information is used to guide further search.....The second source of selectivity in problem solving is previous experience.

Selection of the appropriate business solution based upon previous experience is becoming more difficult. 'Business as usual' is no longer usual (Gordy 1993) and thus conditions within which previous experiences were applicable are no longer relevant. The fact that the world is changing rapidly is clearly enunciated by Peters (1992) who in his book Liberation Management readily admits that the many of the companies used as examples in his earlier book "In Search of Excellence" which were extolled for management excellence, are now having unexpected difficulties in their operation. Peters suggests that there are new forms of organisation that have proved successful in competing in today's uncertain environment.

The implications of disbanding current industrial structures in favour of the much smaller less formally integrated project groups activities, as advocated by Peters, are such that a prudent manager ought to ask whether new

organisational forms can be successful in the long term. Only then might that prudent manager seriously consider adopting these new forms.

This paper identifies an analogy which suggests that the new structural forms can provide the basis for future success in an environment where radical innovation of the type described by Peters. It also provides a conceptual outline, based upon technology development analysis which can be used to analyse the alternatives available to managers who have to decide how to operate in the rapidly changing environment of discontinuous r radical innovation.

Assumptions

The paper is based upon three fundamental assumptions:

- The pace of change in industry is now so fast that it is no longer relevant to base selection primarily upon previous experience.
- The use of analogy from the results of other research disciplines will indicate that alternative industrial structures can be sustained and be successful in the long term. The search for sensible alternatives to the existing industrial structure is therefore worthwhile and may lead to attainable more attractive scenarios that companies can work towards.
- The development of selection methods based upon search algorithms as suggested by Simon will help the manager to make choices which will help companies to accomplish the management task more successfully.

This paper uses the application of evolution concepts as the basis for supplying an analogy consistent with assumption 2 and as the basis for creating a search algorithm consistent with assumption 3.

Evolution and Population Ecology

Success is generally measured by volume. A successful company is one that makes "more" profits, makes "more" sales or even employs "more" people. The population size of the measurement unit appears to be the criteria. This is consistent with the Darwinian evolution concepts which are based upon success being measured by population numbers within a specified environment.

Darwin specifies that success in evolution is a function of selection and variation. Those species which are better adapted to the environment will be most favoured by selection. The reality is that the environment is continuously changing and what is better adapted at one point in time and to one set of conditions, may not be better adapted as the environment changes. A species that has the ability to vary will be able to change the properties it possesses and thus has the potential to continuously match the environment specifications for better adaptedness as the environment changes over time. In environments which are rapidly changing, the facility of rapid variation will be have a higher priority than if the environment is comparatively stable.

Population ecology is the field of study which addresses these concepts, as it is concerned with the environmental adaptiveness and adaptation of organisations ('collectivities of organisms' rather than individual organisms). It describes how successive waves of organisational forms emerge in response to discontinuous environmental change and develop through stages, each of which is characterised by the advent of a new species, eventuating in a stage wherein a dominant species is apparent (Lambkin 1990: 158; cf. inter alia Aldrich 1979; Hannan and Freeman 1977; Kimberly, Miles & Associates 1980; Singh 1990).

In evolutionary biology, the equation which is recognised as describing the evolutionary development process is the Volterra Lotka equation, which is often known as the logistics curve. The population size N is the measure of relative success, the process of population growth is represented in terms of r , the rate of creation of new examples, or birth rate and K , the upper limit of sustainable population size. The two poles of a continuum of ecological strategies have been termed r selection and K selection, after the two terms in the logistical growth equation:

$$dN/dt = rN[(K-N)/K].$$

By inspection of the equation, when N is small in comparison with the carrying capacity K , the size of r is important to the rate of increase in population and therefore success. Where the populations considered are expanding exponentially in an uncrowded environment and where resources are not limiting, selection will favour a high value of r [the natural rate of increase often called the birth-rate]. Organisations with rapid growth potential are designated r type organisations.

Returning to the equation, when N gets close in value to the carrying capacity of the environment K , the term in brackets, which represents the restriction on population growth by an increasingly limiting environment, becomes dominant. At the limit condition of $N=K$, population growth (dN/dt) is zero for all values of r . This implies that whatever the birth-rate, it is matched by the number of items going out of existence. In more stable and long lasting environments where resources are limiting, selection may well favour those characteristics that enable an individual to maintain itself in such a competitive environment. Efficient use of resource to achieve objectives,

rather than simple productivity (achieving objectives), will be selected for. Such organisations are designated K type organisations. (This analysis owes much to the work of Shorrocks (1978)).

An Environment of Changing Carrying Capacity

The environment of industrial society has in the past been one of comparatively stable long product life cycles combined with economic cycles which varied the carrying capacity which supported industry to a limited degree. The overlying economic trend has been one of growth, where small changes in carrying capacity (the economic growth rate changing from say 3% to 1%) have caused significant difficulties to the management of companies. Employment levels have been at high levels where a 10% unemployment figure is considered unacceptably high. Resources, such as usable agricultural land have been fully utilised for many years. There are strong indications that human society has been operating near the carrying capacity and is strongly K structured in nature.

Experience of Large Variation in Carrying Capacity over a Short Time Period.

The modern environment of technological change has reduced the average product life cycle length in at least some market sectors. A manufacturer of high technology goods now finds that product life cycles can be measured in periods of as little as two years (Bob Tillman, Managing Director of Hewlett-Packard (UK) Ltd in a speech to the International Forum for Technology Management, Paris 1990). These market conditions favour discontinuous innovation which is equivalent to a regular change in technology paradigm of the type described by Kuhn (1962,1970). In ecological terms, the carrying capacity of a market for a particular product varies quite dramatically over two years. Small perturbations such as the economic cycle are small in effect

upon carrying capacity compared with such effects.

In an environment where product life cycles are long, the carrying capacity of a particular market is broadly predictable. In the environment of short product life cycles that exist in industries such as the computer industry, there is simply not enough time to build up previous experience as a basis for decision selection. It follows that there are examples which have a significant importance in the current economic system which experience a pace of change in industry is now very rapid. Bob Tilman as a representative of such a company indicated that Hewlett Packard can no longer use the same management methodologies that were used in the past. They can no longer base decisions primarily upon previous experience. Assumption 1 as expounded earlier in this paper is at least true for some companies.

Analogies from the Biological World

Short Product Life Cycles imply that market demand will grow very rapidly and then contract very rapidly. Very rapid changes in increase of the carrying capacity of a market are likely to lead to situations of an uncrowded environment unless the companies can respond by operating at a very high growth rate. Those companies which are likely to be successful in this stage are those which exhibit r type characteristics. The phase of maximum carrying capacity and zero growth exists for a very short time in an environment of short product life cycles. Once growth has finished, decline sets in and then the point rapid approaches when there is no market for a particular product.

Companies must either develop strategies that can cope with such an environment, or they must somehow ensure a return to the old familiar structures of long product life cycles. The question is societal in nature in that

adapting to short product life cycles as a norm for all industry and commerce would change the structure and one needs to be reasonably certain that a new structure can sustain society in a long term Darwinian success.

There is no direct experience in the existing business environment of the type of conditions being applied universally. If analogy is acceptable, and analogy is certainly used in management theory (e.g. product "Life Cycles"), then one must look to see if similar conditions exist in other environments, and if so how Darwinianly successful those that operate there can be considered to be.

If one looks to the biological environment, the seasonal changes in temperature bring about variations in vegetation supply which directly affect the carrying capacity for individual species. To live in such an environment, species have evolved strategies which allow them to operate at a very high growth rate when the carrying capacity is increasing in the Spring, and retrench to survive the reducing capacity of Fall and the very low carrying capacity of Winter.

One such species operating in such an environment is the insect world. It can reasonably claim to have been at least as successful as human - even more so if success is measured merely in Darwinian terms of maximum population numbers. By analogy, it follows that success is possible in an unstable commercial/industrial environment of short product life cycles. There is also by analogy a model to aim for, which if applied to the environment of commerce, could be successful. There are successful examples of assumption 2 as expounded earlier in this paper.

The Application of the r - Type Characteristics Concept as a Suitable Algorithm to the Use in the Search for Solutions to Problems in the Management of Commercial Organisations

Analogies are only of interest if they can lead to a useful insight which can be applied. We propose to apply the r - type biological analogy of the insect world to the short product life cycle world of technology and explore whether the implications can describe a self consistent environment that is feasible. Technological innovation, production, marketing, strategy, finance and organisation form a continuum of behaviours that is of central explicative significance (Foxall and Fawn 1991). What will be done is to develop a framework for organisation that is consistent the possibilities of technology, production, marketing, strategy and finance. This framework will then classify as a possible algorithm for search as advocated by Simon.

Considerable work has been done in the biological field to establish the attributes associated with r type species and K type species. This has been categorised in chart form by Shorrocks with attribution to Pianka (1974). The basic unit used for analysis is the reproductive unit. For non-biologists (such as the authors) it can be helpful in understanding to think in specifics such as an ant colony being an r - style example and a human family being a K - style example.

Factors	r - Style	K - Style
Environment	Temporary, Variable and/or Unpredictable	Stable, Fairly Constant and/or Predictable
Mortality	Often Catastrophic, Density Independent	Density Dependent
Population Size	Variable in Time, Usually Well Below Carrying Capacity, Recolonised each year	Fairly Constant in Time, At or Near Carrying Capacity of the Environment, No Recolonisation Necessary
Competition	Variable, Often Lax	Usually Keen
Selection Favours	<ul style="list-style-type: none"> - Rapid Development - High Maximal Rate of Increase (r) - Early Reproduction - Small Body Size - Single Reproduction 	<ul style="list-style-type: none"> - Slower Development - Greater Competitive Ability - Delayed Reproduction - Large Body Size - Repeated Reproduction
Length of Life	Short, Usually Less Than One Year	Longer, Usually More Than One Year
Leads To	Productivity	Efficiency

A Biological Analysis of Characteristics of Reproducing Units

This chart is then used, through analogy, to produce an equivalent chart of the possible attributes of r - type and K - type commercial organisations. Some liberty has obviously been taken, but the intention is that the sense has not been changed, despite the change in context. The major contrasting characteristics are as follows:

Factors	r - Style	K - Style
Environment	Temporary, Variable and/or Unpredictable	Stable, Fairly Constant and/or Predictable
Company Failure	Often Catastrophic, Density Independent	Dependent upon numbers of companies in the market
Number of Companies	Variable in Time, Below Market Carrying Capacity, New Product = New Company	Constant in Time, Near Market Carrying Capacity, Established Market Reputation
Competition	Variable, Often Lax	Usually Keen
Market Selection Favours	- Rapid Product Development - High Reactivity to the Market - Technology Leader - Small Organisation Size - Discontinuous Innovation	- Slower Product Development - Greater Competitive Ability - Technology Follower - Large Organisation Size - Incremental Innovation
Length of Company Life	Short, Usually Less Than One Product Life Cycle	Longer, Usually More Than One Product Life Cycle
Leads To	Productivity	Efficiency

Table 1 - Organisational Implications of r and K Environments

This paper puts forward the proposition that species that have r-type characteristics closely resemble technological innovations which either have short life cycles or are at the post-introductory phases of their life cycles. An analysis of the chart indicates that r-type characteristic products exist under average conditions of low population density which are marked by small ultimate market penetration .

The limited competition is associated with conventional predatory concepts. In K - type situations where survival means acquisition of a scarce resource such as market share, not getting that resource means death of the organisation and the competition is for survival. In situations where the market cannot be satisfied, a form of competition undoubtedly does exist, but the challenge is transferred to getting the appropriate level of product delivered to market in the time window of opportunity - those companies that do get the market share. The implication to marketers is that new concepts

in the nature of competition are likely to have to be developed.

One of the postulations of the analogy is that "companies" (or reproductive units) exist for less than a complete product life cycle. This implies that those organisations that introduce the product concept are not necessarily the ones who have the capability to respond to the market and are not therefore the most successful in terms of product shipped. Equally it might mean that those companies that have the ability to manage the process of rapid reacting to increases in the market are not best suited to manage rapid decline, and get out of the market early. There are a new set of marketing strategies that will need to be mastered by managers. This is of significant interest, but the strand of such an argument is for another paper. There are organisational issues, as the concept of the unit of reproduction may also be changing. This issue needs addressing before the marketing concepts can easily be considered, although marketing issues will obviously have an impact.

The property of catastrophic mortality of a company has significant implication if combined with the single company - single product operation of limited duration. The implications are that the development of a complete new technologies are likely to be cut off and that there will be none of the continuity that is traditionally associated with technological development. It could be that the rapid technological change, a major factor in the emergence of short product life cycles may be the cause of its own nemesis. If so, the situation we are observing may be transitory in nature and we might expect a return to the more stable environment of the past.

The evidence of the success of the r - type insect population indicates that the short product life cycle environment can generate long term population survival and growth and is therefore viable. The analogy indicates that under

conditions of high environmental change, those organisations that do survive are likely to be the small entrepreneurial companies with a high maximal rate of increase (r), early reproduction or an ability to react rapidly when the market conditions are correct, and a tendency to concentrate on one technology (Fawn 1990: 83-4).

Of most importance to this paper is the fact the r type structure successfully exhibited by members of the insect species presents coherent map of an infrastructure which could be envisaged by analogy in the commercial world.

The Relationship Between Birth-rate and the Ability to Adapt

One of the key characteristics that has been identified as necessary to survival in the rapidly changing environment of short product life cycles is the ability to adapt to the environment.

Earlier in this paper, space was devoted to the process of variation or adaptation as the environment changed. The process of adaptation in biology is facilitated by mutation of the gene. It is the gene which is the level at which information about reproduction is passed from generation to generation. If there is a given percentage chance of mutation to the gene knowledge base occurring at any given reproduction, it follows that there will be more total mutation possible if the time between reproductions is shorter and this is more likely to happen if the life span is shorter. In an environment of rapid change, it is the short life span r type organisation that is likely to have a high rate of adaptation.

If the mutation is entirely random, then some of these mutations or adaptations will be less well adapted and some of the adaptations will be better adapted to the changed environment. Selection will then operate to

favour those that are better adapted and they will be more successful. The higher the birth rate for a given population, the more variation in adapted characteristics there will be.

By contrast, the table indicates that **K** type systems will have a lower birth rate and longer life span than **r** type systems. This is hardly surprising as **K** type organisations are interested in efficiency and the higher the population per number of births, the more efficient the use of resource as less energy has to be put into reproducing. A **K** type organisation by contrast to an **r** type organisation is statistically less likely to be produce high rates of adaptation.

If the **r** type characteristics of biological species can be replicated in commerce, then the characteristics will produce a system where output which is appropriate to the market environment will emerge more quickly. In a rapidly changing market environment, the process of natural selection will favour **r** type organisations over **K** type organisations and there will be a shift in the type of industry structure which predominates towards **r** type organisations.

Identifying the Reproducing Unit in the Commercial Environment

If a high rate of adaptation is critical to the survival of a company, then the strategic executive's job is to ensure that the areas of the company which create this rapid adaptation are managed effectively.

In the biological example, it is the reproducing unit which provides the capability for adaptation. The reproducing unit in a commercial organisation must have the attributes that it must be able to create something and also must be able to create change in the something it creates. If one looks at the biological analogy, Dawkins (1986) suggests that what is transferred in the

reproductive act is the recipe of how to make more of the species. One looks at the commercial world, then what is required is to identify where the recipe for business is stored, transferred and mutated in the transmission. It is this process which allows the business enterprise to be successful in adapting to the changing environment conditions.

There is a difficulty in this process, as some of the factors which make a system successful do not pass on this knowledge. In the insect species of the bee, it is absolutely essential that the workers provide their part in the system of a bee colony. It is they for instance who provide the food supply which ensures the bee economy. However, they play no part in the reproduction process and their genes are not passed on.

In a company, the actual product delivered is rarely reproducing in that although the product is the outcome of knowledge, it does not itself have the capability of reproducing. The product itself is very similar to the worker bee, in that it is essential to provide food (money for the system), but cannot reproduce.

It follows that it is the knowledge itself that is reproducible. The essence of this knowledge is often capable of being codified as a way of transferring and reproducing it, but it initially resides in the human brain. It is within the environment of the human brain and in the transfer between brains that this recipe type knowledge is most likely to be capable of being mutated. Foxall and Fawn (1992) have argued that the process of replication and mutation is facilitated by behaviour.

The same paper argued that there is a continuum of Technology-Marketing-Strategy which is necessary to be co-ordinated if innovation of any sort is to

be successful. It was suggested that there is an ontological development of invention into innovation which is largely dependent upon information gained from marketing and strategic behaviours. The three critical success factors are Technology/R&D, Marketing and Strategic Management. It is those areas where knowledge and behaviour are at a premium

A discontinuous innovation is one where the product is newly launched and at an early stage in the product life cycle. In order to identify it as a new product, there be some feature to distinguish it from existing products. Ansoff (1984) suggests that in the early stages of any product life cycle (incremental or discontinuous innovation), the critical success function in a company is the Technology/R&D activity. In a situation where the manager is presented with a plethora of alternatives, it is logical that the manager should look to the critical success factor first in order to eliminate the maximum number of non-viable alternatives in his search for a strategy for his company.

The Technology/R&D Function

The role of a Technology/R&D function is often unique in that its job is to create new or adaptations of product and process. If no change is required, there can be no justification for such a department.

There appear to be two components that are necessarily embedded in the organisation. The first is the storage of technological knowledge about the technological systems that are produced by a company. The second is the ability is to produce variations, based on this and perhaps additional knowledge which provides additional utility in the perception of the purchaser/user of the product.

Much of the technological knowledge is stored in the brains of the

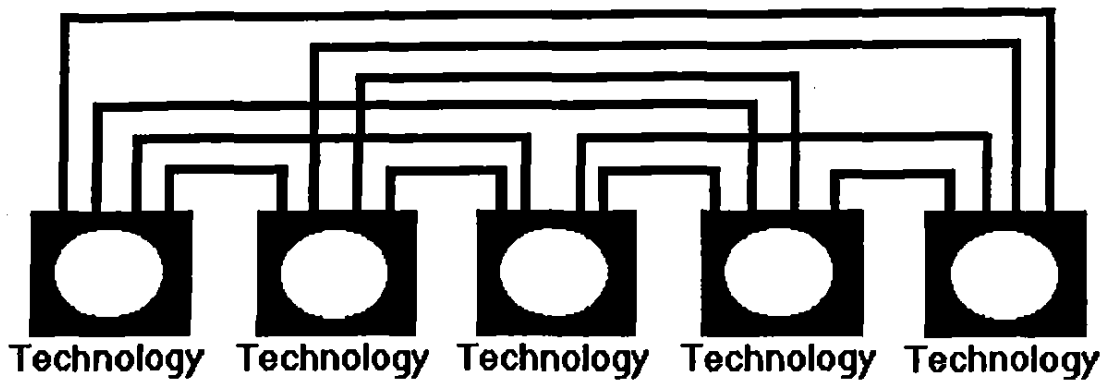
technological team. Some of the knowledge can also be codified in such a way that it can be stored in Design Manuals, Blueprints and more recently there have been significant advances in the storage of knowledge in digital form on computers. The level of knowledge required for complex technological products is such that no one person can own all of the necessary technical expertise and thus there is a requirement for teams of technologists with expertise distributed between them. One of the challenges for a company is to replace and maintain that knowledge as individuals in the team come and go.

The ability to adapt this knowledge has so far been the exclusive preserve of the human mind. In order to understand how knowledge might be developed/mutated by teams and individuals within a team, one needs to understand how technological systems are structured.

Technology Structures

Product systems evolve through a structuring process that involves the combining of technologies or technology subsystems in such a way that the properties provided by each of the subsystems are combined to provide the attributes which provide the product's value added (Fawn & Foxall, Technovation 1992).

There are skills that are required in order to put a system together (the design of the linkages in figure 1) and there are skills involved in creating Technology components which are likely to be subsystems in themselves. Let us designate these skills "Structural" and "Component".



A Simple Technology System

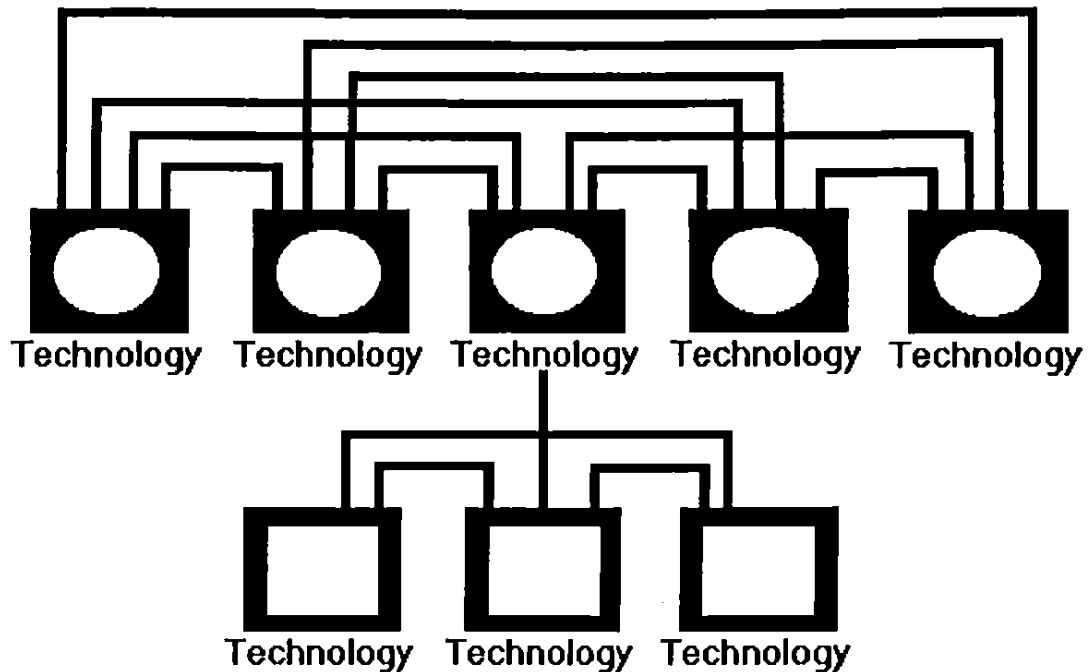
Figure 1

The Structural skills involve systems integration activities. The Technological skills involved in creating the components might be either building subsystems (which might be very similar to those that are required for Structural skills), but may alternatively involve fundamental knowledge of fundamental properties of the base materials from which the products are built up.

In the Foxall and Fawn paper it was argued that technological systems evolve incrementally to a point where the overall system created by the structural skills becomes too complex. It then becomes very difficult to add any further technology to provide additional functionality because the consequences on the overall system become unpredictable and unmanageable. Innovation at that point becomes permissible only within an existing technology, and on the strict requirement that the interface between the technology and its structural system are unchanged. This form of innovation is a description of the process of incremental innovation.

The implications of structural evolution are that there are two types of activity in the process of technological development. The first is that of

altering/developing the system which connects the technologies. The second is developing the individual technology. Indeed, if the notion of structure outlined in the paper is accepted, then these types of activity constitute the only two areas of opportunity in creating technological systems advance.



The Emergence of Hierarchical Structure in a Technological System

Figure 2

The result is the emergence of separately managed self-contained subsystems (Figure 2) in which the technology is forced into taking on a structure. The technology structure and basic interface structure becomes stable and can therefore be considered mature. The development that occurs subsequently is contained within the parameters of a mature system. Once the structure is defined, the subsystem can increase in complexity, provided the interface is not violated. Type r innovation can be observed but only within the subsystem. Our proposed sequence differs here from that advanced by Lambkin and Day in that it posits a sequence of mature technology development which ranges from r to K without an intermediary

phase of 'r and K', but with a final phase of mature technology development which can be described as 'r in K'. We would also draw attention to the possibility of the emergence of further levels of structure since the same argument with respect to developmental sequence can be advanced in the context of the development within a subsystem.

The r activity will generate greater complexity within the subsystem, and the interface constraints will eventually become unmanageable as they mature into a K system in their own right. The solution will then be to create another level where innovation can occur, provided that it does not affect the interfaces among the subsystems at that level. Eventually, the product will develop several layers of subsystem in an 'inverted tree' formation. This suggests that there will be bursts of innovation within the overall cycle of complete product evolution, each burst being associated with r innovation at a particular level within the structure. The concept has been tested using a motor racing industry example in a paper by Foxall, Fawn and Johnson (1992). It is dependent upon the product life cycle being long enough to allow the process to take place before the technological system is superseded by an alternative product.

The Role of Hierarchical Structure as a Transformation Process

So far, we have identified the concept that innovation can occur within technological structures by isolating the innovation in a subsystem which does not violate the boundary conditions of the one level up in the hierarchy. It almost appears that structure is actually required in order to permit innovation to occur within the system. This is in part substantiated by Dawkins (1991) who observes that 'the invention of segmentation (akin to a hierarchical structure) was a watershed event in evolution'.

This structuring is analogous with the phenotype knowledge stored in genes in the biological situation and does not have the same limits as the component process (analogous to the genotype information in genes) described earlier which has ultimate limits related to the physical properties of the materials involved. The structuring is created by the human mind and the actual limits are human in nature. A possible limit comes out of the ability to conceptualise a complex design, but a more likely limit is the ability of a human to adapt the system at a particular hierarchical level to make it work, when either the original concept does not meet its objectives or alternatively, the required objectives have changed.

One identifies that the structural levels perform some function which is identifiable and which requires the information flow across the level to be defined and limited. There are theories which quantify the amount of information transfer that can take place between levels of structures. Alvarez de Lorenzana (1990), building on the Combinatorial Hierarchy Theory, proposes that this mathematics in combination with discrete mathematics developed by Noyes & McGoveran (1989), can be used to quantify social as well as sub atomic particle analysis. This mathematics offers the possibility of further quantifying search paths that Simon suggests will be of assistance to managers who have to take decisions. There is huge scope in this area for further theoretical research. However for the argument that is being put forward, it is merely enough that, however complex the interactions that are taking place at any one level, there is a strict limit as to information flows between levels.

The argument has been evolved that technological systems actually break down into self contained clusters of knowledge involving separate subsystems. The combining of these separate clusters of knowledge involves

yet another cluster of knowledge, but this cluster of knowledge is at a higher level in the hierarchy of a system..

Division of Technological Expertise within the R&D Team

It is managerially sensible that the knowledge responsibilities held by individual technologists are divided in similar ways to the structuring of the technological system.

The organisational structure of most R&D departments is such that one finds a person, or group of people, who are responsible for creating the structure at a particular level in the technology system hierarchy. This is an integrative role which takes the individually limited inputs from each subsystem and manages their interfaces in such a way that utility is created to add to the level of hierarchy above. Organisation does reflect the structure of the technology knowledge.

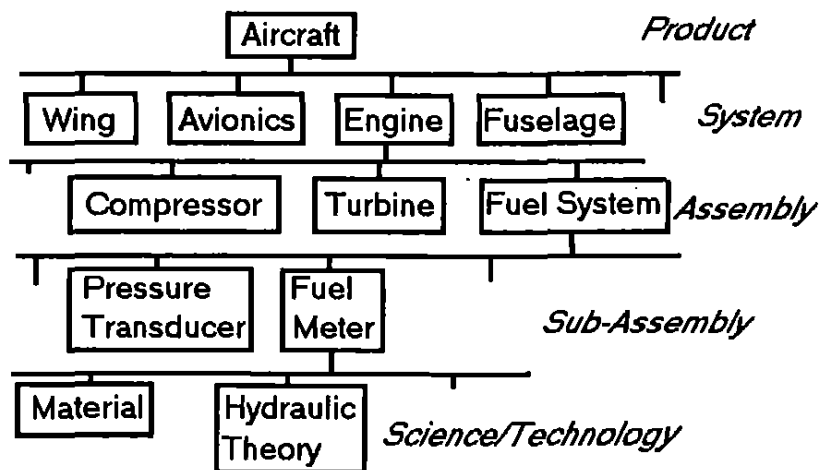
The Emergence of Specialist Separate Companies in the Structure

The process of creating separate departments to contain the knowledge of the technology systems also sets up barriers to the free flow of information between departments. This is acceptable because the information flows based upon a defined interface are restricted. The process of creating separate departments to contain the knowledge of the technology systems also sets up barriers to the free flow of information between departments. This is acceptable because the information flows based upon a defined interface are restricted.

Each organisational structure comprises several people as it is almost certainly too risky to entrust specialist knowledge to just one person and the development of specialist technological knowledge tends to be a group

activity. As a product gets technologically more complex, more and more groups of people tend to be needed both to provide the necessary technologies and to provide the transformation knowledge. It becomes obvious therefore that there is a limit where even the largest company cannot afford to employ, nor can they recruit enough able people, to provide all of the necessary skills.

The outcome is that one is likely to see Original Equipment Manufacture (OEM) companies emerging to supply transformation capabilities at each hierarchical level.



The Hierarchical Organisation of an Aircraft Technological System

An analysis of a technological system such as an aircraft is a good example, but equally one might perform the same analysis for automobiles or computers.

At the product level, there are several companies which compete. In the aviation arena. One can identify Boeing, Airbus Industrie, McDonnell Douglas etc. These companies will also possess capability in some of the major systems such as wings. In other areas, such as aircraft engines, there are

several major competitors such as Pratt & Whitney, General Electric and Rolls-Royce who each have products which act as major systems. At this level, all of the engine manufacturers supply all of the airframe manufacturers. If one follows the example of a subsystem such as the fuel system, there are again another set of companies which supply systems to the engine manufacturers. The examples of separate companies operating at each level in the hierarchy can be traced on through the supply chain.

The Dichotomy of Technologically Based Vertical Integration.

Tom Allen (1990), in his research at MIT, has found that those companies which have worked together regularly to produce systems which integrate into a technological hierarchy, tend to produce a more effective product combination than those working together for the first time. It is therefore advantageous for companies to form long term (stable) relationships between themselves and companies at the next level in the hierarchy, both up and down. Such a policy would lead to sets of closely vertically integrated companies which are mutually dependent or indeed companies which deliberately operate a policy of delivering several levels of the technological hierarchy within the one company.

An alternative analysis based upon the success of a product such as the Boeing B747 aircraft and its product policy of offering choice of engine supplier, indicates that each engine manufacturer in combining its product with the airframe, have held the technological utility advantage at different times. It follows that it may be possible for companies at each level in a technological hierarchy to be able to compete successfully as a separate entity to supply a multiple of similar customers at the next level up in the technology hierarchical structure. Such a strategy is good for the company at the higher level of the hierarchy, as it ensures a competitive environment

where there will be technical performance, and price competition as a minimum. Equally, it can be perceived of as good for the company operating at the lower level of the hierarchy, as that company is not solely dependent upon the fate of a single company higher in the hierarchy for its own future prosperity.

The question each manager must ask is how this dichotomy of the commercial advantage of close vertical integration into the technological hierarchy versus the business risk reduction facilitated by inter-relating with multiple customers in the market place, should be resolved for his own company.

The dichotomy exists in other environments than just the commercial technological system environment. In the biological world, the predator prey hierarchical system in its simplest form has a species at each level of the system. which has the capability of reproduction of and passing on of the gene information. Variation can take place at each level of this hierarchy because genes are reproduced at each level. Sober (1984) in his book "The Nature of Selection" addresses the problem that within this hierarchy, highly successful variations can occur involving grouping of individuals in a species into herd and hunting group activities. The formation of a herd involves the creation of another level of the hierarchy which cannot of itself directly reproduce, but requires the acquiescence of the level below in the hierarchy. This is exactly akin to the r in K structuring that is described in Foxall & Fawn (1992). It relies on the higher level of the hierarchy being fixated such that innovation at that level is very difficult. Innovation takes place hierarchies at the lower level of the hierarchies.

Variation as the Key

The key to the solution of the dichotomy may lie in the fact that when information is reproduced, it also has the capability of being mutated. Biologists have naturally concentrated upon the reproductive implications of a species because it is this which defines how a species survives. They do of course readily acknowledge the importance of mutation, but the Timescales that exist in biological study make successful variation arising from mutation a secondary effect.

In a rapidly changing environment, the ability to adapt to new conditions is of paramount importance. It appears that structure in technologically advanced systems is inevitable. In stable conditions, adaptation is achieved by adaptation at the lower levels of hierarchy. In unstable conditions, adaptation must occur at all levels in a hierarchy. By analogy with biology, one therefore needs the ability to reproduce at each level in the hierarchy and thus a different species must exist at each level. In the technological sense, this implies a separate independent organisational structure must be present at each level in the hierarchy, for it is the human brains contained within the structure of a company which store and transfer or reproduce the technological knowledge. It is the human brain which provides the capability for mutation of that knowledge.

A Technology Marketing Strategy Continuum at Each Hierarchical Level

A development of a technology system on its own is a process of invention. Innovation is the process of successfully commercialising that invention. Foxall and Fawn indicated that there must be a continuum of all business skills for innovation to occur. In this paper, there has been a concentration on the technological aspects of the continuum. Technology, as proposed by Ansoff, is the critical factor in the early stages of innovation, but innovation must include all of the commercial aspects to be successful.

It has been argued that in conditions of environmental/market uncertainty, technological adaptation must be achievable at each level in the technological hierarchy. This is most likely to happen if knowledge at each level in the hierarchy is organisationally separate. Added to this requirement is that technology, marketing and strategy are a continuum and therefore any changes in one must be mirrored in all.

It follows that it is highly likely that in conditions of environmental uncertainty, separate commercial units will emerge spontaneously to create new products. It might be deduced therefore that the industrial structure to be expected in conditions of environmental uncertainty is one of small companies concentrating on one level of technological hierarchy will emerge. What has been discussed may be the explanation of the phenomena described in Tom Peter's book "Liberation Management" where small specialised companies are emerging as a successful form where previously large firms dominated.

The Uniqueness of Each Level in the Hierarchy

The concept of an industrial structure which is compatible with the technological hierarchical structure is not new. It was Chandler (1966) that suggested that form followed function. The extension of this to separate organisations contributing to different levels of hierarchical structure is merely a logical extension.

An initial examination of each level of structure would indicate that the task at each level is similar. Typically the role of an organisation is to interact in a two way flow of information in a structure way with organisations at both a lower and higher levels in the hierarchy. At the level that the organisation

operates, the job is to integrate and resolve the complexities in order to meet the fixed criteria imposed at the interfaces. It might therefore follow conceptually that an individual organisation can perform such a role at any level in the hierarchy.

The reality is that specialist technological knowledge is needed to resolve the conflicts arising from complexity, and this knowledge will exist only where it is commercially appropriate. The technological knowledge required at each level will differentiate that level. In addition, the mathematics of hierarchical structuring developed by Alvarez de Lorenzana (1991) indicate that the process of transferring information between levels in a hierarchy involves a transformation process dependent upon scale effects. These scale effects are different at each level of the hierarchy and thus the skills involved in managing the process will be different. Each company at a level will have a unique capability with each capability being necessary to the creation of a total technological product.

Compatibility with the Concept of an r-type Organisation

It would be nice if the proposed theoretical technological/organisational structure that has been evolved is compatible with observed developments and is inherently stable in the way that the r type organisation is stable in

Factors	r - Style
Environment	Temporary, Variable and/or Unpredictable
Company Failure	Often Catastrophic, Density Independent
Number of Companies	Variable in Time, Below Market Carrying Capacity, New Product = New Company
Competition	Variable, Often Lax
Market Selection Favours	- Rapid Product Development - High Reactivity to the Market - Technology Leader - Small Organisation Size - Discontinuous Innovation
Length of Company Life	Short, Usually Less Than One Product Life Cycle
Leads To	Productivity

nature. The Tom Peter's book indicates that such forms are observable. It is therefore worth exploring how compatible the concept is with the specified conditions and requirements of an r type

structure.

In an environment of uncertainty, individual companies will emerge, have a short life cycle and disappear. When a company disappears the process will be catastrophic and it is unlikely that it will reappear. Companies will need to have rapid response to market by producing advanced technology fast and the type of innovation will be discontinuous rather than incremental in nature.

The "Lego" Type Future

The key to the process of discontinuous innovation must be the rapid creation of hierarchical structures. The interfaces will be defined, and the innovation will be in the creation of new subsystems by assembly of subsystems which are evolving rapidly but are built up of standard units. The concept is reflected in the emergence of object oriented programming in software development, the use of standard interfaces in the personal computer where innovation can be seen in plug in boards and even in the architecture of mother boards but the interface remains designed and fixed. A simplistic view of the process can be understood from the children's toy "Lego".

The "Lego" company regularly brings out new shapes of "module", and the children are able to use these modules, based upon a standard interface, in conjunction with their imagination, to produce a myriad of constructions. Even with a simple concept such as "Lego", the range of possible outcomes is almost limitless. If a new shape or module does not prove popular, it is rapidly discarded by the manufacturer. The individual modules may have a very limited life, but the overall concept has remained attractive to children of all ages and there has been long term stability from this innovation.

The "Lego" approach allows companies to market their specialised skills to a larger market. specialisation plus standard interfaces allows small companies to offer specific skills to a broader market whilst remaining as a small creative unit. The creative unit will have a complete range of the commercial skills that are necessary to survive. The small size inherent in an r type organisation allows a high level of integration which will allow complex products to be developed quickly.

Preservation of Technological and Commercial Knowledge

The major problem in the scenario presented is the short life cycle of an individual company. The most likely possibility is that a group of appropriately skilled people would come together to form what would most easily be understood as a project team in a large organisation. The difference is that such a team would have complete profit responsibility for their operation and have no infrastructure to provide support services. The group would put an innovative product on the market and the company would depend upon that product. As the market evolves and the product is superseded, the company would die.

The problem is one of what happens to the knowledge that is developed during the existence of the company. Any recorded information is likely to be lost, but the knowledge which is retained within a human brain can be retained. The sort of knowledge that is required in a broad industry sector is transportable in that people can move from job to job and indeed must do so if companies fail.

What is likely to emerge is groupings of people, working in networks who are available as projects emerge and who have skills which correspond to levels appropriate to a specific technological hierarchical level (even if that skill is

marketing). The knowledge base that is at risk can therefore be retained within a peer group and is less at risk than might be imagined from the disintegration of a particular company.. It is the continuation of individuals and the knowledge contained within them that is likely to sustain the knowledge that society requires to be maintained.

Conclusions

The environment exhibits areas where change, often created by technological advance can produce instability.

It appears that it is possible to postulate an alternative r type industrial structure which is based upon the concepts observable in a successful biological species. It is possible to propose a development process of technology and technology based companies which operate on the "Lego" principle which fits with the concepts of r type industrial structures. Limited evidence, which may therefore be considered anecdotal at this stage, can be found to support the idea that such alternatives are financial viable. One has therefore developed a structural evolutionary model which may help businessmen to define new ways of doing business which can be successful. One has therefore defined a search path of the type suggested by Simon. There is even the possibility of a mathematics which might be developed to help quantify the developments of structure.

Such an industrial structure, if it gets established, is likely to enhance the ability to innovate and therefore to speed technological progress. This will in turn create a continuance of the unstable environment which will reinforce the emergence of a new pattern of industry.

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ALTERNATIVE MATHEMATICS PROJECT

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This paper is concerned with methods which show the pattern behind concepts. An attempt is made to generalise four such concepts namely iteration, continued fractions, coefficients of power series and trigonometric functions.

Problem 1

Iteration is normally carried out in discrete steps. Would it be possible in some sense to make this procedure continuous and somehow use a non-integral number of iterations?

Characteristics.

Something to do with functions is done in a discrete way. Some in between results are needed.

Analogical Structure.

The method of finite differences seems a likely approach.

If we can convert a function $u = F(y)$ into the form $f(x + 1)$, where $x = f^{-1}(y)$ is the inverse function to f . i.e. $u = F(y) = f(f^{-1}(y) + 1)$, then it becomes easy to iterate the function F any number of times.

e.g. $F \circ F(y) = f(f^{-1}(f(f^{-1}(y) + 1)) + 1) = f(f^{-1}(y) + 2)$

If we take $f(f^{-1}(y) + t)$ to be F iterated " t " times then if we iterate one more time we get

$F \circ f(f^{-1}(y) + t) = f(f^{-1}(f(f^{-1}(y) + t)) + 1)$

$= f(f^{-1}(y) + t + 1)$. So by induction this works

for integer values of " t ". Let us assume that it will also work for non-integer values.

From our previous notation a value of particular importance is $f'(x) = f' \circ f^{-1}(y)$. With respect to $F(y)$ this behaves in some ways like a logarithm and in other ways like a derivative. To get from $F(y)$ to this value we use an operator denoted by λ i.e.

$f' \circ f^{-1}(y) = \lambda F(y)$. The inverse operator is denoted by λ^{-1} i.e. $\lambda^{-1}(f' \circ f^{-1}(y)) = F(y)$. $F(y)$ iterated 't' times

is then given by $\lambda^{-t} F(y)$. For example $F \circ F(y) = \lambda^{-2} F(y)$ & $F^{-1}(y) = \lambda^{-1} F(y)$ is the inverse of $F(y)$.

If $u = F(y)$ let us denote $\lambda F(y)$ by $\phi(y)$ then an idea

of what the operation λ means can be got from the fact that $\frac{du}{dy} = \frac{\phi(u)}{\phi(y)}$. This relation holds because λ

represents a kind of speed of iteration. An application of this notion to Chaos Theory arises in

the following way. Let $F(y) = y^2 + c$ be the function which is iterated to produce a Mandelbrot Set then if

F is represented with respect to a fixed point y_0 then λF about y_0 has coefficients which have

denominators of the form $1/(q^N - 1)$ where N is a +ve integer and q is the coefficient of $y - y_0$ in λF .

The value q is of course given by $\lambda F'(y_0)$ which equals $F'(y_0)$ since λF always shares its fixed points

with F no matter what F may be. Because of the nature of the denominators of λF it turns out that λF is

always infinite no matter what y may be whenever q is a complex root of unity. So in this case the speed

of iteration is infinite and it turns out that when this happens, the value that c takes is on the first

boundary of the Mandelbrot Set namely the cardioid shape in the case of $F(y) = y^2 + c$ but it can of course

be other shapes for different starting functions.

The fixed point for $F(y) = y^2 + c$ is y_0 such that $y_0^2 + c = y_0$.

i.e. $y_0 = (1 + (1 + 4c)^{\frac{1}{2}}) / 2$ so $F'(y_0) = 1 + (1 + 4c)^{\frac{1}{2}}$. Let $q = e^{i\theta}$

then $e^{i\theta} = 1 + (1 + 4c)^{\frac{1}{2}}$ so $c = ((e^{i\theta} - 1)^2) / 4$ or $c =$

$((\cos 2\theta - 2\cos \theta) + i(\sin 2\theta - 2\sin \theta)) / 4$ which is a cardioid.

Problem 2.

The usual methods of solving algebraic equations which lead to one after another decimal place give no idea of a pattern in the results obtained. Could a method be found which would clearly show the relationship of the algebraic numbers obtained as roots of the equation to other nearby numbers ?

Characteristics.

Set of numbers required which approximate results with increasing accuracy.

Analogical Structure.

The method of continued fractions would be a good place to start and a suitable analogical structure for the continued fractions themselves are square matrices.

A simple continued fraction is a real number of the form $a_0 + 1/(a_1 + 1/(a_2 + \dots))$

e.g. $30/13 = 2 + 4/13 = 2 + 1/(13/4) = 2 + 1/(3 + 1/4)$

The continued fraction for any rational number always terminates. The continued fraction for any irrational number never terminates and in the case of a real root of a quadratic equation there is a recurring sequence after a fixed part. e.g. $\sqrt{3} = 1 + 1/(1 + 1/(2 + 1/(1 + \dots)))$

$\sqrt[3]{2} = 1 + 1/(3 + 1/(1 + 1/(5 + 1/(1 + 1/(1 + 1/(4 + \dots))))))$

Let us write our first example as (2;3,4) and the others as (1;1,2,1,2,1,2,...), (1;3,1,5,1,1,4,...)

Now $1/(a_1 + 1/a_2)$ or $(0; a_1, a_2) = a_2/(a_1 a_2 + 1)$

this could be represented by $\begin{bmatrix} 0 & 1 \\ 1 & a_1 \end{bmatrix} \begin{bmatrix} 1 \\ a_2 \end{bmatrix}$ which equals

$\begin{bmatrix} a_2 \\ 1 + a_1 a_2 \end{bmatrix}$ or even better still by $\begin{bmatrix} 0 & 1 \\ 1 & a_1 \end{bmatrix} \begin{bmatrix} 0 & 1 \\ 1 & a_2 \end{bmatrix}$
 which equals $\begin{bmatrix} 1 & a_2 \\ a_1 & 1 + a_1 a_2 \end{bmatrix}$

and $a_0 + 1/a_1$ could be $\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} 0 & 1 \\ 1 & a_0 \end{bmatrix} \begin{bmatrix} 0 & 1 \\ 1 & a_1 \end{bmatrix}$
 $= \begin{bmatrix} a_0 & 1+a_0.a_1 \\ 1 & a_1 \end{bmatrix}$ and so on.

A possible generalisation of this notation might be

$$\begin{bmatrix} 0 & 0 & 1 \\ 1 & 0 & d_1 \\ 0 & 1 & c_1 \end{bmatrix} \begin{bmatrix} 0 & 0 & 1 \\ 1 & 0 & d_2 \\ 0 & 1 & c_2 \end{bmatrix} \begin{bmatrix} 0 & 0 & 1 \\ 1 & 0 & d_3 \\ 0 & 1 & c_3 \end{bmatrix} \text{ OR } \begin{bmatrix} 0 & d_1 & d_2 & d_3 \\ 0 & c_1 & c_2 & c_3 \end{bmatrix}$$

If this system is extended other roots have recurrence. In the following short notation the continued vectors represented are such that if they are put into the full matrix form, ever closer approximations to the roots involved can be obtained. Asterisks indicate the repeating part. The initial zeroes are missing.

$$\begin{bmatrix} 1, 2 \\ * \end{bmatrix} \begin{bmatrix} 1 & 2 & 3 \\ 1 & 3 & 3 \\ * \end{bmatrix} \begin{bmatrix} 1 & 2 & 3 & 4 \\ 1 & 3 & 6 & 6 \\ 1 & 4 & 4 & 4 \\ * \end{bmatrix}$$

$$\begin{bmatrix} 1 & 2 & 3 & 4 & 5 \\ 1 & 3 & 6 & 10 & 10 \\ 1 & 4 & 10 & 10 & 10 \\ 1 & 5 & 5 & 5 & 5 \\ * \end{bmatrix}$$

These are related to $\sqrt{2}$, $\sqrt[3]{2}$, $\sqrt[4]{2}$ and $\sqrt[5]{2}$ respectively.

The convergents for the last one are:

1	5	35	235	1580	...	611,489,327,404,315
1	6	40	270	1815	...	702,416,784,487,580
1	7	46	310	2085	...	806,865,004,863,190
1	8	53	356	2395	...	926,844,503,791,021
1	9	61	409	2751	...	1,064,664,756,842,789

The ratio of each number to the one next above it in each of these columns is approximately $\sqrt[5]{2}$.

Problem 3

The coefficients of power series are not normally treated as functions of the index concerned but clearly they are. What type of function would be involved anyway and might it have some meaning in the case of non-integral arguments.

Characteristics

The functions of integral values would be somehow connected with differentiation or integration and involve linear operators. The elementary functions should be a good guideline as to which way to go.

Analogical Structure

The elementary functions of a variable z are in turn functions of $\exp(z)$.

Let $f(w) = a_0 + a_1.w + a_2.w^2 + a_3.w^3 + \dots$

then for $w = \exp(z)$ we get:

$$\begin{aligned} f(\exp(z)) &= a_0 + a_1.\exp(z) + a_2.\exp(2z) + a_3.\exp(3z) + \dots \\ &= (a_0) + (a_1 + a_1.z/1! + a_1.z^2/2! + a_1.z^3/3! + \dots) \\ &+ (a_2 + a_2(2z)/1! + a_2(2^2 z^2/2!) + a_2(2^3 z^3/3!) + \dots) \\ &+ (a_3 + a_3(3z)/1! + a_3(3^2 z^2/2!) + a_3(3^3 z^3/3!) + \dots) + \dots \end{aligned}$$

Now the coefficient of $z^n/n!$ is interesting for it is $\sum_{t=0}^n (a_t t^n)$ but $f(w) = \sum_{t=0}^{\infty} (a_t w^t)$

Let us call the above coefficient the Upsi function associated with f and let us denote it by Y_f

if "n" above is replaced by w .

i.e. $Y_f(w) = \sum_{t=0}^{\infty} (a_t t^w)$ or by $Y_n f$ if it has the form

above.

From the above it will be seen that $Y(a.w^m+b.w^n) = a.m^w+b.n^w = aY(w^m)+bY(w^n)$ so Y is a linear operator. A particularly interesting result is obtained from $Y((w-1)^n/n!)$. To see how the values of this vary consider $(e^z-1)^n/n! = (z+z^2/2!+z^3/3!+\dots)^n/n!$ in which the coefficients of $z^m/m!$ are 0 for m less than n and so the corresponding values of $Y((w-1)^n/n!)$ for w less than n are all zero. The functions obtained by this procedure give the well known Stirling numbers of the 2nd kind. A short table of these latter numbers with the corresponding Upsi functions on the right is:

		$S(n,k)$						
$k \backslash n$	1	2	3	4	5	6		
1	1	1	1	1	1	1	$Y((w-1)/1!) = (1^w - 0^w)/1!$	
2	0	1	3	7	15	31	$Y((w-1)^2/2!) = (2^w - 2.1^w + 0^w)/2!$	
3	0	0	1	6	25	90	$Y((w-1)^3/3!) = (3^w - 3.2^w + 3.1^w - 0^w)/3!$	
4	0	0	0	1	10	65	$Y((w-1)^4/4!) = (4^w - 4.3^w + 6.2^w - 4.1^w + 0^w)/4!$	
5	0	0	0	0	1	15	$Y((w-1)^5/5!) = (5^w - 5.4^w + 10.3^w - 10.2^w + 5.1^w - 0^w)/5!$	
6	0	0	0	0	0	1	$Y((w-1)^6/6!) = (6^w - 6.5^w + 15.4^w - 20.3^w + 15.2^w - 6.1^w + 0^w)/6!$	

In the above we use the convention that $0^w=1$ for $w=0$. From the above $S(n,k)=Y((n-1)^k/k!)$.

Further values can be obtained by the recurrence relation $S(n+1,k)=k.S(n,k)+S(n,k-1)$.

Since many functions of $w-1$ can be represented as sums of $(w-1)^m/m!$ for either a finite number of different m 's or an infinite sum, their Upsi functions can be found provided that the infinite sums obtained converge for the particular value being considered.

To obtain the value of a function represented by the coefficients of a given function excluding the factorial denominator we need to find $Yf(\ln z)$.

Take the function $w=1/(1-z)$ which can be expressed as $\sum_{r=0}^{\infty} r! (z^r/r!)$. The coefficient is $r! = \Gamma(r+1)$ and we use $Y(1/(1-\ln z)) = Y(1/(1-\ln((z-1)+1))) = Y(\sum_{r=0}^{\infty} (a_r (z-1)^r/r!))$ where the first few a_r 's are 1, 1, 1, 2, 4, 14, 38, 216, 600, 6240, 9552.

Problem 4

Trigonometric or Circular Functions are so useful for expressing the answer to a large number of problems and they have simple properties which make them easy to handle. Their inverses are particularly useful for obtaining the integrals of certain expressions involving square roots. They are complemented in this latter use by the hyperbolic functions. Would it be possible to generalise all the above functions for use with integrals and other problems involving other roots such as cube roots etc. ?

Characteristics

Functions needed would be periodic and involve some variable that could be thought of as an angle. Homogeneous functions would also occur in relation to these functions.

Analogical Structure

The simplest approach is to generalise the equation for a circle to get that for a so called supercircle. The angle between two radial lines is best represented by the area of the sector enclosed by these lines and the arc of the curve between them. The unit of angular measure is however, chosen so that the actual value of the angle is twice the area of the sector.

In the usual rectangular Cartesian coordinates the equation of a supercircle with exponent 'n', radius 1 and centre at the origin is $X^n + Y^n = 1$. For the point (X, Y) on this supercircle let the corresponding polar coordinate be (R, θ). Then $\theta = \text{ARCTAN}(Y/X)$. Let ϕ denote the 'angle' in the supercircle given by $2 \int_0^{\theta} \frac{1}{2} R^2 d\theta = \int_0^{\theta} R^2 d\theta$
 $= \int_0^Y R^2 (d\theta/dY) dY = \int_0^Y R^2 \cdot 1/(1+(Y/X)^2) \cdot (X \cdot 1 - Y \cdot (dX/dY)) / X^2 \cdot dY$
 $= \int_0^Y R^2 / (X^2 + Y^2) \cdot (X - Y(dX/dY)) \cdot dY = \int_0^Y (X - Y(dX/dY)) \cdot dY$ since $R^2 = X^2 + Y^2$. $X = (1 - Y^n)^{1/n}$ and $dX/dY = 1/n(1 - Y^n)^{1/n-1} \cdot -nY^{n-1}$.
 So $\phi = \int_0^Y ((1 - Y^n)^{1/n} + (1 - Y^n)^{1/n-1} Y^n) dY = \int_0^Y (1 - Y^n)^{1/n-1} (1 - Y^n + Y^n) \cdot dY = \int_0^Y (1 - Y^n)^{1/n-1} dY$.

The above equation is strictly only true in the first quadrant of the supercircle. It should be

$$|x|^n + |y|^n = 1 \text{ where the bars denote absolute value.}$$

Since Y is an ordinate and we have a unit supercircle it corresponds to 'sine'. Let us call it SIN_n then

we have $Y = \text{SIN}_n \phi$ and $\phi = \text{ARCSIN}_n Y$ by extending the usual notation. By the earlier work we see that

$$\phi = \text{ARCSIN}_n Y = \int_0^Y (1 - Y^n)^{1/n-1} dY \text{ and from this it follows that}$$

$$d\phi/dY = (1 - Y^n)^{1/n-1}. \text{ So } dY/d\phi = (1 - Y^n)^{1-1/n} = (1 - Y^n)^{(n-1)/n}$$

$$= ((1 - Y^n)^{1/n})^{n-1} = X^{n-1} = (\text{COS}_n \phi)^{n-1}. \text{ But } Y = \text{SIN}_n \phi.$$

So we have $d(\text{SIN}_n \phi)/d\phi = (\text{COS}_n \phi)^{n-1}$ and it can be shown that similarly $d(\text{COS}_n \phi)/d\phi = -(\text{SIN}_n \phi)^{n-1}$.

We have in particular, for $n=3$, $d(\text{SIN}_3 \phi)/d\phi = (\text{COS}_3 \phi)^2$ and $d(\text{COS}_3 \phi)/d\phi = -(\text{SIN}_3 \phi)^2$. Taking further derivatives we get $d^2(\text{SIN}_3 \phi)/d\phi^2 = 2(\text{COS}_3 \phi) \cdot -(\text{SIN}_3 \phi)^2$ & $d^3(\text{SIN}_3 \phi)/d\phi^3 = 2(\text{SIN}_3 \phi)^2 \cdot (\text{SIN}_3 \phi)^2 + 2(\text{COS}_3 \phi) \cdot -2(\text{SIN}_2 \phi)(\text{COS}_2 \phi)^2 = 2(\text{SIN}_3 \phi)^4 - 4(\text{SIN}_3 \phi)(\text{COS}_3 \phi)^3 = 2(\text{SIN}_3 \phi)^4 - 4\text{SIN}_3 \phi(1 - (\text{SIN}_3 \phi)^2)^3 = 6(\text{SIN}_3 \phi)^4 - 4\text{SIN}_3 \phi$. Similarly $d^2(\text{COS}_3 \phi)/d\phi^2 = 4\text{COS}_3 \phi - 6(\text{COS}_3 \phi)^4$.

We can thus construct differential equations whose solutions are $\text{SIN}_3 \phi$ & $\text{COS}_3 \phi$ and they turn out to be respectively $d^3 Y/d\phi^3 - 6Y^4 + 4Y = 0$ & $d^3 X/d\phi^3 + 6X^4 - 4X = 0$

Also series can be found by solving these equations.

$$\text{In fact } \text{SIN}_3 \phi = \phi - \frac{4}{4!} \phi^4 + \frac{160}{7!} \phi^7 - \frac{1952}{10!} \phi^{10} + \frac{6315520}{13!} \phi^{13} + \dots \&$$

$$\text{COS}_3 \phi = 1 - \frac{2}{3!} \phi^3 + \frac{40}{6!} \phi^6 - \frac{3680}{9!} \phi^9 + \frac{7040}{12!} \phi^{12} - \frac{42100920}{15!} \phi^{15} + \dots$$

Other functions can also be treated e.g. $\text{TAN}_3 \phi$.

$$\text{Examples are } d(\text{TAN}_3 \phi)/d\phi = \text{SEC}_3 \phi \text{ \& } d(\text{ARCTAN}_3 Z)/dZ = (1+Z^3)^{-2/3}.$$

Generalised the last result is $d(\text{ARCTAN}_n Z)/dZ = (1+Z^n)^{-2/n}$.

$$\text{So } \text{ARCTAN}_n Z = \int_0^Z (1+Z^n)^{-2/n} dZ. \text{ Now } \pi/4 = \text{ARCTAN}_2 1 = \int_0^1 (1+Z^2)^{-1} dZ$$

$$\text{We could generalise this to get } \pi_n/4 = \int_0^1 (1+Z^n)^{-2/n} dZ$$

$$\text{or as a series } \pi_n/4 = 1 + \left(\frac{-2}{n}\right) \left(\frac{1}{n+1}\right) + \left(\frac{-2}{n}\right) \left(\frac{-2-n}{n}\right) \left(\frac{1}{2n+1}\right) / 2! + \dots$$

For what 'n' does this converge?

DERIVING THE PLANCK AND OTHER CONSTANTS FROM ANOTHER NATURAL PHILOSOPHY ALTERNATIVE

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INTRODUCTION

We present here two extremely simple derivations of h and of the complete self energy of the electron. This is based, however, on an extensive set of ideas consisting of a dual fluid plenum which retains relativistic invariance. These ideas have been presented extensively elsewhere and so for those not familiar with these ideas an extensive bibliography is appended to this paper. The most recent summary of these ideas will appear shortly for those who wish to see a capsule summary.¹

Even so, a few words must be said about this fluidic approach relevant to h and to the fluid models for the electron and for electromagnetic dipole waves. The basic concept involves replacing the QM paradigm with a realistic dual fluid plenum consisting of continuous positive and negative fluids. These give a neutral vacuum space and give fluid models of the canonical particles and electromagnetic waves (mainly dipole waves which form the basis for all electromagnetic waves). Relativistic invariance is retained, at least on an empirical and realistic basis and this is explained extensively in the bibliography (see at least a-d in the bibliography).

The fluid model for the electron is a negative spinning droplet surrounded by equal amounts of positive fluid which characterise the fields and all other qualities of the electron. The prototype electromagnetic wave is the half wavelength dipole field distribution which is treated as a discontinuous independent entity which has been named the "Photex" and which is the seat for the explanation of all QM phenomena. Converting all these phenomena to fluid models makes possible the realistic description for electromagnetic radiation from the fluidic electron model (Again see at least a-d in the bibliography).

Electromagnetic wave generation consists of the shedding of a toroidal vortex in either positive or negative fluid which then evolves very much as per the sketches first given by Hertz of dipole waves. This vortex shedding occurs upon the acceleration or deceleration of the fluidic electron models, principally in collisions. Thus if the fluidic electron is pictured like a tennis ball which rebounds back and forth between 2 walls, a "Photex" is emitted upon the electron contact with the wall and its momentary deceleration to zero velocity and then another "Photex" (of opposite charge and spin) upon its rebounding acceleration and velocity in the opposite direction. The meaning for h (or rather $h/2$) has been shown to permit an estimate of the energies of each of these "Photexi" of the order of a little less than 10^{-15} ev. Thus the decrement of energy for each collision of the moving electron is very small unless the number of such collisions is extremely large (like 10^{+15} collisions for a 1 ev decrement).

THE DERIVATION OF h

We start with remarks about the significance of deriving h . Dirac in discussing this has said:² "I think one is on safe ground if one makes the guess that in the physical picture we shall have at some future stage, e and c will be fundamental quantities and h will be derived. If h is a derived quantity instead of a fundamental one, our whole set of ideas about uncertainty will be altered ... [The] uncertainty relations(s) cannot play a fundamental role in a theory in

which h itself is not a fundamental quantity. I think one can make a safe guess that uncertainty relations will not survive in the physics of the future."

We point out here how the very simple formula of Larmor can be used to get a very close estimate of h .

We start with the expression of h as energy per cycle per second and what we do is ask if we can get from Larmor's formula the energy emitted for one half cycle of radiation from an electron. Of course his formula giving the energy per unit time must be converted to energy per half cycle per second (sic!). Detailed discussions of these points are given in a-d, f, and g in the bibliography and in ref.1.

We start by noting the relation between \hbar (h -bar) and h :

$$\hbar = h/2\pi \quad (1)$$

We then write the well-known relationship between $h/2$ and the other well known fundamental constants:

$$\alpha = e^2/4\pi\epsilon_0\hbar c \quad (2)$$

Solving for \hbar :
$$\hbar = e^2/4\pi\epsilon_0 c \alpha \quad (3)$$

or:
$$\hbar = e^2(137)/4\pi\epsilon_0 c \quad (4)$$

or:
$$h = e^2(137)(2\pi)/4\pi\epsilon_0 c \quad (5)$$

or
$$h/2 = e^2(137)(\pi)/4\pi\epsilon_0 c \quad (6)$$

or
$$h/2 = [e^2/4\pi\epsilon_0 c][430.4] \quad (7)$$

Eq. (6) will be compared with the forthcoming result of operating on the Larmor formula. The Larmor formula can be written as:³

$$S = [e^2 \overline{\dot{v}^2}] / [6\pi\epsilon_0 c^3] \quad (8)$$

with the units: energy/time and the \dot{v} -dot term is the average of the square of the acceleration. We approximate the collision of the electron droplet with a wall (in the x direction) by means of a simple sinusoidal function where only a half cycle will be used for the first half of the motion; with fluids such a continuous function should be a good approximation for the motion. Thus the motion taken as:

$$\begin{aligned} X &= A \sin \omega t \\ \dot{X} = v &= \omega A \cos \omega t \\ a = \dot{v} &= -\omega^2 A \sin \omega t \end{aligned}$$

The average of $\sin^2 \omega t$ (from Eq.8) for an integral half cycle is 1/2, so that S is:

$$S = [e^2 \omega^4 A^2] [1/2] / [6\pi\epsilon_0 c^3] \quad (9)$$

The units of S are power or energy/second, but this can also be written as energy-cycle/second because the word cycle has been superfluous up to now and has been suppressed, i.e., energy/second is recovered when cycle is suppressed. The task now is try to convert S into a measure, say T which has the units energy per cycle per second or rather energy per half-cycle per second. It should be evident upon study that if S is multiplied by $1/2f^2$ it becomes T . This is because one f converts S to pure energy, the other f puts cycle per second in the denominator of S , and the 2 in the above factor finally converts S into energy per half cycle per second, thus:

$$T = [1/2f^2] [S] = [1/2f^2] [e^2 \omega^4 A^2] [1/2] / [6 \pi \epsilon_0 c^3] \quad (10)$$

which becomes:

$$T = [e^2/4 \pi \epsilon_0 c] [519.5] [A^2/2\lambda^2] \quad (11)$$

Now if the last factor is close to one, or $A = 2^{1/2} \lambda$ which appears to be a reasonable assumption, then Eq. (11) lies within 27% of Eq. (7). It should be mentioned that A.O. Barut⁴ derived a related result from purely QM considerations in 1978.

The ideas presented here possess physically realistic and heuristic qualities which come from the fluid models. This appears to be the first indication that h is derivable from a fluidic electron model in a vortex shedding situation and relates well to the Dirac comment.

FINDING THE COMPLETE SELF ENERGY OF THE ELECTRON

Since only charged fluids are the means used for the construction of the various canonical particle models, a knowledge of the varying concentration of charge and velocity of the fluids of a model can be used to define a continuously variable charge and charge-velocity 4-vector function, J_4 . This also permits that an electrostatic energy and charge-motion energy 4-vector potential function, A_4 , also be defined or derivable. In the case of the fluidic electron model which is a rotating droplet of negative charge surrounded by a varying radial concentration of positive charge and charge velocity, estimates for the total energy necessary to assemble the fluidic electron should also give estimates for the mass of the electron.

This assumes that the $E = mc^2$ relation provides the connection between the assembly energy of the fluid model and its mass. Most of this is covered in a-d, f, and g of the bibliography. We give here the energy of various parts of the electron droplet model which tend to show that the complete energy for the assembly of the model gives the full self energy of the electron.

We start with the well known work on this subject. Sommerfeld³ and many others have shown that an evaluation of the self energy of the classical electron falls short of the full self energy by amounts that are of the order of 25% of the self energy. This has been considered a pretty good estimate because of the ignorance that presently exists about the exact nature of the electron. The spinning droplet electron because of its nature permits a clearer idea of the nature of this extended model of the electron. One starts with the energy of the classical electron as the electrostatic energy outside a charged spherical sphere:

$$\text{Energy electron} = m_0 c^2 = e^2 / [4 \pi \epsilon_0 c a] \quad (12)$$

where a is the classical radius of the electron. The pictorial qualities of the droplet electron permit that an alternate way of assigning energies be made. This consists of allotting equal energies to the electrostatic (e.s.) and to the motional velocities of the fluids of the model. Thus instead of Eq.(12) above one may write:

$$\text{Energy electron} = \text{Energy e.s.} + \text{Energy motional} \quad (13)$$

$$\text{and} \quad \text{Energy e.s.} = \text{Energy motional} \quad (14)$$

The reason for doing this is that it has a desirable symmetry which is also aesthetic. One may rewrite Eq. (13) allotting equal energies to each component so that their sum will still be that shown in Eq.(12):

$$\text{Energy electron} = \{e^2/[8 \pi \epsilon_0 c a]\} \text{ e.s.} + \{e^2/[8 \pi \epsilon_0 c a]\} \text{ motional} \quad (15)$$

where the total electrostatic energy of the 2-fluid droplet electron is the first term in Eq.(15) and has been explained in detail (Ref. 1 and a-d) and where the necessity for the '8' term is obvious. Bucherer⁵ in 1905 derived the magnetic fields inside and outside a uniformly charged sphere spinning at the angular velocity ω . If one assumes that

$$\omega a = c \quad (16)$$

this gives the droplet an equatorial velocity equal to the velocity of light and the evaluation of the magnetic field energy inside the droplet comes out to be 1/3 of the second term (the motional term) in Eq.(15).

Furthermore, Lorentz⁶ has shown that the Poincare stress needs an energy which is also 1/3 of the second term in Eq.(15). In this case the stress is oppositely directed to that which Poincare consider since it prevents the positive external fluid of the droplet from falling into the droplet. Note that no force is required to keep the charge of the droplet from flying apart because of the nature of the dual fluid plenum.

Thus almost all of the energy of the droplet electron is accounted for: the electrostatic energy is easily shown to be equal to half of the self energy, this is the first of the terms in Eq.(15). Two thirds of the other half of the self energy is accounted for as explained above. This leaves an amount of 1/6 of the self energy unaccounted for. It leaves out however the motional energy of the external fluids of the electron droplet model. It seems reasonable here to assume that this energy is also equal to the internal magnetic field energy of the droplet because equal and oppositely velocities for the internal and external fluids would appear to be necessary to the model's construction. All the above is discussed in some detail in item a of the bibliography.

FINAL REMARKS

We make some concluding remarks which may clarify our purposes a bit. It has been shown that in a global, abstract, and non-empirical sense QM is both inconsistent and contradictory. In a local and empirical sense, however, it is indeed fully consistent and empirically verified. Furthermore, Special Relativity has been shown to have a similar logical structure. It is well known that inconsistent theories can be used to literally prove anything. Thus, it is not possible nor will it ever be possible to refute QM. It may however, be possible to come up with realistic type theories which provide predictions and which are fertile in new testable ideas and heuristic in that they will lead to further ideas and theories which are testable. QM, however, will always be superb, as it has been in the past, in postdictive explanations even for the predictions of new realistic theories such as the one advocated fully in the bibliography. Details of the logical considerations of QM and dual fluids are discussed in items g, h, and i of the bibliography and where in item i, nonlocal realistic fluid models are also discussed.

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QUANTUM HOLOGRAPHY AND THE FALLACY OF INTRINSIC QUANTUM UNCERTAINTY

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Abstract

It is known that entropy, chaos and quantum uncertainty are not as is usually thought simply obstacles to the creation of order, but under the right conditions its progenitors. The conditions appropriate to quantum uncertainty define quantum holography or the inverse operations of the geometric encoding and decoding of arbitrarily complex time behaviours. This resolves the dichotomy between quantum mechanics and general relativity through a mechanism of adaptive resonance defining evolution and learning in terms of the same fundamental core process. It explains why the cosmos, life, intelligence and consciousness manifest themselves through geometric forms, or decodings, constituted in the form of energy or matter.

Introduction

There is a general belief among many scientists which dominates media and public perception that there exist three irrevocable obstacles to the creation of order. These are

- 1) the monotonic increase in entropy as a consequence of the Second Law of Thermodynamics,
- 2) chaos or the butterfly effect resulting in sensitivity to boundary conditions in nonlinear systems, and
- 3) microscopic or quantum uncertainty resulting from the Heisenberg commutation relations of quantum mechanics.

Nothing is in fact further from the truth as the existence of life on Earth makes clear and as is now becoming possible to demonstrate both theoretically and in the laboratory. Each of the above processes under the appropriate conditions constitutes a means by which in fact the creation of order can be accelerated exploiting the exponential mapping or combinatorial explosion that indeed in other circumstances is the very obstacle to order. I believe these conditions constitute the basis for the paradigm changes that will revolutionize science and technology in the 21st century and that they are essential mechanisms used in living systems and brains that Nature has inevitably uncovered in the course of evolution.

1) Entropy

The entropic mechanism concerns holes that open and close in a surface/membrane to admit molecules or ions ie the well known Maxwell Demon working by entropy production. These are a ubiquitous feature of living systems and in particular of living cells and of neurons. But since entropy production may create or destroy machine states¹, see figure 1, such cells or neurons are more general systems than finite automata where there is a fixed set of states among which transitions take place. In a system working by entropy production (and reduction) a state may be evolved that before previously never existed.

•2) Chaos

A great deal has been said in recent years about chaos, the butterfly effect, and how the extreme sensitivity of non-linear systems to tiny perturbations makes the prediction of future behaviour impossible beyond a certain critical point. However systems may evolve so that they exploit the extreme sensitivity of chaos to tiny perturbations - the butterfly effect - so as to both stabilize regular dynamic behaviours and to direct chaotic trajectories rapidly to any desired state². Incorporating chaos deliberately into practical systems therefore offers the possibility of achieving greater flexibility in their performance and can allow such systems to reach dynamic trajectories that could not be reached if the system were under the same conditions treated as completely deterministic.

For example, a few years ago NASA scientists used only small amounts of residual fuel to send spacecraft ISEE-3/ICE more than 50 million miles across the Solar

System thereby achieving the first scientific cometary encounter. This feat was made possible by the sensitivity of the three body problem of celestial mechanics to small perturbations and would not have been possible in a non-chaotic system, or by the usual form of deterministic celestial trajectory where a large effect typically requires a large control ie demanded a large amount of fuel that was in this case no longer available. In the event the sling-shot effect with three or four minor injections of the residual fuel were sufficient to bring about the encounter in a planned way. This was once again possible because, as in the case of Maxwell's Demon³, the sensitivity of the system in the appropriate circumstances corresponds to an exponential mapping. Thus the butterfly effect can be exploited to achieve a desired result and even to accelerate its occurrence rather than, as is usually thought to be the case with chaos, of leading to ever increasing errors away from the desired solution. It even seems likely that the evolution of the physiology of perception in brains has exploited this possibility both to enhance the rapidity with which brains work and to keep energy utilization to a minimum. For example the neurophysiological investigations of W. J. Freeman⁴ conclude "The brain transforms sensory messages into conscious perceptions almost instantly. Chaotic collective activity involving millions of neurons seems essential for such rapid recognition".

3) Heisenberg quantum uncertainty

The belief that this cannot be overcome is particularly regrettable - even astonishing. In 1928 soon after Heisenberg's discovery of the uncertainty relations, Hermann Weyl showed that the canonical commutators from which they are derived, are the structure relations of a certain nilpotent Lie group now known as the Heisenberg group⁵. The inverse operations of the group therefore determine the nature of the constructive and destructive quantum wave interferometry not apparent from the perspective of the Heisenberg uncertainty principle. It turns out that this group G and its corresponding Lie algebra \mathfrak{g} and nilmanifold describe such interferometry as for example is used in the design of radar systems and as it applies to quantum holography⁶. Thus the geometric encoding and decoding of data in quantum holographic signal processing as specified through the Heisenberg group are such inverse operations. They can be demonstrated in the laboratory using Mach-Zehnder interferometry and include the self-interference of phonons modelling the classic beam-splitter quantum interference

experiments which are the principal means of demonstrating the fundamental difference between quantum and classical physics.

Important support for this postulate comes from the recent laboratory experiments demonstrating the optimum control of uncertain quantum systems employing such constructive and destructive wave interferometry^{6,7}. This was used on a sample of molecules employing a laser under the control of a computer learning by means of a genetic algorithm so as to produce the right spectral irradiation of the molecular sample. It is able to optimize the output of a particular desired chemical and to do so in real time. This form of chemistry therefore differs significantly from that currently employed using statistical thermodynamical means. It thus predicts a revolution in industrial chemistry and also the highly likely scenario that it is this mode of chemistry that is employed in living systems where chemical processes are frequently observed to be taking place in an optimized way, through control exercised by means of the genetic code. The code in the biological system replaces the computer and the genetic algorithm of the laboratory process as the optimized control, geometrically decoded in the course of evolution, as my colleagues and I have shown in a recent paper⁸. And once again the reason why such optimum controls are possible can be inferred on the basis of the Heisenberg Lie Group^{9,5}.

This implies the existence of an exponential map between the centre c of the Group's Lie algebra g and the Group G 's one dimensional centre C_0 such that $\exp(c) = C_0$. See Appendix. It can therefore be inferred that in a machine working by quantum holography exponentially complex time behaviours may both be geometrically encoded into stationary quantum interference patterns and subsequently decoded, or transmitted as real signals for further processing. This therefore allows such machines to deal with the combinatorial explosion of real world complexity that is the obstacle to efficient computation or learning in other processing models.

Thus quantum holography shows the model of the neuron utilizing such holographic signal¹⁰ processing not only provides an explanation of the overall morphology and signal processing dynamics of the biological neuron, see figure 2, it is functionally equivalent to a neural net system by means of which for example from a set of stored

patterns P_i ; $i = 1$ to n , the closest pattern P_{i-k} to a new pattern P_{n+1} may be selected according to some threshold criteria using a learning process. In the model the neural soma or body functions as a square law detector working by adaptive resonance such that the stored pattern P_i or image with the smallest distance to the input pattern survives and is amplified in mode competition at the expense of the more distant images which are simultaneously attenuated. This process produces an axonal signal corresponding to P_{i-k} provided the threshold criteria are met. The advantage of the model over traditional neural nets however is that the patterns P_i correspond to holographic/global representations of the stases or dynamics of real world objects in geometrically encoded form, and thus may represent arbitrarily complex time behaviours. Furthermore these holographic representations are actual physical simulations not mathematical or computational ones which require an accurate specification and subsequent programming necessitating human intervention directly or indirectly. This is avoided by means of sensory apparatus or transducers which construct the naturally available holographic representations/encodings by simulation. That is the action of the transducer is to simulate the incident external sensory wavefield by means of a corresponding internal physical wavefield so that the two have equivalent properties or qualia. This is done by exercising what is called a phase conjugate control so that the object images produced by the sensory apparatus by geometric decoding are totally coincident with the objects themselves. This control therefore not only allows the sensory apparatus to 'data capture' each object's geometric properties (hence the terms geometric encoding and decoding) but allows the objects themselves to iconically provide the canonical labelling essential to a process of computation. That is, under such control the holographic signal processing constitutes computation, in the technically formal sense.

Its existence with respect to the physiology of perception can be experimentally validated with simple demonstrations. Look at an object just in front of you and reach out and touch it. Please do just that. The visual object image the brain/eye system reconstructs is totally coincident with the tactile object image the brain/touch system also constructs, and therefore with the object itself. Similarly with acoustic object images constructed by the brain/ear system. Snap your fingers close to your head and ask yourself where the acoustic object image of the snap is located. It is at

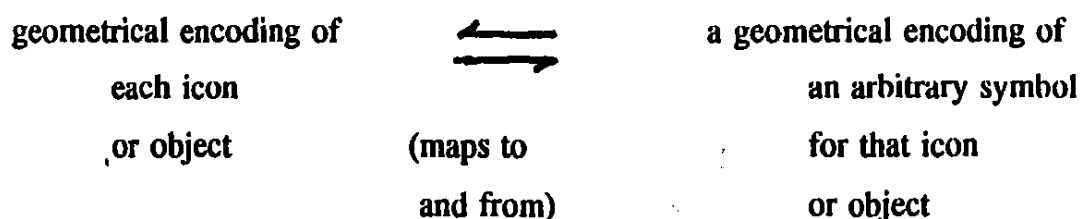
the point at which the snap occurred outside the head in real geometric space as is clearly possible with geometric encoded holographic information. And this is also the case for dynamic or time behaviours of object images, except the nature of such behaviour must be learned: consider for example balls caught in flight.

Not only therefore does the model give the biological correspondences required as in figure 2, it says that the neurons working by quantum holography¹⁰ are holographic supercomputers capable of massive quantum parallelism. That is of working together in a totally coordinated way without the use of co-ordinating signals between spatially separate and currently active brain segments^{12,11,9}. Such a processing mode, not possible in classical machines, may be interpreted as brain interaction with the dynamic quantum vacuum, Figure 3. This provides a Cartesian model of consciousness where the brain is classical and mind, possessing a definite structure quite separate from the brain is quantum. It is a model in which mind by adaptive resonance learns to control the brain; such wilfulness is observed in all young children as they begin to exercise their Self. It may, in a particular mode, control the brain which in that mode functions purely as an input/output mechanism to its sensory apparatus¹³. And it was this quantum parallelism, or the ability of the mind to change from one massively parallel computation to another instantaneously as observed by brain tomography which led the Nobel Laureate neurophysiologist Sir John Eccles¹⁴ to postulate that mental events may cause neural events analogously to the probability fields of the quantum mechanics - as indeed is the case in this model working by quantum holography. Furthermore the model confirms the mechanism remarked upon by Eccles¹⁴ of the release of a single synaptic vesicle probabilistically from the presynaptic vesicular grid following neural firing so as to provide the synaptic gain across the synaptic cleft. It places the vesicular grid at the focal plane of the axon relative to the neural soma or body¹⁰ where this is a resonating cavity as already described. That is to say in this case the brain is a holographic filter bank or sieve, where the holographic or geometric encodings arriving from its sensory apparatus, continually upgrade the filtration and storage of data held the model implies in the form of dendritic arborizations across the assembly of neurons.

Such a model of the brain has initially no built in knowledge base (unless it be

provided genetically) but continually acquires it throughout life in the form of holographic encodings of experiential knowledge furnished by its sensory apparatus or from these by adaptive resonance. This implies that each sense's conscious awareness will be produced by the sensory cortices, one for each sense, which are again resonating cavities continually producing the most significant global image appropriate to that sense in relation to the current sensory input, and coordinated across the brain by a reference wave subsystem. Such reference waves from a subsystem corresponding to a clock in other computer systems, are required for the production of all holographic encodings. These require wavelet mixing between the incoming sensory waves and the reference waves which coordinate the various senses and cortices so that the arbitrarily complex time behaviours each sense encodes are coherently coded and canonically labelled for the purposes of computation. The existence of such a reference system is a testable hypothesis.

If this is the case then evolution or adaptive resonance through geometric decoding, should imply the coming into existence of an additional brain morphology for such canonical labelling itself. This is possible because quantum mechanics allows the simulation of symbol processing or counting as shown by both Feynman¹⁵ and Deutsch¹⁶. Such a morphology would take the form below that



Thus such an additional higher morphology or geometric decoding would correspond to that of the two brain hemispheres where the maps are morphologically realised by the corpus callosum. It indicates that once this additional morphology has been fully developed by means of adaptive resonance as evolution, then the abilities of natural language and counting will constitute its dynamics working by means of adaptive resonance as learning.

The evidence of hemispheres in the human brain/mind system therefore supports the

contention made here, that adaptive resonance may manifest itself in geometrically decoded form i.e. material structures or morphologies which are energy manifestations over varying time scales.

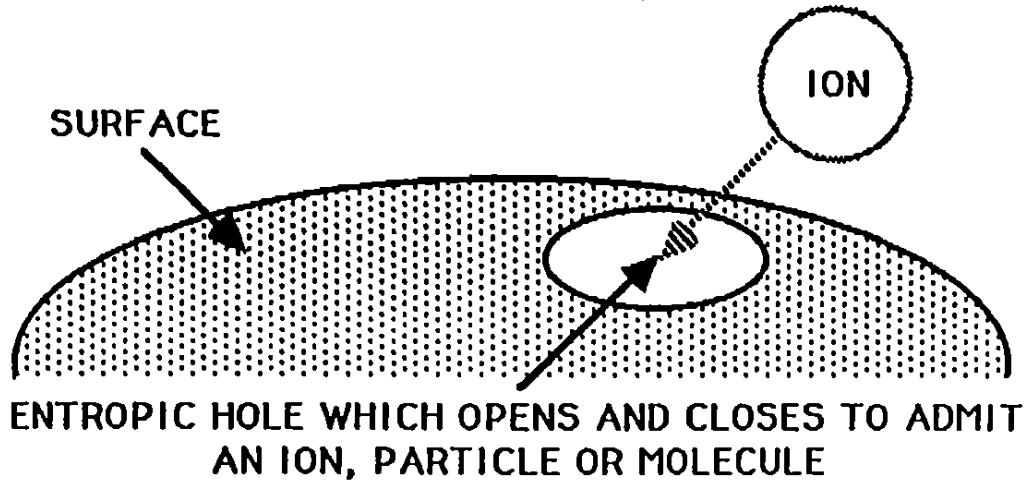
Thus one may postulate that it is through this geometrical form of encoding/decoding that the dichotomy between quantum theory and General Relativity is resolved. With hindsight it seems naively obvious that the Cosmos itself is the geometric decoding of the unifiend field that from our knowledge of the Hierarchy can be modelled i.e. in the more usual widely understood binary encoded form, in terms of the set $Z_2 = (0,1)$ in progressive approximation as evolution proceeds¹⁷. This is surely the message of the geometrization of physics as first mooted by Riemann and brought partially to fruition by Einstein in his General Theory of Relativity. It is the message of Gabor, of Bohm and the Bohm School and of Kron, and of Bastin and Kilmister's paper on the Concept of Order - the Space-time Structure¹⁸, and of other more recent adherents to ANPA who are not here today, Brian Clement and Goran Enstrom. The latter demonstrated to us at a previous meeting that it could well too have been the view of Hamilton.

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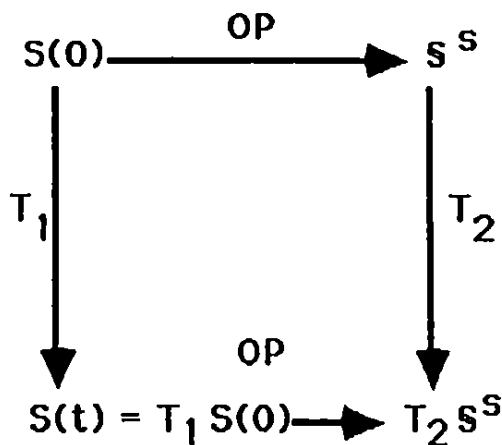
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HUYGENS' ANALOGUE COMPUTATION GATE OR MAXWELL'S DEMON



where, for illustration, below is the commutative diagram that expresses the Huygens' mechanism:

ENTROPY



*ENTROPY PRODUCTION,
WHICH CREATES OR
DESTROYS STATES IN
THE MOLECULAR OR
IONIC FIELD OF THE
CONTROL, OP.*

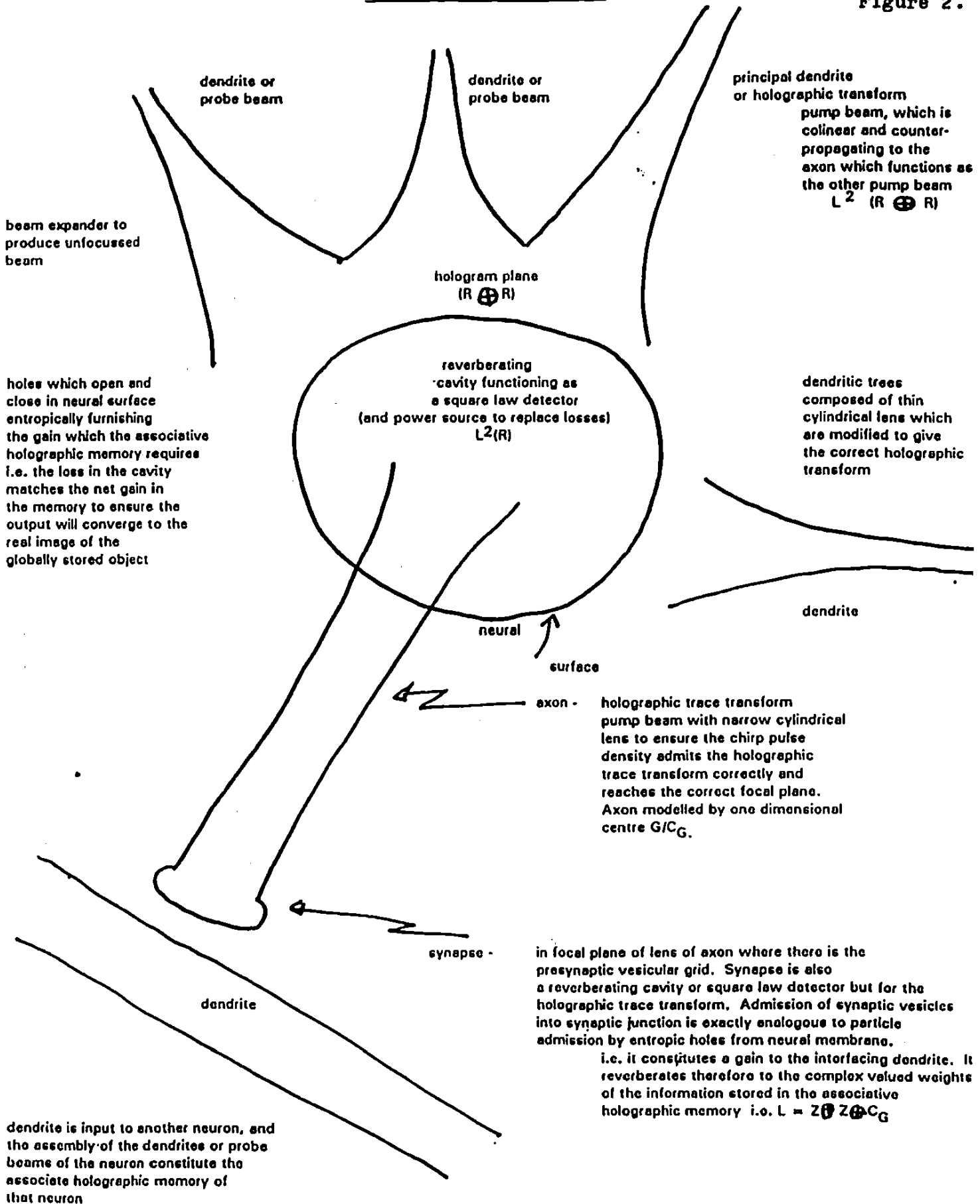
$$\text{thus } T_2 S^S = S(0) \frac{\partial T_1}{\partial t} + \underline{J}^S \cdot \nabla T_1$$

because the entropy in an isolated system is governed by the continuity equation $\frac{\partial S}{\partial t} + \underline{\nabla} \cdot \underline{J}^S = S^S = OPS(0)$

where $\underline{J}^S = S\underline{v}$, the flux of the entropy over the surface of the hole.

NEURONAL SYSTEM PERFORMING QUANTUM HOLOGRAPHY BY WAVE CONJUGATION

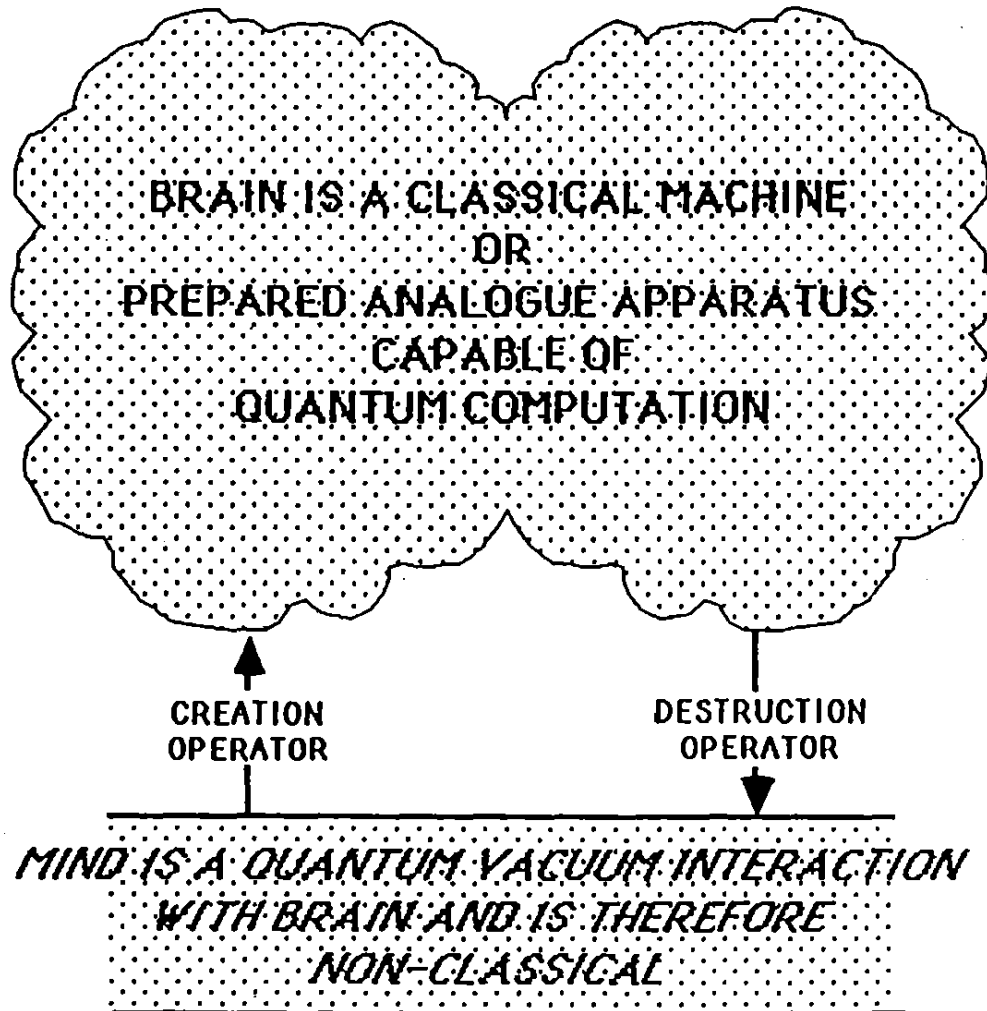
Figure 2.



The working of the neuron corresponds therefore to a projective or dually affine Lie transformation system, as proposed by S. Amari

Figure 3.

THE PICTURE OF THE MIND/BRAIN SYSTEM APPROPRIATE TO THE HUYGENS' MODEL



Vacuum may be visualized as a "sea" of dynamic medium from which particles such as photons are created and destroyed in accordance with the uncertainty principle, so that mind may run the brain by stealing energy from the vacuum provided it restores it as the Heisenberg relation requires.

THE CARTESIAN MODEL OF TWO SUBSTANCES + BRAIN IS CLASSICAL, WHILE MIND IS NON-CLASSICAL, AND UNOBSERVABLE DIRECTLY, ALTHOUGH INTERACTIONS ARE IN PRINCIPLE COMPLETELY PREDICTABLE.

The Heisenberg Group G , Lie algebra \mathfrak{g} and nilmanifold.

This group and its Lie algebra reveal the fine structure of constructive and destructive wave interference not apparent from the perspective of Heisenberg's uncertainty principle.

In the three dimensional case for example, G is a simply connected two-step nilpotent Lie group diffeomorphic to the differential manifold $(\mathbb{R} \oplus \mathbb{R}) \times \mathbb{R}$ with the one dimensional centre C_0 so that

$$C_0 = \{(0,0,z) \mid z \in \mathbb{R}\} \quad \text{where}$$

G denotes the multiplicative group of all unipotent real matrices

$$\begin{pmatrix} 1 & x & z \\ 0 & 1 & y \\ 0 & 0 & 1 \end{pmatrix} := (x,y,z)$$

with unit element $(0,0,0)$ and is a realisation of the three dimensional Heisenberg group so that

the Lie algebra \mathfrak{g} of G formed by the upper triangular matrices

$$\{(x,y,z) - (0,0,0) \mid x,y,z \in \mathbb{R}\} \quad \text{i.e.}$$

$$P := \begin{pmatrix} 0 & 1 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}; \quad Q := \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{pmatrix}; \quad Z := \begin{pmatrix} 0 & 0 & 1 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$$

are such that $[P,Q] = PQ - QP = Z$ and $[P,Z] = 0$; $[Q,Z] = 0$

and hence the centre \mathfrak{c} of the Heisenberg Lie algebra \mathfrak{g} of G is one dimensional and satisfies $\exp(\mathfrak{c}) = C_0$. Thus not only can exponentially complex time sequences be directly geometrically encoded into stationary quantum interference patterns including both phase and amplitude but modelled by the group G 's one dimensional centre C_0 , this information can be transmitted by a real signal for remote processing elsewhere, as is clearly necessary in a brain working quantum holography, and where the stationary quantum interference patterns are encoded and decoded on the hologram planes $(\mathbb{R} \oplus \mathbb{R})$ of the holographic filter bank. Such a bank, one for each sense would therefore also terminate in one such hologram plane where by adaptive resonance the most significant i.e. the wave having the greatest complex valued wavelet packet density would be decoded following incremental amplification of it and corresponding incremental attenuation of all others in the bank. That is, such a terminal plane corresponds to a brain cortex.