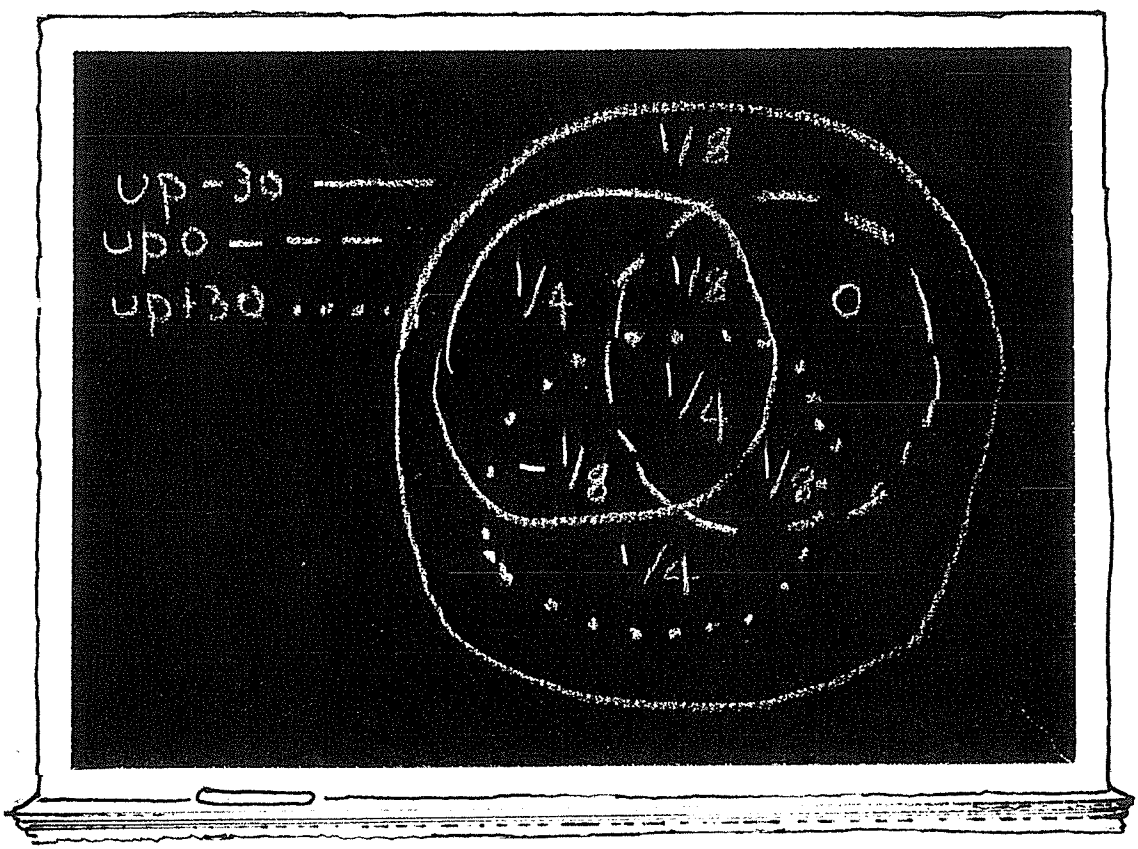
ANPA WEST

Journal of the Western Regional Chapter of the
Alternative Natural Philosophy Association



Volume One, Number Three - Spring 1989

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Journal of the Western Regional Chapter of the Alternative Natural Philosophy Association
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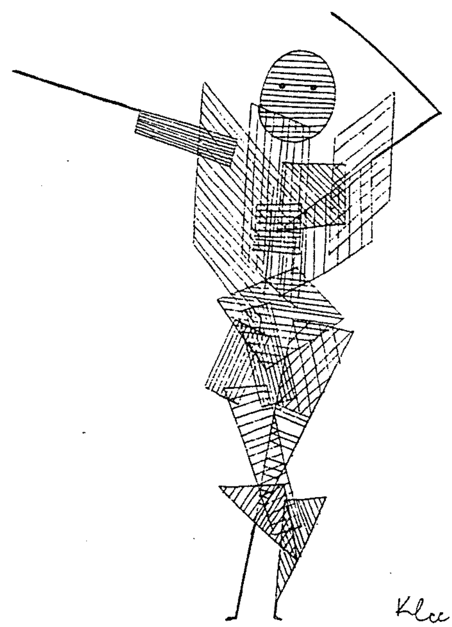
Editorial Office: Tom Etter, 25 Buena Vista, Mill Valley, CA 94941

EDITORIAL

Though the quantum pioneers were well aware of non-locality as a puzzling aspect of their theory, Bell's theorem, by making non-locality inescapably concrete, marked a point of no return in the journey of twentieth-century science away from its classical origins. Our present issue is devoted to Bell's theorem and to the place of non-locality in the emerging post-classical science.



On a more practical note, your editor has been receiving some flack from one of our authors concerning our Draconian rules against technicalities. The rules still stand firm. However, the author in question, who happens to be your editor himself, has managed to extract certain concessions in matters of detail. Technicalities are now allowed in footnotes and appendices - but only in moderation, and they must never carry the main message! If your best ideas are unavoidably technical, put them in another paper, and let your readers know here how to avail themselves of it.

OUR COVER

Our cover shows a Venn diagram of the measurement situation commonly described in proofs of Bell's theorem (see Nick Herbert's article), with the three circles standing for photon spin up measured at -30, 0, and 30 degrees respectively. Now Bell's theorem rests on Bell's inequality, which says it is impossible to put numbers in such a diagram that add up to the right quantum probabilities (see also the article by Tom Etter in this issue). Bell's inequality only applies to positive numbers, of course, since a negative number would mean that a certain property was possessed by fewer than 0 things, which common sense immediately rejects as nonsense.

In physics, common sense has not always proved to be the best guide, however. There is a new kind of "shadow" set theory in which sets *can* have fewer than 0 members (see Wayne Blizard's article), so that Bell's inequality doesn't hold. Thus the question arises again whether Venn diagrams with numbers, now allowed to be negative, might yield the right quantum probabilities. Our cover shows a case where they do, as one can quickly verify by adding them up in the appropriate partitions. It turns out that such numbers exist for any system of quantum properties, so if quantum theory rests on shadow theory, as is argued in Etter's article, the standard arguments for non-locality are no longer valid.

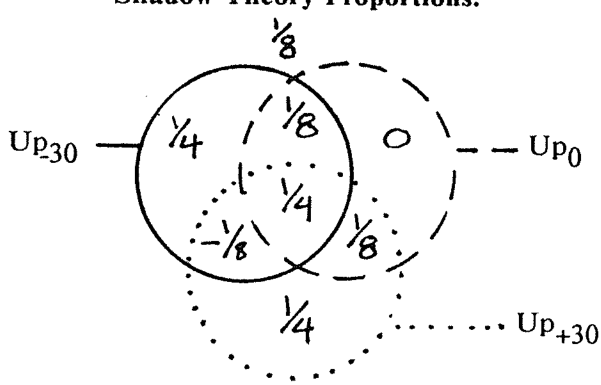
Quantum Probabilities:

$$\mathrm{Prob}(\mathrm{Up}_{-30}) = \mathrm{Prob}(\mathrm{Up}_{0}) = \mathrm{Prob}(\mathrm{Up}_{+30}) = {}^{1}/_{2}$$

$$\mathrm{Prob}(\mathrm{Up}_{0}, \mathrm{Up}_{-30}) = \mathrm{Prob}(\mathrm{Up}_{+30}, \mathrm{Up}_{0}) = {}^{3}/_{4}$$

$$\mathrm{Prob}(\mathrm{Up}_{+30}, \mathrm{Up}_{-30}) = {}^{1}/_{4}$$

Shadow Theory Proportions:

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IN THIS ISSUE

We have learned to use negative numbers to represent the size of *changes*, but not to represent the size of *states*. Yet change, in the form of velocity, is part of what physics means by state. The conceptual difficulties in quantum physics concerning the relationship of velocity to position suggest that the time has come to consider "static" as well as "dynamic" negative numbers, to learn what it means for -n things to be *here* as well as for -n things to have *come* or *gone*.

Wayne Blizard, a mathematician and logician at Cambridge, has taken an important step in this direction by axiomatizing set theory in a way that allows for *negative membership* while still remaining in the spirit of the classical axioms of Zermelo and Fraenkel. His article here is a very readable introduction to this work.

Before we turn to what Bell's theorem means, we must be clear about what it says. This article, which is reprinted from *The New Scientist* 21, *August 1986*, is probably the best short introduction to Bell's theorem around, giving both its historical context and a proof which sets some kind of record for the ease with which it conveys a subtle abstract idea.

You won't learn this from Star Trek, but Einstein's theory of relativity says that "warp speed" can take you into your own past. There are some fallacious proofs of this around, and at least one fallacious disproof has found its way into a respectable journal; here is a brief and painless (and valid) proof.

As science enters its post-classical phase, we must expect it to stray a bit from its classical methods. How about doing science in your sleep? Sounds crazy? Ah, but to quote Neils Bohr, ".. is it crazy enough to have any chance of being true?" Read this article and judge for yourself.

Karel Pstruzina is head of the philosophy department at the Prague School of Economics.

Pstruzina's method may work because the sleeping brain, freed from its practical chores, becomes some kind of super- computer. But then again, maybe it works for a very different reason: maybe the waking world, and especially the quantum part of it, is more of a piece with the dream world than we realize. Perhaps, just as the molecular bonds in a cloud are too unstable to hold together solid material bodies, the logical bonds in whatever underlies the quantum are too unstable to hold together solid material facts.

Etter sketches here a theory of such cloud-like "pre-logic" that is a mathematical generalization of quantum theory. This "cloud logic", which, by the way, is quite different from von Neumann's quantum logic, exhibits a form of non-locality that gives meaning to Blizard's negative set membership.

Taking his editor's advice (see Editorial, this issue), Etter has made available a longer technical paper for those who want more details. It's called *Pre-logic,* and can be ordered from the ANPA West office; please send $3.00 to cover xeroxing and postage.

Page 29. A Chimeric kind of causality. **by Dr. Jabir 'abd al-Khaliq FRS**

Dr. Jabir is a nomadic monad, quantum connection specialist and foreign correspondent for the Fezziah Research Sector, Fez, Morocco, who has written the definitive paper on quartz crystal sexing. Here he gives us an illuminating refutation of certain claims about so-called symmetrical causality made by Nick Herbert in his book "Faster Than Light".

Page 30. ... I'll Take the High Route. **by David McGoveran**

Everyone who has worked with quantum theory knows there is something a bit "off" about it. As one physicist put it, "There are things in quantum mechanics which make me very uncomfortable, but I can't quite say what my discomfort is about."

Etter's diagnosis of what this discomfort is about points to logic. McGoveran, on the other hand, locates the malady, and its cure, in the realm of causality. In this paper, he proposes a theory of relativity of cause and effect. He postulates a multiplicity of *causal frameworks,* analogous to the multiple inertial frames of Einsteinian relativity, but more radically diverse in that their arrows of cause and effect needn't agree. The causal arrows in each causal framework define a Lorentz- invariant space-time for that framework, within which "A arrow B" means that B is in A's light cone. However, a transformation taking one causal framework into another will, in general, scramble its arrow pattern and thus scramble its space-time topology; such transformations are *discontinuous.* The new relativity principle says that all causal frameworks yield valid descriptions of the course of events that we perceive and measure, hence we should expect to observe "non-local" correlations in our particular space-time.

Page 34. Advances on Two Fronts. **by H. Pierre Noyes.**

We wrap things up with a brief communique from the headquarters of bit-string physics concerning a new calculation of the "weak" G_F and the cosmological baryon/photon ratio, plus a summary of the current status of the theory.

A THEORY OF SHADOWS

by Wayne Blizard

In the classic children's story *Charlotte's Web* by E. B. White, Wilbur (the pig) speculates about the concept of negativeness - "I don't think there is any such thing as *less* than nothing. Nothing is absolutely the limit of nothingness. It's the lowest you can get. It's the end of the line. How can something be less than nothing? If there were something that was less than nothing, then nothing would not be nothing, it would be something - even though it's just a very little bit of something. But if nothing is *nothing*, then nothing has nothing that is less than *it* is."

Wilbur is in good company. Hindu, Arab and European philosophers and mathematicians expressed exactly these reservations about negative numbers. For centuries, negative numbers have been described as fictitious, absurd and nonsensical, Acceptance was slow. Nowadays, negative numbers are part of standard everyday school arithmetic. Acceptance is complete.

In Europe before the Renaissance, the concept of negative number involved a conceptual barrier which was eventually overcome. In China, however, negative numbers were accepted and widely used by the second century BC. They were represented by black rods on the counting board, positive numbers being represented by the red ones - the exact opposite of current accounting convention. The Chinese apparently had no difficulty with the idea of negative numbers, perhaps because mathematics in China was always closely allied to finance, commerce and trade in which deficit amounts are common. Acceptance would also have been made easier within an oriental philosophical tradition of complementarity, symmetry and balance.

Although 'negative number'is a difficult concept for some, it is a very natural concept for others. For example, at the age of four, Paul Erdos remarked to his mother, "If you subtract 250 from 100, you get 150 below zero." No one had taught him about negative numbers. Erdos was exceptional, but many young schoolchildren indicate, when tested, that the sequence ...,3,2,1,0 does, in fact, continue below zero to "one less than nothing", or "minus one, minus two,...".

A *set* is a collection of elements. We say "x belongs to y" to mean "If one scans the elements of y, one will find an x". Elements occur at most once in a set. In classical logic there are only two possibilities - either "x belongs to y" of "x does not belong to y" which we shall read as "x belongs to y exactly once and "x belongs to y zero times". There is little conceptual difficulty in proceeding from zero to one and then beyond one. We then have "x belongs to y twice", "x belongs to y thrice", ..., "x belongs to y exactly *n* times". Such a generalization leads from the concept of set to the concept of *multiset* - a collection of elements in which an element may occur more than once. For most people, there is a serious conceptual barrier to overcome when one proceeds from one to zero and then below zero. What does it mean to say, "x belongs to y minus seven times"? On reflection, however, one finds that the conceptual barrier encountered with respect to 'negative membership' or 'belonging a negative number of times' is exactly the same conceptual barrier that slowed the acceptance of negative numbers. We proceed, therefore, to develop a formal theory of 'belonging a negative number of times' secure in the belief that the conceptual difficulties will be overcome. Possible interpretations of 'negative membership' have been proposed by mathematicians like T. Hailperin, R. Rado, W. Reisig, M.P. Schutzenberger and H. Whitney. Ignoring the ominous warnings of Jorge Luis Borges, "...the dark I cannot name, the dark I must not name" (from the poem *Talismans)*, we plunge headlong into the unknown depths, the dark shadows of 'negative membership'.

Classical set theory founded on first-order logic (1) is known as ZF (for Zermelo and Fraenkel, who were among the founding fathers of axiomatic set theory). Since most of mathematics can be formulated within ZF, classical set theory is called a *foundation* of mathematics. One can also formulate, in first-order logic, a formal theory MST of multisets which contains ZF as a special case. We say that MST is *relative consistent* to mean that MST is no less consistent than ZF (that is, if there's a contradiction in MST, then there's also a contradiction in ZF). In first-order logic, one can extend the theory MST to a new theory MSTZ of multisets in which elements may belong a positive or negative number of times. MSTZ is also relative consistent and contains both MST and ZF as special cases. The acceptance of MST (or, more radically, MSTZ) as the foundation of a new mathematics, would most certainly bring about a revolution in classical mathematics, and in the sciences that use mathematics as their formal language.

The *shadow* of a multiset which contains the element x exactly *n* times, the element *y* exactly m times, ... et cetera is the multiset that contains x exactly *-n* times, y exactly *-m* times,... et cetera. It is important to note that if the original multiset is in MST (where *n, m* ... are *positive* integers), then its shadow is in MSTZ (since *-n, -m* ... are *negative* integers). If, however, the original multiset is in MSTZ (where *n, m* ... are *any* integers (positive or negative)), then its shadow is also in MSTZ. If *n* is negative in the original multiset, then *-n* is positive in its shadow. Thus "taking the shadow" simply reverses the sign of numbers of occurrences of elements. Every multiset in MSTZ is the shadow of some other multiset in MSTZ;

namely, that multiset resulting from reversing the signs of occurrence of its own elements. The multiset x and the multiset "shadow of x" are shadows of each other, and "the shadow of the shadow of x" is x. For these reasons, we refer to arbitrary multisets in MSTZ as "shadows", and the theory MSTZ is called "a theory of shadows".

Before the introduction of negative numbers, the subtraction $n - m$ only made sense if integer n is greater than or equal to integer m. But with negative numbers, the subtraction $n - m$ is defined for *all* integers n and m. Thus, overcoming the conceptual barrier of negative numbers liberated subtraction from a partial operation to a total operation. In exactly the same way, the introduction of negative membership (winning the mental struggle involved in the idea of "containing something a negative number of times") liberates the relative complement in set theory. In classical set theory, x - y is the result of removing all elements from x that belong to both x and y; if x and y have no elements in common, then x - y is of course just x. Though x - y is a total operation in the sense of being defined for every x and y, y doesn't always "count"; it's as if there were numbers other than zero which could be subtracted from n without changing it. In MSTZ, however, every y counts; x - y removes the elements of y from x whether they belong to x or not.

The shadow x - y contains all elements belonging to either x or y, and the number of occurrences of each element in x - y is determined as follows: for all elements belonging to both x and y, subtract the number of occurrences of the element in y from the number of occurrences of the element in x; for all elements belonging only to x, leave the number of occurrences unchanged; for all elements belonging only to y, reverse the sign of its number of occurrences in y. Therefore, even if x and y have no common elements, the shadow x-y is very different from the shadow x. Subtracting y from x only leaves x unchanged if y is empty, just as subtracting m from n only leaves n unchanged if m is zero.

The mathematical physicist Michael Guillen (*Bridges to Infinity: The Human Side of Mathematics*, Rider, London, 1983) observes that "...anti-matter is now recognized to be as significant a part of the natural world as negative numbers are of the algebraic realm," "...scientific theories agree that anti-matter is the embodiment of mathematical negativity ..." and "...it is accurate to say that particles of anti-matter are the mathematicians' negative numbers incarnate." The theory MSTZ may prove useful in physics to formalize the anti-matter, dark matter, Dirac holes or other concepts. For example, in one of his last papers, Richard Feynman used shadows as a conceptual device to introduce the notion of negative probability. The range of possible application is not restricted to physics, but such matters must await the verdict of others.

As a pure mathematician, my personal view is that the theory MSTZ is of mathematical and philosophical interest regardless of application. I am aware of Jung's use (or uses) of the word "shadow". The concept runs deep within society and within ourselves. What I have in mind is a physical and metaphysical interpretation of the words of David Brooks (*The Book of Sei*, Faber and Faber, London, 1988): "All things, it seemed, soaked up their portion of shadow as they took on their corporeality, as if, to *be* in the full light of noon, they must first contain their allotment of night." ● *(For Footnotes, see last page.)*

HOW TO BE IN TWO PLACES AT ONE TIME

by Nick Herbert

Quantum theory is the conceptual basis for computer science, lasers and nuclear power plants, among other things. It has been flawlessly successful at all levels accessible to measurement. And yet, although physicists from London to Leningrad agree on how to use this theory, they disagree profoundly over what it means. After more than 60 years there is still no consensus on how to picture the "quantum reality" which underlies the everyday world.

Although he was one of its founders, Albert Einstein was never comfortable with quantum theory. Most people remember that he objected to the fact that the predictions of quantum theory are fundamentally random. "I cannot believe," he said, "that God would play dice with the universe." Randomness, however, was not the only feature of quantum theory that bothered Einstein. He could not accept the orthodox view that atoms, electrons, photons and all such quantum entities exist only when they are observed. They do not possess attributes of their own, but only acquire them in the act of observation." I cannot imagine," he said, "that a mouse could drastically change the Universes by merely looking at it ... The belief in an external world independent of the perceiving subject," Einstein maintained, "is the basis of all natural science."

"Atoms are not things," retorted Werner Heisenberg, one of the founders of the orthodox view. Heisenberg compared "thing-nostalgic" physicists like EInstein to believers in the flat Earth. "The hope that new experiments will lead us back to objective events in time and space," said Heisenberg,is about as well founded as the hope of discovering the end of the world in the unexplored regions of the Antarctic."

Einstein could perhaps have learned to live with these features of quantum theory. Sixty years of practical success have gradually accustomed most physicists to its randomness and thinglessness (or at least persuaded them not to think too deeply about these puzzles). But Einstein objected most strongly to a third peculiar aspect of quantum theory: the fact that, when two quantum entities, A and B, briefly interact and then move apart beyond the range of known interactions, quantum theory still does not describe them as separate objects, but continues to regard them as a single entity. I one takes seriously this feature, called "quantum inseparability," then all objects which have once interacted are in some sense still connected.

Moreover, this lingering quantum connection is "non-local." Unlike gravity or electromagnetism, it is not mediated by fields of force, but simply jumps from A to B without ever having been in between. Because nothing ever really crosses the intervening space, no amount of interposed matter can shield a non-local connection. Since non-local connections do not actually stretch across space, they do not diminish with distance. They are as potent at a million miles as at a millimeter. Just as non-local connection takes up no space, likewise it takes no time. A non-local influence leaps between A and B immediately, faster than light. For some observers, as a consequence of Einsteinian relativity, this instantaneous connection appears to go backwards in time, a performance peculiar by any standards (see article #3 in this issue - Ed.)

This sounds more like magic than solid science. Voodoo practitioners,for instance, work in a world criss-crossed by non-local connections. By acting on a part - something a person once touched or wore - they believe they can influence at a distance the whole man, in a manner unmediated and immediate. Whatever witchdoctors may think, physicists from Galileo to Gell-Mann have unanimously rejected such voodoo-like place-to-place leaps as a basis for explaining what goes on in the world.

In the early 1930's, the Austrian physicist Erwin Schrodinger was particularly fascinated by quantum inseparability. He called it quantum theory's most distinctive feature, the place where quantum theory deviates most from classical expectation. Quantum inseparability, with its unsavory non-local connections, undoubtedly exists mathematically in the quantum formalism, Schrodinger conceded. But do these connections actually exist in the real world? Einstein's special theory of relativity forbids all faster-than-light signals, so we can be reasonably sure that if non-local connections really exist they cannot be used for sending signals.

Since it postulates pure randomness at the heart of things, quantum theory renounces precise predictions and gives only the probabilities of the outcomes of a particular experiment. Actual calculations show that even though quantum theory is connected non-locally inside, these connections never get out to the level of quantum probabilities - the only aspect of quantum theory that can be put to direct test. Any measurable influence, in terms of transmission of information, still travels at the speed of light or slower. Thus despite its non-locality, quantum theory does not predict a single non-local effect - as Philippe Eberhard, of the University of California at Berkeley first showed. In line with quantum theory's perfect predictive success, no non-local connections have ever been observed, either in the wild or in the laboratory. The perfect locality of all quantum predictions suggest that non-local connections are a theoretical artifact with no more reality than the dotted lines that outline the constellations on star maps.

All experiments at the quantum level result ultimately in discrete events - a flash, click, bubble, or pulse in some detector. In common with other statistical theories, quantum theory does not deal with individual events but with pattern - average values - of individual events. Because they ar the very brick from which all phenomena are constructed, I shall call these individual events "real events," or simply "reality," a usage initiated by Einstein. Since Eberhard's result requires that all statistical averages should be locally connected, one might reasonably expect that each of the individual real events which make up these averages would also be locally connected. John Stewart Bell, of the European center for particle physics, CERN, achieved the remarkable feat of showing that such a reasonable expectation is impossible to fulfil. Although the quantum averages are local for all systems, for certain quantum-inseparable systems these averages cannot be simulated by locally-connected real events. Bell's theorem proves, in short, that reality must be non-local, but at a level beneath detection in terms of the usual statistical measurements. Bell proved this theorem for a particular experimental set-up, involving two photons rendered quantum-inseparable (in their mathematical representation, at least) by virtue of being emitted from the same calcium atom. This type of two particle system was first considered by Albert Einstein and his Princeton colleagues, Russian-American Boris Podolsky, and Brooklyn-born Nathan Rosen. The intent of Einstein, Podolsky, and Rosen (EPR) was to attack the orthodox "thinglessness" interpretation - the doctrine that unobserved quantum entities do not possess intrinsic attributes called "elements of reality" by Einstein. EPR originally considered a pair of particles with correlated momenta, but their arguments (and Bell's subsequent proof) is more easily understood in terms of two photons with correlated polarizations, a system first suggested by David Bohm, of Birkbeck College, London.

In Bohm's version of the experiment, a calcium atom emits a pair of photons which, for the sake of clarity, we will label "blue" and "green." They travel in opposite directions to two calcite crystals where they are deflected either up or down. Calcite is a transparent mineral which bends light polarized along its optic axis up, and bends light polarized at right angles to its axis down.

Three facts sum up the behavior of Bohm's version of EPR (see fig.1):

- Each crystal's output is always 50/50 random, with half the photons polarized "up" and half "down."
- When crystals are aligned, blue output isidentical to green for every pair of photons emitted.
- When crystals are misaligned, the fraction of identical events is observed to decrease with angle Θ between calcite axes like $\cos^2\Theta$.

These facts remain true no matter how far the blue and green calcite/detectors are from the light source or from one another.

EPR's argument that a photon possesses intrinsic attributes is based on the fact that there is perfect correlation when crystals ar aligned - plus the assumption (which seemed reasonable to everyone in 1935) that the real events occurring at the blue and green detectors are locally connected, so that no connections tie them together faster than light.

The assumption of locality means that something done to one system cannot in-

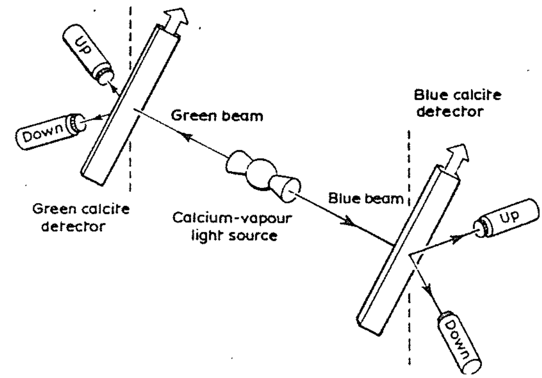


Figure 1. David Bohm's version of the celebrated experiment first dreampt up by Einstein, Podolsky, and Rosen.

fluence the behavior of another if the systems are so far apart that a light signal cannot connect them. In particular, how the green photon's calcite is set when traversed by its photon cannot affect the blue photon's "decision" (to go up or down) as it traverses its calcite. Since these photons are travelling back-to-back, each at the speed of light, and we can set the green calcite at the last instant, information concerning green's setting could influence the blue's decision only if it travelled faster-than-light.

Einstein ridiculed the notion that non-local quantum influences might really exist, calling such influences "spooky" and "telepathic." EPR developed their argument as follows: Move the green calcite/detector close to the source so that it triggers first. Now we know that when the blue calcite is aligned at the same angle as the green, then the blue photons will exactly mimic the behavior of the green photons. So we can predict with certainty the polarization of the blue photon at any angle by setting the green calcite at that angle. If the green photon goes up or down, then the blue photon will so likewise. But, by the locality assumption, each b photon's real situation cannot be influenced by the setting of the green calcite, so the blue photon must already possess a definite polarization before it hits its calcite crystal and is actually observed. EPR conclude that here is an observed quantum entity - the blue photon - that possesses a definite attribute: its polarization in a particular direction.

Einstein, Podalsky and Rosen's original four-page paper triggered hundreds of articles on the "EPR paradox," none of which either refuted the argument nor shed further light on the alleged intrinsic attributes of the photon. In 1964 the EPR stalemate was broken by John Bell who proved that the locality assumption is untenable. Bell's theorem is most easily understood by construing the series of real events at each calcite/detector as a "message"-a particular binary sequence of Us and Ds, marks on a data tape. When both calcites are aligned, these messages are identical: no errors. When the calcites ar misaligned, the messages diverge: errors creep in.

Start with both calcites aligned. Now consider the angle α for which the errors are 25 per cent (1 in 4). Whenever you move either calcite by α degrees, in either direction, one error bit appears, on average, in every four data marks. When you move the calcite back, these errors all disappear. The proof of Bell's theorem begins with the locality assumption - that moving the green calcite can change only the green mark. Locality means that green's move cannot change blue's mark.

Move calcite by α degrees: errors are 25 per cent (1 in 4). Return blue calcite: errors vanish. Move green calcite by $-\alpha$ degrees: errors are 25 per cent (1 in 4). Return green calcite: errors vanish. Now move both calcites by α degrees (in opposite directions.) Calcites are now misaligned by 2α degrees. What is the new errors rate?

Since moving the blue calcite puts 1 in 4 errors in blue marks, and moving the green calcite puts 1 in 4 errors in green marks, we might hastily conclude that moving both calcites would produce 2 total errors in 4 marks. But this argument neglects the possibility that a few blue errors might cancel green errors, leading to a rematch. Allowing for such accidental error-correction, the locality assumption predicts that when the calcites are misaligned by 2α degrees the error rate will be no more than 2 errors in 4 marks - that is, in the range of 0-50 per cent. This prediction, a direct consequence of the locality assumption, is an example of a "Bell inequality." For calcium light, the angle for which the error rate equals 25 per cent is 30º. Hence the Bell inequality predicts an error rate of no more than 50 per cent at 60º. However, quantum theory predicts, and experiment confirms, an actual error rate of 75 per cent at 60º. This experimental result generously violates the Bell inequality. Hence the locality assumption is wrong.

Bell's theorem proves that, for these correlated pairs of photons, a local reality, with no influences travelling faster than light, cannot explain the experimental facts. Bell's result shows that the much-dreaded non-local connections are present not merely in the quantum formalism but in the real world. These connections exist, however, not at the level of quantum averages, but at the level of individual quantum events. This discovery of their necessary non-locality of real events resolves the Einstein-Podolsky-Rosen paradox, in Bell's words, "in the way Einstein would have liked the least."

Bell proved his theorem in 1964, by showing that the predictions of quantum mechanics violate the Bell inequality. But no one had measured the quantum facts at that time. Within a few tears, however,

Figure 2 (right)

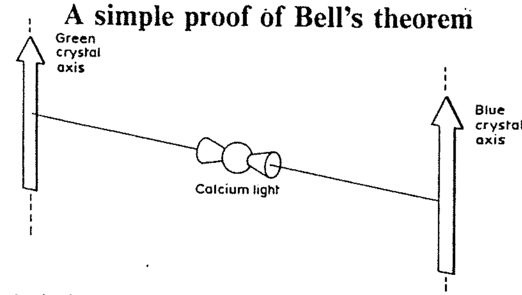
We have to conclude that no local model of how the events are produced can explain the observed variation of error bits with calcite angle. Hence, for this experiment, reality must be non-local. Even if quantum theory is one day supplanted by a better one, the experimental facts still show that the locality prediction is in error. ●

John Clauser and Stewart Freedman at Berkeley actually performed the experiment and showed that Bell's inequality was violated. Important variations on the experiment were carried out by Clauser and others, culminating in the delicate work of Alain Aspect and his colleague in Paris, in the early 1980s (*Physical Review Letters*, vol 49, p 1804.)

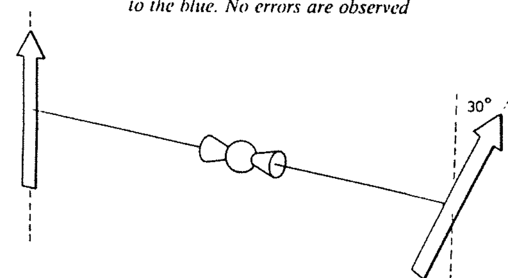
These experiments are important because they show that not only is Bell inequality (locality violated by quantum theory, is also violated by quantum fact. Though is originated in disputes about "quantum reality," Bell's theorem is actually more general than quantum theory. Someday, quantum theory may fail, joining caloric, ether, and pholgiston in the junkyard of physics, but because it is based on facts and arithmetic, Bell's theorem is here to stay.

Bell's theorem was originally formulated in terms of "hidden variables," hypothetical attributes of unobserved quantum

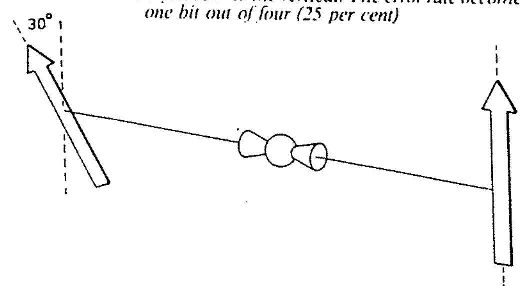
A simple proof of Bell's theorem



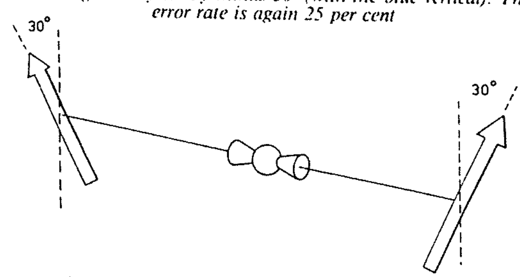
In the first case, illustrated above, the green crystal is oriented in the same direction as the blue. The green "message" is identical to the blue. No errors are observed



Now tilt the blue crystal 30° to the vertical. The error rate becomes one bit out of four (25 per cent)



Tilt the green crystal by minus 30° (with the blue vertical). The error rate is again 25 per cent



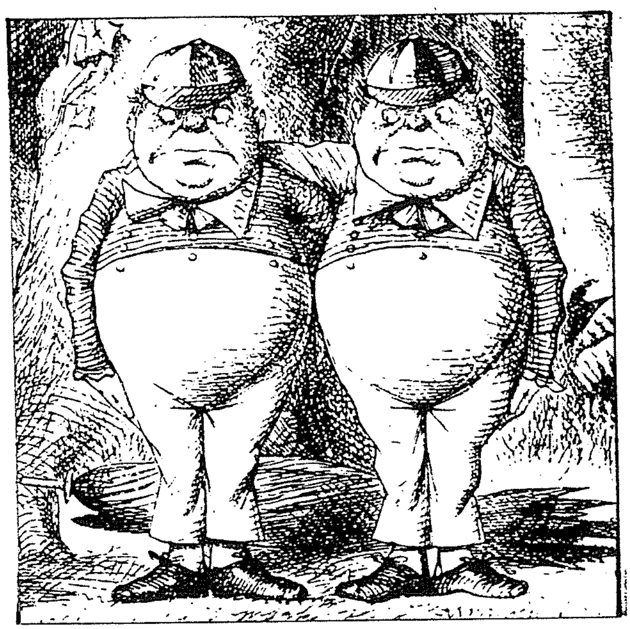
Now tilt both crystals by 30° in opposite direction so that the total misalignment is now 60°. What is the error rate? If we believe in locally connected real events, the error rate should be fewer than 2 out of 4 (0-50 per cent). The quantum prediction is an error rate of 3 out of 4 (75 per cent). This is what is actually observed systems. But in the past two decades Bell's theorem has been generalized by Bell himself, Clauser, Eberhard, and another physicist at Berkeley, Henry Stapp. Bell's theorem can be formulated entirely in terms of macroscopic phenomena - marks on a data tape, moves of a calcite crystal - with no reference whatsoever to the attributes of hypothetical microentities. In its thoroughly macroscopic form, Bell's theorem requires blue's marks to be linked non-locally to green's move. Bell's theorem now takes non-locality out of the inaccessible microworld and locates it squarely in the everyday world of calcites, cats, and bathtubs.

Bell's demonstration of the necessity of non-local connections raises the question of whether we can use these connections to send signals faster than light. Many in genious attempts have been made to exploit the EPR set-up to send such messages, but all have failed. What blocks attempts at faster-than-light telegraphy is the uncontrollable randomness of real quantum events. One may move the green calcite and change the blue sequence faster than light, but on close inspection one succeeds only in exchanging one inscrutable random sequence for another. Howsoever green's calcite is set, blue's sequence of data is always 50/50 random.

Special relativity prohibits all signals that travel faster than light. Because the non-local connections are uncontrollable, they cannot be used for signalling, so they evade this relativistic prohibition. These Bell-mandated connections are not open to human manipulation, but are private lines accessible to nature alone.

To me Bell's theorem suggests an alien design-sense loose in the Universe. We live in a world that seems strangely overbuilt. Why, for instance, does nature need to deploy a faster-than-light subatomic reality to keep up merely light-speed macroscopic appearances? ●

New Scientist 21, August 1986



HOW TO BE YOUR OWN GRANDFATHER

By Tom Etter

If things could travel faster than light, they could make round trips in which they return before they leave. This follows from what is perhaps the strangest consequence of Einstein's theory of relativity, the relativity of the present.

It turns out that when we speak of contemporary events, just which events we are referring to depends on our state of motion. The easiest way to see the difference between classical and Einsteinian simultaneity is to look at space time graphs of motion. Fig. 1 shows a graph of "here" at rest; time goes up, space across. The central point is here-now, the vertical line is here extended through time, and the horizontal line is now extended through space.

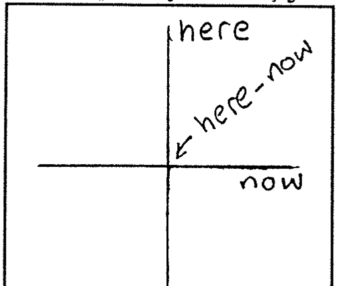


Figure 1

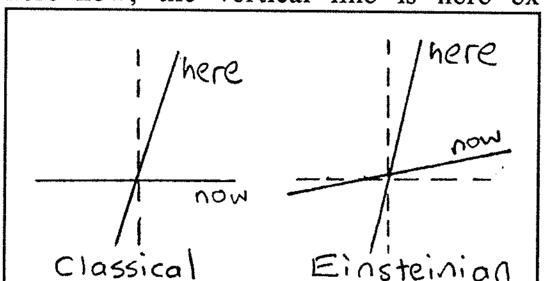


Figure 2

Fig. 2a shows classical motion, with here referred to the moving body. The here line becomes tilted with respect to the old here at rest, but the now line, the present, remains the same. Fig. 2b shows Einsteinian motion with space-time units chosen to make the speed of light 1. Note the now line is no longer horizontal but is tilted upward at the same angle that the here line is tilted forward.

Fig 3 shows the two space caravels Nina and Pinta sending each other messages via their warp-100 (100 times light speed) telegraphs. Nina, at rest, sends off a message at A. Following a trajectory that looks almost instantaneous on the graph, this message reaches Pinta at B. At C, a short time later, Pinta, which is in rapid motion, sends a message back to Nina at warp speed 100. But since Pinta is herself in rapid motion, this return signal path is tilted to lie close to the peculiar Einteinian class of what from Pinta's viewpoint are events contemporary with C, which means that it reaches Nina at point D before A.

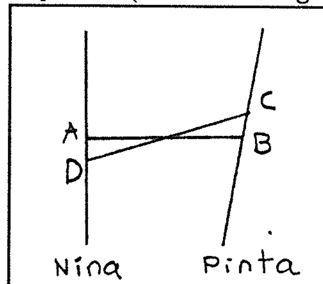


Figure 3

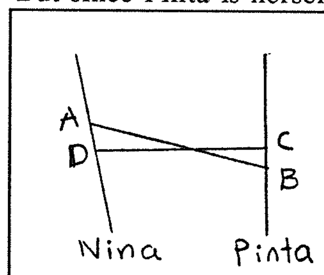


Figure 4

This construction is often given as a proof that warp speed leads to backward time travel. However, looking more carefully at fig. 3 we see that, from Nina's point of view, the line from C to D doesn't show an arrival but a departure; Nina appears to be sending the message at D, not receiving it. True, it's a bit strange that Pinta also thinks she is sending this same message, just as she thinks she is sending the same message that Nina sent at A (fig. 4). But this doesn't show that information travels along the path A, B, C back to D. To come to that conclusion, we would have to assume that departing signals carry arriving information, i.e. that there is "backward causality," which is what we are trying to prove.

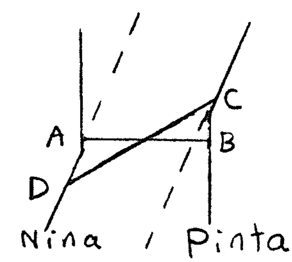


Figure 5

The essential idea of a proof is there, though, and we just need a slightly more complicated construction to capture it.

Let's turn to fig. 5. As before, Nina, at rest at A, warps a message at Pinta. But Pinta is now at rest too, so the message actually arrives there, at point B, according to Pinta's own definition of the trajectory of an arrival. After recording the message, Pinta blasts off, accelerating to a sub-warp cruising velocity v, after which, at point C, she relays Nina's message back, where it reaches Nina in the past at D, as before. However, Nina, at the time of D, was not yet at rest, but was cruising at this same velocity v. Since the two ships are mutually at rest at C and D, they both agree that a departure from C means an arrival at D, in this case the arrival of the message that "began" its travels at A.

This circular story has a stern moral for those who believe they have invented "Bell telephones" (Nick Herbert's term for faster-than-light signallers). Imagine a computer on Nina which is programmed to receive a yes-or-no phone message at D and send its out opposite (no-or-yes) at A over our inventor's "Bell telephone lines", which are wired according to fig. 5. If both the computer and inventor's telephone worked, there would be a logical contradiction. Thus if the inventor hopes to invoke the laws of physics to persuade us that his gadget works, he must be able to invoke these same laws of physics to explain why, in this situation, the computor must fail. ●

HOW DO SCIENTISTS WORK?

by Karel Pstruzina

How do we get new ideas? What is most important when we do scientific work? I claim that one thing which is very important in scientific work is our sleep. Though some may find this claim perplexing, it is well-founded. There are serious reasons for assuming that the brain brings order to information and creates an inner thought model of the world during the rhombencephalic (REM) phase of sleep.

It is a very influential result of neuroscience that the character of knowledge changes after puberty when the thalamus, as the filter of sensory perception, comes under the control of the cerebral cortex. From this time on our thought model of the world *precedes* our perception, and we can see only that which we are prepared to see, according to A. R. Luria and I. S. Vygotski (1). K. H. Pribram (2) declares that our inner thought model of the world is shaped by habituation. It is undeniable that habituation plays a major role here, but in my opinion an even more important role is played by the REM phase of sleep. During REM-sleep we not only dream but are *dreamt!* We are near to meditation, and our brain slips into a natural process in which the present-day information becomes involved with our endoceptive structure of thinking.

Our thinking is not formed only by everyday practical life. We hold within us all that has been shaped by phylogenetic development, all historical achievement; I call this the endoceptive structure of thinking. (3) The endoceptive should not be identified with the Freudian subconscious. Rather it comprises large systems of past experience, thoughts and images which do not currently release action, are not easy to express in words but are felt as dispositions to thinking. And it is during REM-sleep that all this is revived and becomes part of our thought-model of the world.

Thinking that arises during REM-sleep is inarticulate. It isn't easy or convenient to become aware of it. Everybody who does any work in science knows about the problem of confused thoughts. We often wait for the release of sleep, taking refuge in alcohol or sleeping pills in the hope of stopping our restless but aimless cogitations. I claim that we can change this unpleasant state of affairs into productive work.

Most thinking is reality-oriented thinking. Only after breaking through the psychical barrier, which we build by algorithmizing thought processes, can we mobilize the whole structure of thinking. We cannot rely only on automatic processes of the brain. During the day, work is needed to pick up bits of information, to file them, compare them, to infer new facts and so on. But if all these actions do not suffice we must make use of the subsidiary means: REM-sleep. And we must try to control it.

By REM-sleep I mean the state between consciousness and sleep, between vigilance and dream, the state which reflects our processes of thinking but still retains a single theme, and in which, if necessary, we can still by an act of will come back to the starting point of our thought. It is not easy to achieve. The difficulty lies in the fact that the integrity of thinking may in this phase be disturbed. Behind the shut eyes there run products of our imagination, thinking is diverted to remote associations, and free imagination enters in.

Quite a few practical and scientific problems have been solved thanks to the reflection of thinking in the rhombencephalic phase of sleep. I. D. Mendelejev's periodic system of elements and H. Kekule's discovery of the benzine ring are two well-known examples.

We will arrive at the next stage in the development of science when we learn to control REM-sleep. Scientific work is nowadays very demanding and we can see that this sort of knowledge touches the limit of our mental faculties. Therefore we must mobilize all the possibilities that we have, including REM-sleep. During REM-sleep we oust our will, our intention, our interpretation of the world, and according to Husserl (4) we let our nature speak.

Such an approach to scientific work participates in subjectivity. It is an attempt to overcome the distinction between subject and object, an endeavor to explore all of the brain's processes. It is really a new epistemology, an epistemology that I believe can lead to more productive scientific work.

When we analyze our knowledge of the world by means of this new epistemology which underlies cognitive science, we can also get inspirations for the construction of a new race of self-conscious robots (Nick Herbert wrote about this in ANPA-West Journal) (5). Further steps, in my opinion, must go even beyond the new artificial Eccles' gate; a future generation of robots will really be a new generation if they generate models of the world which precede their knowledge of it, and if through sleep or by other means they will every day reconstruct these "thought models" of the world. ●

(References: see back page)

DREAM LOGIC

by Tom Etter

How does the waking world differ from the dream world?

Western culture generally regards the dream world as a *private* world, an elaborate picture show mysteriously produced for an audience of one. This is very much a waking opinion, however, which is certainly not shared by the supposed audience of one, who is quite taken in by his apparent companions. It's not everyone's waking opinion, either; some psychologists regard dream characters as genuinely autonomous beings, albeit fragments of self. "They're still just myself", you say. But are you sure that in this respect they are so different from your fellow waking creatures? That we are all in some sense each other's selves has been a tenet of every great religious tradition, even Christianity (it was the Anglican minister John Donne who wrote "Ask not for whom the bell tolls. . .")

Granted all this, granted even that the waking and dream worlds may ultimately be of a single piece, differing only in degree of wakefulness, the fact is that they do differ. This paper is about one of their key difference, which oddly enough may also be the crucial difference between the everyday world of ordinary objects and the world underlying the quantum. What unites the nether realms of dreams and quanta in contrast to the daylit world of rocks and tables and chairs is the mutability of their objects, or more accurately, the radical instability of the characteristics that make such objects *definite.*

I dream that I am driving my car to the library. I arrive, have trouble finding a parking space, eventually pull over onto a patch of ground, get off my motorcycle, and go in. In another dream I leave my home, which is a city apartment, and go down to the river. Suddenly remembering the picnic basket, I run home to my country cottage on top of the hill to get it. These are of course the "histories" of my dreams, put into waking words the next day. Reading them one thinks how odd that the car turned into a motorcycle and the apartment into a cottage - aren't dreams crazy. But this is a waking distortion; the dream car didn't turn into a motorcycle, it simply was the motorcycle.

Asleep or awake, how do we tell whether we've encountered two different things or the same thing twice? The primary way we detect *sameness* is through its directly felt presence: "This is that" reaches us as a single unit, not as a relationship between this and that. Primary sameness is what we feel when we call something a "substance" to which "accidents" occur. It's what underlies our idea of the *thing* that is the "subject" of changing "predicates". It's one of the reasons I can say "I".

In our dealings with things, once we have graduated from primary encounters to ideas, we find ourselves making what I shall call <u>secondary</u> judgements of sameness. Although this and that are encountered separately, they are equated because they possess the same unique characteristic, the same *identifying label,* as it were, as when I recognize a friend on the phone by a distinctive quality in his voice. Note that these secondary judgements still rest on primary judgements of the sameness of the labels, and on the possibility of primary judgements inherent in the very concept of the persistent "thing" to which the labels are attached.

Primary sameness is a precondition of

any world, whether sleepy or wakeful. But secondary sameness, if it is to be more than just a wavering play of impressions, demands a kind of stability that no dream world seems able to support. The problem

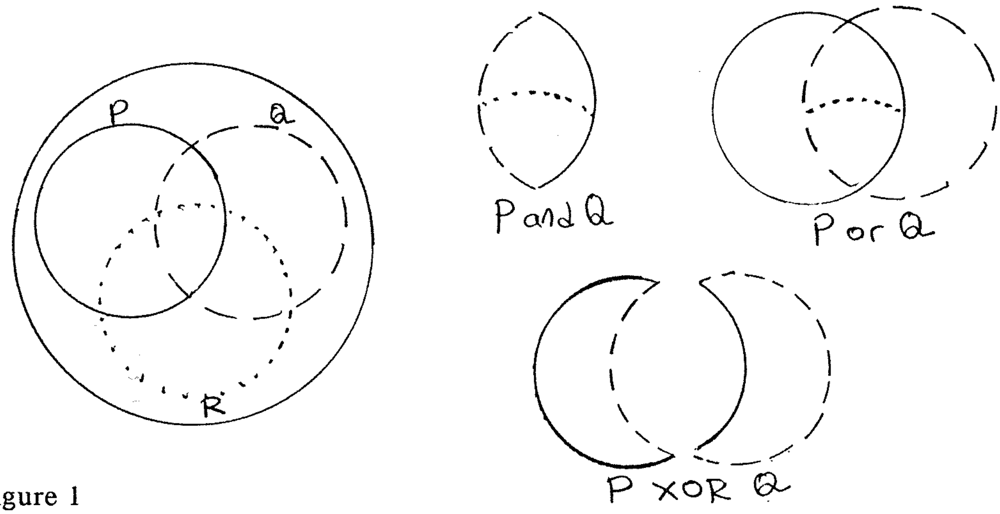


Figure 1

is that labels don't adhere very well to dream objects - the car becomes the motorcycle etc., not through any law of change that could be expressed in terms of recordable events, but just because it *is* the motorcycle, in the primary sense of "is".

This makes trouble for logic, which consists of statements like "all P's are Q's" and "no P's are Q's" whose truth can be inferred from the *sense* of P and Q without taking into account what objects are covered by "all". For instance, logic says that all P&Q's are Q's. All red cars are cars, though not if they are motorcycles.

It's useful to think of logic in terms of so-called Venn diagrams. We start with certain characteristics or properties that we regard as simple, and draw them as circles in such a way that they overlap in all possible combinations. Here's a three-circle Venn diagram, with the unbroken, dashed and dotted circles representing P, Q and R respectively.

The outer circle represents some universal property, i.e. some label which we assume is attached to everything in the context under consideration; it marks all the "subjects" of which P, Q and R could be "predicates". Every enclosed area is a label compounded from P, Q and R. With scissors we could cut out any of 253 different compound labels, of which four are shown above. The conjunction X&Y of two labels X and Y is the area they have in common, while their disjunction (X or Y) is their two areas combined; the negation ~X of X is the remainder of the big circle outside of X. A bounded area like P&Q&R without internal lines is called a logical atom; clearly any area can be written as a disjunction of logical atoms.

In speaking of properties as labels, we correctly invoke the metaphor of reading a label on an object, and logic rests on the possibility of reading in such a way that spatial inclusion in the Venn diagram matches class inclusion among the labelled objects - if one label is cut out of another, then the class of objects labelled by the former is included in that labelled by the latter. In principle, we should be able to read every label on every object with the assurance, verified by rereading, that the labels don't come unstuck. In practice, conditions must enable us to read and re-read a fair sample of the labelled objects to verify that the Venn diagram is indeed a stable class diagram.

Such conditions are rarely met in the dream world, so logic has a very tenuous hold there. They can't always be counted on in the everyday world either. Suppose in reading the labels of the objects on my table I read those involving color from the side of my table where the light is good, and those involving only position from the opposite side. First I find that all things labelled "on the right" are labelled "not on the left." But then I find that all things labelled "red and on the right" are labelled "on the left"! This reminds us that reading is something we do, not just something that happens, and we must make the right choices about how we do it in order to satisfy the Venn diagram.

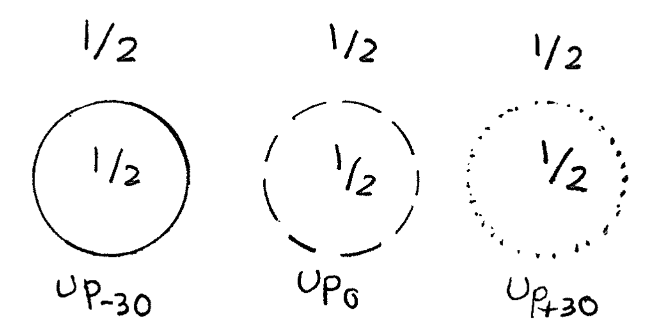


Figure 2

We have little doubt that such right choices are always possible in the everyday world, though, and this faith is unthinkingly carried by science into more exotic places, such as the realm of the quantum. It now appears that this has been a mistake. Quantum properties can't be portrayed by Venn diagrams. There's no way of attaching labels Up-30, Up0 and Up+30 and their compounds to photons that satisfies both the laws of logic and the probability rules of quantum mechanics. The point here is a critical one, so let me spell it out more carefully.

By a logical encounter with the world I shall mean, roughly, the secure attachment of the labels of a Venn diagram to some population of entities. We don't care what these entities are - physical objects, events, states, alternatives etc. - just so long as we have a consistent and stable way of reading them. In drawing the Venn diagram of a logical encounter, we'll write within the space representing each logical atom (space without internal lines) the proportion of objects labelled by that atom; the proportions having any other label can be found by adding up the numbers in its component atoms. The simplest logical encounter involves a single property; there are three such simple Venn diagrams, representing the measurements of up0, up-30, and up+30 on a population of photons in a so called white or unprepared state (1) (the outer circles are omitted).

Now let's consider the encounters that involve measuring two of these quantum properties, one after the other. Are such double encounters logical? Heisenberg didn't think so; he argued that the first measurement unpredictably disturbs the second -when you read one label on a quantum object, you unglue most of the others.

But Einstein came up with a very strong counter-argument. He pointed out that measurements on quantum "twins" behave just like pairs of measurements on a single particle (see Nick Herbert's article); if such behavior results from one measurement disturbing the other, such a disturbance must travel instantly between the measured twins, contrary to relativity. Since tests on twins for the same property always agree, his conclusion was that quantum properties are well-attached labels, and our measurements accurately read them. Philosophers speak of this as realism, and Einstein, as opposed to the other quantum pioneers, was known as a realist.

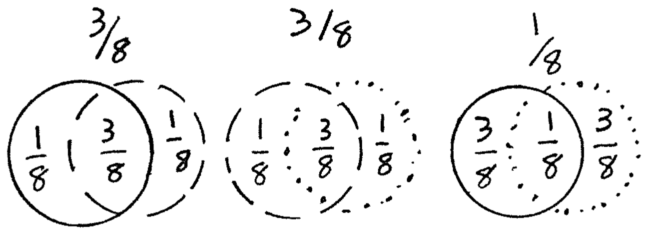


Figure 3

If this conclusion is valid, then it must be possible to draw a Venn diagram, whose numbers agree with the observed probabilities, for any set of quantum properties. Indeed this can be done for any pair of the properties up-30, up0 and up+30:

But can it be done for all three? Note that Einstein's argument, which involves quantum twins, only shows that we can read two labels; to draw his larger conclusion from it would require a similar argument involving quantum triplets etc. But are there such things as quantum triplets?

Each pair of a set of quantum triplets would be quantum twins, with Venn diagrams like those above, and the Venn diagram of triplets would contain all three of the above pair diagrams, just as these pair diagrams contain pairs of the single-circle diagrams in the previous figure. But as Bell showed in his famous proof of "non-locality", simple arithmetic makes this impossible: since 3/4 of up-30's are up0's and 3/4 of up0's are up+30, at least 1/2 of up-30's must be up+30's, contradicting the third pair diagram, which shows only 1/4 of up-30's as up+30's. Quantum triplets are literally inconceivable!

Most physicists who have considered the matter regard this as the downfall of Einsteinian realism. Heisenberg was right: measurements rewrite or tear off the other labels, even instantly at a distance in the case of quantum twins. But are we really forced to this conclusion? Must we search for some mysterious kind of non-local causal mechanism which underlies quantum phenomena? I doubt if Einstein would be happy about this; it's too reminiscent of the nineteenth-century ether. He would look for a more aesthetically satisfying solution, even if it meant giving up deeply entrenched habits of thought.

Let's try to follow his lead. Our situation is this: We find that pairs of quantum measurements have valid Venn diagrams;

they seem to be ordinary logical encounters, and indeed they constitute the empirical basis of quantum physics, which is a perfectly logical theory. However, when we try to go beyond pair encounters, when we try to measure something three times or more, the Venn diagrams break down. Is there not something dream-like about this? I get into the car, I drive the car - so far the label "car" sticks - but then I get off the motorcycle. "Car" is adhesive enough for two logical encounters, but not for three.

I propose that quantum properties originate in a realm which is like the dream world in that the necessary conditions for logic simply don't exist, just as the necessary conditions for the everyday solid material world don't exist in a hot plasma. In both cases there is an excess of fluidity; for matter this sweeps away the stable bonds of molecular structure, while for logic, it sweeps away the necessary stability in the bonds between primary and secondary identity.

How might we gain access to such a realm? What would it mean to study it? Clearly our only intellectual access to anything is through logical encounters, and the only way we could know we are encountering "pre-logic" is when these start to become inconsistent, *incompatible*. But then what do we do? Are we reduced to merely recording surreal narratives, as when we write down our dreams? Quantum mechanics suggests otherwise. Three quantum measurements may not be compatible, but we can and do measure quantum objects three times and get results that make theoretical sense. Thus, assuming my analysis of the situation is correct, there is a precise quantum theory of pre-logic. As we shall now see, there is also a more fundamental and general mathematical theory of pre-logic, within which quantum theory is a special case (3).

This general theory of pre-logic is abstracted from logic as a least common denominator of logical understanding. I shall assume that compatibility is the exception in our logical encounters. However, I shall also assume what is a pre-condition for even speaking of "our encounters", and of judging their compatibility, which is that they in some sense are encounters with the same world. This suggests that they must all share at least three basic concepts: "sameness," "everything," and "nothing". The mathematical science of pre-logic may be defined as the study of what is common to logical encounters that share these three concepts and no others.

Let's start with sameness. At the most primitive level, objects aren't differentiated from their properties and relations; predication makes no sense, and sameness is only the feeling of a one-ness in two-ness. It's only when we *remember* a dream, or *measure* a particle, that we can say "This and that are two occurrences of the same property", or "This is the same object as that, seen in a different way".

I'll write "$X \equiv Y$" for this primary feeling of the one-ness of X and Y. $X \equiv Y$ is a fellow entity of X and Y and can thus can itself be involved in a two-ness like $X \equiv Y$ and Z, which has its own one-ness $(X \equiv Y) \equiv Z$, etc. Note that the feeling $X \equiv Y$ does not imply either that X is or is not Y; it doesn't imply anything at all, since it doesn't *state* anything.

We shall also need another version of sameness, the relation of equality, which doesn't exactly apply to the netherworld itself, but to entities we haul up into the everyday world when we "fish" there, whether by remembering dreams or measuring photons. Note that we must carefully distinguish the relation of equality (written "=") from the sameness operator "$\equiv$"; the former creates *sentences* like "X equals Y" (i.e. "X is the same as Y"), while the latter creates *terms* like "The sameness of X and Y".

Finally, as I mentioned, we need the concepts of everything, which I'll call 1, and nothing, which I'll call 0. With this furniture in hand I shall now give a definition of negation, and five axioms:

Axiom 1: Equality is an equivalence relation, i.e. things are equal to themselves, equality goes both ways (if X = Y then Y = X), and equals of equals are equal.

Axiom 2 (Substitution of equals): If we substitute an equal of X for X in an equation, it remains an equation (note that this is necessary in order to use defined terms).

Definition. Define "not X" as the sameness of X and nothing. We'll write "~" for "not", so this definition has the formal statement $\sim X = X \equiv 0$.

Axiom 3. Two things being equal means that their sameness is universal, i.e. X = Y if and only if $X \equiv Y = 1$.

Axiom 4 (Associative law of sameness): $(X \equiv Y) \equiv Z = X \equiv (Y \equiv Z)$

Axiom 5: 1 is unequal to 0.

Axioms 1 and 2 are obviously true of equality, in any ordinary sense of the word, while axiom 5 says merely that there is more than one thing in the world. Axiom 3 establishes the basic connection between the *predicative* and *nominative* cases of sameness. The reason for Axiom 4 is less obvious; suffice to say here that it is true of the Boolean logical operator if-and-only-if, on which our conception of ≡ is partly based (2).

These definitions and axioms lead to a surprisingly rich theory which extends quantum-like ideas to all branches of mathematical science, and in which quantum theory proper arises in a natural way as a kind of equilibrium case (3).

One of the strangest things about pre-logic is that it gives a different account from logic of what it means for two systems, or two worlds, to be separate.

Just what do we ordinarily mean by "separate?" Let A be the events on Earth which start at 12 noon and last for 1/10 second, and let B be the events on the Moon during the same period. Ignoring Bell's theorem influences, we would say that A and B are separate because they don't influence each other - each goes its own way independently of the other. To put it another way, A and B are separate because whatever order is to be found in their joint history is to be found in their two histories separately -to explain what happens in one, it is of no help to know what happens in the other.

It's convenient to talk about separateness in the language of *events* and *cases*, which was prudently invented by Pascal to help his patron win at dice, or at least to keep him from losing too much. The key concept here is that of a separable event. Snake-eyes (two 1's) is a separable event, because it can be given as two events, one at each die, taken together; it has the form "A=1 and B=1". Roll-7, on the other hand, is inseparable, since it involves a relationship between the dice, which is that they add up to 7. We can regard a pair of dice as a system S consisting of parts S1 and S2 such that every joint case of S1 and S2 is a case of S, cases here being the possible outcomes of a roll. The general rule for the separability of an event E in such a system is that there are events E1 and E2 in S1 and S2 whose joint cases are the cases of E, or to put it another way, E is (E1&E2).

Let's define a pre-event to be an event which is the same in several incompatible logical frameworks. (It becomes the same because of logical encounters which turn nominative sameness into a true predication of sameness). We want to talk about pre-events in a way that doesn't depend on which framework we find them in; assuming pre-logic, this limits us to what can be said in terms of ≡, 1 and 0. What, then, would it mean for a pre-event P to be pre-logically separable into parts P1 and P2 in systems S1 and S2? It can't mean that P = P1&P2, since & is not a pre-logical invariant; indeed, it can only mean one thing, that P = P1≡P2, where P1 and P2 are pre-events in S1 and S2. In other words, pre-events are not joined by "&" but by "≡", where, within any logical framework, "P≡Q" has the logical meaning "P&Q or ~P&~Q".

Since the event P1≢P2 isn't logically separable, then it follows that phenomena whose order comes from the *separability* of underlying pre-events will appear, to our common-sense understanding, to be *inseparable*. If separate pre-events were encountered on the Earth and Moon and thereby turned into events, these events would be correlated!

Now we come to an interesting twist. Recall that another definition of separable is that the case set of E is the set of joint cases of E1 and E2. This of course is not true of pre-events, which is why we say that P1 and P2 are correlated. It's not true in ordinary set theory, that is. It is true, however, in Blizard's shadow set theory (see appendix, and also Blizard "A theory of Shadows", this issue). An event, when it occurs, divides cases into those which are still possible, and those which have become impossible. A pre-event, on the other hand, which does not occur at all unless it is logically encountered, doesn't forbid any cases, but rather divides the cases into negative and positive in the shadow-theoretic sense. When you encounter an event, you count its cases by the rules of shadow set theory, which means that + and - cases cancel.

Given these rules, it turns out that Pascal's case-counting mathematics of probability works for pre-events in exactly the same way that it works for events - it even gives the theorem that the joint "probability" of separate pre-events is the product of their separate "probabilities" (joining means ≡, of course). The big difference, however, is that in pre-logic there are *negative* probabilities. The mysterious fact that these can cancel positive probabilities is what explains the details of pre-logical "non-locality," including that famous detail known as Bell's theorem. The numbers on our cover weren't pulled out of a hat; they were calculated as pre-logical probabilities.

NOTES.

1. By a white state, in a finite-dimensional Hilbert space, I mean a mixed state in which all component pure states are equiprobable. The white state contains no macroscopic information, and thus may fairly be described as the unprepared state. It is the sole state which is invariant under all unitary transformations. The statistical outcome of any measurement of it is unchanged by prior measurements, and the conditional probabilities between a pair of measurements doesn't depend on their order, so any pair of measurements on a white state are compatible. Incompatibility always involves three encounters, one of which may be a preparation. To speak of the incompatibility of two measurements of a non-white state is an elliptical way of referring to the incompatibility of these together with the preparation that made it non-white. But what about position and momentum, you will ask? These only occur in infinite-dimensional Hilbert space, where the white state is impossible - all states are prepared!

2. If the two-ness of X≡Y is of two distinctive appearances of one thing, then the qualitative presence of their sameness can itself be regarded as a quality imputed to all things, namely that of appearing both as

X and Y, or as neither. Take Frege's famous example: "The morning star is the evening star". If there is such a thing (and in fact there is, namely Venus), this says "For all x, either x is both the morning star and the evening star, or neither". Thus the putative sameness of X and Y is what we believe to be the universal compound quality ((X and Y) or (non-X and non-Y)); this compound, as a Boolean operator on X and Y, satisfies axiom 4.

3. See Etter, "Science without Logic," ANPA West 1.1, Fall 1988, and also Etter, "Pre-logic", a more technical paper currently available from the ANPA West office; please enclose a self-addressed label and $3.00 to cover postage and Xerox. ●

APPENDIX. Pre-logic and Boolean algebra.

Theorem 1. $\equiv$ is group multiplication in a group where every element is its own inverse.
Proof: Since axiom 4 is associativity, we must establish the existence of an identity I and prove the equation $X \equiv X = I$:

step 1. $X \equiv X = 1$. This means $X = X$ by axiom 3. and thus is true by axiom 1. We shall now see that 1 is the identity, as follows:
step 2. $(1 \equiv X) \equiv X = 1 \equiv (X \equiv X)$ by axiom 4.
step 3. $1 \equiv (X \equiv X) = 1 \equiv 1$ by step 1 and axiom 2.
step 4. $1 \equiv (X \equiv X) = 1$ by steps 3 and 1 and axiom 1.
step 5. $(1 \equiv X) \equiv X = 1$ by steps 1 and 4 and axiom 1.
step 6. $1 \equiv X = X$ by step 5 and the definition of $X = Y$. This step says that 1 is the identity. QED.

Definition. Define $X + Y$ to mean $\text{not}(X \equiv Y)$

Theorem 2. $\equiv$ and $+$ and $\sim$ behave like iff, orex and negation in a Boolean algebra where 1 is the universal element and 0 the null element.

Outline of proof: First, we show that $+$ is a group operator isomorphic to $\equiv$. Then we show that the $+$ group can be regarded as a vector space over the field (0,1). Pick a basis B in that vector space; then the vectors are represented by the characteristic functions on B, and hence they correspond to the elements in the Boolean algebra of all subsets of B. We then verify that $\equiv$, $+$ and $\sim$ behave like their corresponding subset operators, and that 1 and 0 correspond to B and the null set.

When we treat pre-logic as a vector space over (0,1), we discover that there are some remarkable parallels with Hilbert space in quantum theory. Logical encounters are like quantum measurements in that they involve choosing a basis. The relationship between two incompatible logical encounters is represented by a linear transformations which changes this basis. Propositions are represented by projections. Separate systems are represented by the tensor product; this allows us to define things like Foch space and even "particles", which curiously enough are fermions!

A CHIMERIC KIND OF CAUSALITY

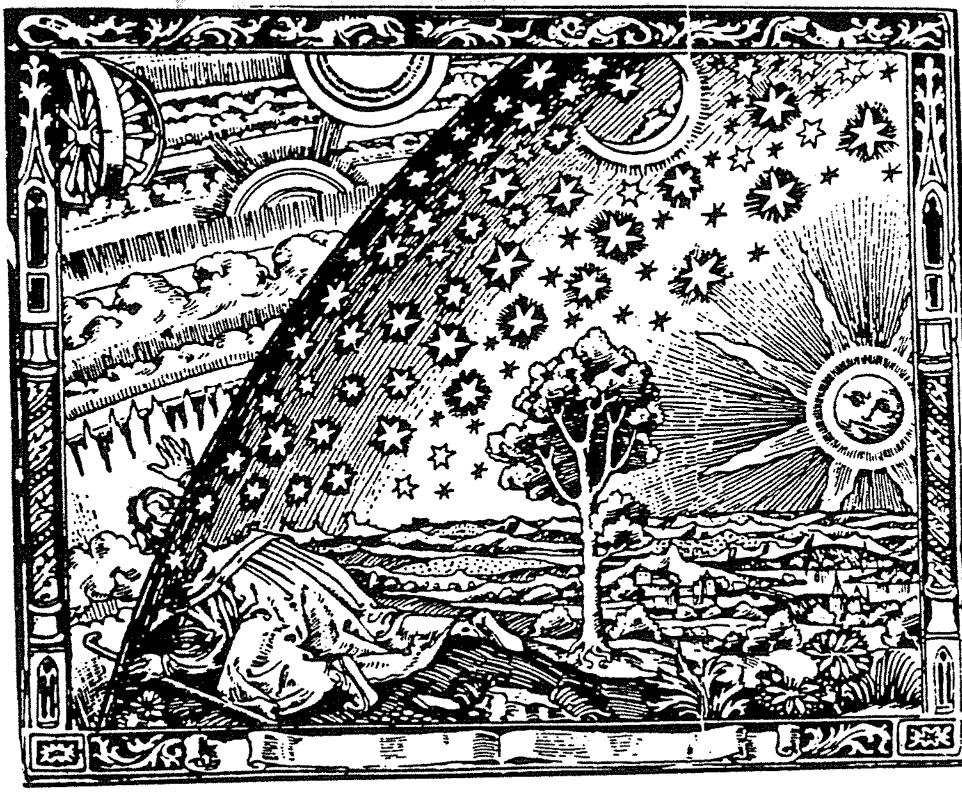
by Dr Jabir 'abd al-Khaliq

In 1964 John Bell proved that no local model of how the world works can explain the results of the EPR experiments -- results predicted by quantum theory and experimentally confirmed by Clauser at Berkeley, Aspect in Paris. Bell's theorem and Clauser's results then require physicists to forever refrain form considering models of "how the world works" or to accept the real existence of non-local (superluminal) connections in nature. Bohr preached a cautious restraint concerning questions about "reality;" Einstein, on the other hand, believed that "reality is the real business of physics."

Post-Bell Einsteinian realists however must come to grips with the existence of superluminal connections, connections which, on the face of it, seem to violate Einstein's own dictum that signals that travel faster than light are impossible. In view of this dilemma, it has become fashionable to speak of the EPR connection as a "superluminal influence" where an "influence" is to be understood as something less than a signal. But what must we subtract from the notion of signals to produce an EPR-type influence?

One way of explaining the EPR connection is to say that it does not violate Einstein's FTL prohibition because would-be signallers are frustrated by uncontrollable quantum randomness at both ends of the EPR communication channel. Quantum "essence noise" does you in. In his recent book "Faster than Light" Nick Herbert claims to have discovered another kind of superluminal connection -- symmetric causality -- which evades the Einstein prohibition and might be operative (along with quantum randomness) in the mysterious EPR connection. Herbert claims that Einstein forbids only *directed* superluminal links -- from sender (cause) to receiver (effect), but does not forbid *symmetric* superluminal links where sender and receiver mutually influence one another at superluminal speeds but it is impossible to unambiguously localize the source of this influence as coming from either party to the conversation.

Although symmetric causality on the face of it does seem to represent an attractive conceptual loophole for evasion of the Einstein speed limit, further examination shows that the notion of symmetrical causality is completely nonsensical. Imagine two observers at opposite ends of an EPR link. If we want to invoke symmetric causality then we must be unable to distinguish sender from receiver under all circumstances. But suppose *Harry does nothing* at his calcite crystal while Mary moves her crystal in a message-coded fashion. In this case, sender and receiver are easily identified by their actions. In particular the guy who does nothing will always be construed as the receiver of the "influence." Thus symmetric causality fails as an explanation of the difference between a superluminal influence (allowed) and a superluminal signal (forbidden). We will have to look elsewhere for an explanation of the immensely subtle EPR connection. ●



... AND I'LL TAKE THE HIGH ROUTE

David McGoveran

What would a generalization of Einstein's relativity look like? This is one of the questions I posed some four years ago in trying to understand the EPR results. The answer which I have been investigating suggests that there is not one "speed of light", but many, each finite and well-defined. It states that light is not the only thing which obeys the Principle of Relativity. It takes us beyond light. And in a superluminal, non-instantaneous way.

I took seriously Einstein's postulates (that there is no absolute rest frame and no special frame - the Principle of Relativity - and "that light is always propagated in empty space with a definite velocity c which is independent of the state of motion of the emitting body), but I found myself wondering why electromagnetic properties (light being the carrier of these properties) should be any different than other properties of the world. Is there a (mathematical at least) sense in which all properties have a "carrier"? In which each has a limiting velocity? Each a notion of reference frame?

The generalization of special relativity which answers these questions affirmatively is a pre-geometric one. It deals with reference frames which are not defined in space-time and with propagating entities other than light. The task becomes one of identifying the entities which "carry" the properties, the mathematical space in which they exist, and examining their interaction with the usual space-time.

It turns out that each must, within the space in which it is defined, refer to a propagation which obeys the Lorentz transformations. Again, these propagations are not in space-time as we know them in physics. They exist in a space of "similarities", where distance is a function of the similarity between properties. Ordinary space-time is subsumed as a very special case of this family of "similarity spaces".

I do not mean that the speed of light is not unique. Rather, the question is whether or not there is a way of understanding the world in which multiple causal structures can co-exist, each intertwining with the others, each having its own limiting velocity defining a "light cone". Of course, the propagating entity would not be light as we know it.

Some of these other causal structures might be strictly subordinate to the usual causal structure. In particular, if it is possible to describe such a causal structure completely within the context of some portion of space-time so that each point in one is uniquely mapped to the other by the description, then the space-time causal structure subsumes the other one. This makes the notion of "locality" a term relative to the causal structure.

As statisticians might well suspect, the assumption of Einsteinian locality can be expressed solely in terms of statistical independence IF the concept that two statistical events are local (or not) can be expressed in terms of samplings from disjoint (or non-disjoint) populations.

Clearly, this can be done in any system which imposes a unique causal structure. By a unique causal structure we mean the usual notion that any two "events" A and B are connected in the sense that A and B are partially ordered, and that it is not the case that A is both "before" and "after" B or vice-versa. This causal structure idea is just our layman's usual experience of time at work - the modern view of which incorporates thermodynamics to express the arrow of time and Einsteinian locality to express boundedness (imposed by the speed of light).

To understand how deeply rooted these ideas are, just try to conceive of an everyday experience in which you do something which turns out to be both before and after something else you do. Pretty hard! This is the stuff of which science fiction writers manufacture time-travel paradoxes. Things like being your own grandfather or your own twin or aging more rapidly than your twin and living to tell about it!

H. Stapp at Lawrence Berkley Laboratories uses the notion of the forward and backward light-cones to distinguish the two disjoint populations he requires in his argument. What I find curious is that he and numerous other EPR researchers then (communication to H.P.Noyes, Stanford University) deny that "superluminal correlations" are the least bit relevant to EPR and violations of the Bell inequalities. Now while I agree that such correlations are not mysterious or abnormal, proposing an adequate deterministic mechanism for the kind of correlations found in Clauser's or Aspect's experiments has been considered (traditionally) extremely difficult.

Our position allows us to describe such a mechanism in detail. It is not just a denial of the postulates of counter-factual definiteness (CFD - the notion that "would-have-been" measurements nonetheless correspond to unique, well-defined values)) and Einsteinian locality. Instead, we state exactly what we mean by a violation of Einsteinian locality and CFD; that is, what is to replace them. Indeed, we find that this is not enough. We are also required to show how we can have a deterministic mechanism which provides Einsteinian locally (note that "local" must be qualified for us) discrete random events. En fin, we give a computer model of the process.

For the time being, however, lets take an easier approach. We're all familiar (at least by hearsay) with the speed of sound and the "sound barrier" and similarly with the speed of light and the barrier imposed by the light cone. Each of these can be used to provide disjoint populations of events - things one could or could not as yet have heard (or seen) of all the things that can ever be heard (or seen). The populations are clearly divided - either I could or could not have heard (or seen) some given sound (light signal). There is no situation in which I both can and can not have heard (seen) an event, all other things such as hearing (seeing) ability being equal.

But what happens if there is not a single unique causal structure, but a multiplicity of them? How then are we to understand statistical independence? Under these circumstances, it is not possible to replace the notion of locality with a statistical independence condition. This leaves a loophole in various proofs of Bell's Theorem, since the notion of joint probabilities of statistically independent events is essential to them.

The apparatus I describe here is one which I could build. Suppose now that I performed an experiment with the apparatus and kept the usual laboratory notes. I then copy my data, changing references to (the speed of) sound references to (the speed of) light and references to light to some undefined and uncalibrated parameter, with appropriate changes of scale everywhere (note that these changes constitute an affine transformation on the data so that I am only changing the semantics, not the information conveyed). I then show these semantically altered results to a physicist familiar with EPR experiments. I claim that the results would be as befuddling as those of Aspect's experiments and that no one could tell that an experiment with sound had been substituted for an experiment with light.

As you read the description of the apparatus, keep in mind two salient points: first, the notion of locality is dependent on being able to say that two events are either local or non-local (i.e. not both). Current theory does not concern itself with the possibility that two events may be "local" in one sense and "non-local" in another. Current theory supports a single causal structure - it is singly connected.

In our theory, we allow for multiple notions of locality (not just Einsteinian locality) and therefore our causal structure is multiply-connected. Every region of our space is like a rubber sheet which is folded on itself - there is a longest way to get from event A to event B and a shortest way and many ways of intermediate length. These are not perceived as distances however: they are perceived as superluminal correlations - causal connections - between similar events.

Note that I did not say between similar points. This is because our events have structure whereas points do not. Hence it is legitimate to say that they can be similar and to speak of a measure of the similarity of any two events.

Second, that a sequence of events are judged statistical random if it is impossible to distinguish them from random events. Part of the mystery of the EPR experiments is that each arm of the experiment seems to generate random measurements. This is extremely difficult to accept if true. However, I and others have shown that it is always possible to obtain such results from an algorithmic number generator. Thus there is a "loop-hole" in the arguments regarding the experimental evidence and one which allows for a deterministic theory with non-local (though only in the Einsteinian sense of non-local) hidden variables.

Imagine the following ill-defined audio system. It consists of an audio source S which feeds two acoustical waveguides. At the end of each acoustical waveguide is an assemblage consisting of transducers with volume "controls", P1 and P2 and speakers, D1 and D2.

The behavior of this system is rather curious. First, the source S only emits bursts of sound and only into one of the two waveguides - when sound is heard at D1 it is not at D2 and vice-versa. Furthermore, apparently no sound is heard at D1 or D2 unless it is emitted at S, and only after the appropriate propagation delay. Second, P1 and P2 do not seem to have a deterministic effect on the volumes at D1 and D2, respectively. When the position o1 of P1 is correlated with the volume at D1, it appears to be a purely random relationship. However, when the relative positions of P1 and P2 ($\Theta 2 - \Theta 1 = \Theta$) are compared to the correlation between the volume at D1 and the volume at D2, it turns out that there is a cos Θ correlation which is not affected by the propagation delay. How can these conditions exist or arise?

There are two problems to be solved. First, the correlation: note that, in terms of the "causal structure" imposed by the propagation velocity of sound, each detector D1 and D2 is "local". However, P1 and P2 can be connected by signaling means other than sound: electromagnetic signaling between them is possible. Thus Θ is, in terms of sound, a non-local system or global parameter. o1 is a measure of not just a position of a dial but the interaction of the transducer with an acoustical wave. To speak of o2 without the wave as in the single arm randomization test of o1 is meaningless, as is then Θ. EM signaling can serve to enforce the cos Θ distribution.

In particular o1 is, in a sense, completely uncalibrated. The zero position is unknown - i.e. it appears independent with each new measurement. This raises the second issue. How can this be possible? All that is needed is that the algorithmic complexity of the relationship between P1 and P2 can not be conveyed via the measurement of o1 and the volume, and the sequence of the measurements alone.

In other words, V1 = F(o1, t) is a many-to-one mapping. Furthermore, o1 = G(A,N) where A is some set of acoustical parameters and N of non-acoustical parameters. G is also many-to-one and such that the domain is greater than the range n of o by a factor which is greater than the n-th power of 2.

These conditions ensure that, without knowledge of the electromagnetic signaling (which appears instantaneous if no measurements greater than the speed of sound are allowed), the local (in terms of sound propagation) events are "random" but can be perfectly anti-correlated.

In a space where there are multiple "causal structures" such as that due to sound propagation and light propagation, there are "short" and "long" routes between causally connected events. So, in the EPR-Bohm experiments, the light merely takes the low (long) route and its never at both detectors before the polarization. As Schroedinger might have said had he been Scottish, "There be more than one route to skin a cat, lassie." ●

ADVANCES ON TWO FRONTS

Pierre Noyes

Until recently our theory* could calculate numerical values for a few elementary particle parameters, but could only give heuristic or at best semi-quantitative estimates of the range for the next order corrections; for cosmology, the arguments were much vaguer. This situation changed dramatically when McGoveran made the fine structure breakthrough last year. McGoveran recently noted that, following the same line of reasoning, the correction to the "weak" (Fermi theory of β-decay) G_F should be $(1 - \frac{1}{3\times7})$,which works to four significant digits. Once one recognizes that $sin\ \theta_{Weak}$ is also a coupling constant factor, and has lowest order value $\frac{1}{2}$ because of the missing "right-handed" neutrinos, the same factor of $(1 - \frac{1}{3\times7})$, also corrects the sine of the weak angle and brings our calculation within the currently accepted experimental range.

For our model, in the absence of further information, one would expect baryon number zero, i.e. equal numbers of 0's and 1's in the bit-strings. However, we have to start with 1 rather than 0 to get off the ground. By the time we have formed 256 labels, and hence have the fourth power of that number of particles which have engaged in (2,2) scatterings (our scatterings conserve baryon number) and have closed off the first generation of quarks and leptons, we will still have an unavoidable bias of one part in 256^4; hence $n_B/n_\gamma = 1/256^4 = 2.328 \times 10^{-10}$. Since the higher generations repeat the same construction, this will *also* be the bias for the whole scheme when the $2^{127} + 136$ labels have been constructed. The current observational value of the number of baryons per photon is $n_B/n_\gamma = 2.8 \times 10^{-8}\Omega h_o^2$ where Ω is the ratio of the relevant matter density to the critical density, and h_o the ratio of the hubble constant to the currently accepted value $[\frac{1}{2} < h_o < 1]$. Observationally $\Omega h_o^2 = 0.007$, and hence $n_B/n_\gamma = 1.96 \times 10^{-10}$. It begins to look like we can write a reasonable version of Genesis. Whether our Deuteronomy comes out as it should remains to be seen.

⋆ H.P.Noyes and D.O.McGoveran, *Physics Essays* **2**, 76-100 (1989).

Summary of **WHERE WE ARE** in May, 1989

General structural results

- 3+1 asymptotic space-time
- transport (exponentiation) operator
- combinatorial construction of π
- limiting velocity
- supraluminal synchronization and correlation *without* supraluminal signaling
- discrete events
- discrete Lorentz transformations (for event-based coordinates)
- relativistic Bohr-Sommerfeld quantization
- non-commutativity between position and velocity
- conservation laws for Yukawa vertices and 4- events
- crossing symmetry

Gravitation and Cosmology

- the equivalence principle
- electromagnetic and gravitational unification
- the three traditional tests of general relativity
- event horizon
- zero-velocity frame for the cosmic background radiation
- mass of the visible universe: $[2^{127}]^2 m_p = 4.84 \times 10^{52}\ gm$
- fireball time: $[2^{127}]^2 \hbar / m_p c^2 = 3.5$ million years
- critical density: of $\Omega_{Vis} = \rho/\rho_c = 0.01175\ [0.005 \leq \Omega_{Vis} \leq 0.02]$
- dark matter = 12.7 times visible matter [10??]
- baryons per photon $= 1/256^4 = 2.328... \times 10^{-10}\ [2 \times 10^{-10}?]$

Unified theory of elementary particles

- quantum numbers of the standard model for quarks and leptons
- gravitation: $\hbar c/Gm_p^2 = 2^{127} + 136 = 1.70147... \times 10^{38}\ [1.6937(10) \times 10^{38}]$
- weak-electromagnetic unification:
  $G_F m_p^2/\hbar c = (1 - \frac{1}{3\cdot 7})/256^2\sqrt{2}] = 1.02\ 758... \times 10^{-5}\ [1.02\ 684(2) \times 10^{-5}]$;
  $sin^2\theta_{Weak} = 0.25(1 - \frac{1}{3\cdot 7})^2 = 0.2267...\ [0.229(4)]$
- the quark-lepton generation structure
- generations weakly coupled with rapidly diminishing strength
- color confinement — quark and gluon masses not directly observable
- $m_{u,d}(0) = \frac{1}{3} m_p$
- the hydrogen atom: $(E/\mu c^2)^2[1 + (1/137N_B)^2] = 1$
- the Sommerfeld formula: $(E/\mu c^2)^2[1 + a^2/(n + \sqrt{j^2 - a^2})^2] = 1$
- the fine structure constant: $\frac{1}{\alpha} = \frac{137}{1 - \frac{1}{30 \times 127}} = 137.0359\ 674...[137.0359\ 895(61)]$
- $m_p/m_e = \frac{137\pi}{\frac{3}{14}\left(1 + \frac{2}{7} + \frac{4}{49}\right)\frac{4}{5}} = 1836.15\ 1497...\ [1836.15\ 2701(37)]$
- $m_\pi \leq 274 m_e$: $[m_{\pi^\pm} = 273.13 m_e,\ m_{\pi^0} = 264.10 m_e]$

ALTERNATIVE NATURAL PHILOSOPHY ASSOCIATION

Statement of Purpose

1. *The primary purpose of the Association is to consider coherent models based on minimal number of assumptions to bring together major areas of thought and experience within a natural philosophy alternative to the prevailing scientific attitude. The combinatorial hierarchy, as such a model, will form an initial focus of our discussion.*
2. *This purpose will be pursued by research, conferences, publications and any other appropriate means including the foundation of subsidiary organizations and the support of individuals and groups with the same objective.*
3. *The Association will remain open to new ideas and modes of action, however suggested, which might serve the primary purpose.*
4. *The Association will seek ways to use its knowledge and facilities for the benefit of humanity and will try to prevent such knowledge and facilities being used to the detriment of humanity.*

ILLUSTRATIONS

NOTES

Blizard

1. First-order means that predicates are not themselves objects of predication. Set theory has largely obviated the need for higher-order logics in mathematics, since most of what needs to be said about predicates can be translated into statements about the sets to which they apply. Ed.

Pstruzina

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