The Scientific Proof of Non-Locality
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The Einstein-Podolsky-Rosen Paradox and Bell's Theorem

" It is an illusion we are all separate, the universe at one mathematical level is still one. It is our job as humans to expand our circle of compassion to include all things" ,

*"One can escape from this conclusion only by either assuming that the measurement of **B** (telepathically) changes the real situation at G or by denying independent real situations as such to things which are spatially separated from each other. Both alternatives appear to me entirely unacceptable. Non-Locality is an ever increasingly undeniable aspect of science"*

Albert Einstein

"There is no such thing as noise, but only quantic shared information we do not understand. Such is the Nature of the universe that there is a shared subspace dimension of all regular matter that generates non-locality" ,

*" The universe at one mathematical **subspace** level is still one. It is our job as humans to expand our circle of compassion to include all things, and our circle of compassion must begin with ourselfs. We must learn to forgive ourselfs, forgive others, and forgive God before we can expand our minds through expansion of our compassion"*

William Nelson

In our movie and treatise on the PROOF, we established 8 steps pf proof for the non-local universe. Here they are again. Bell's theore is but just #5.

Proof Of the Powers of The Mind

The most important argument in the world of science today is the clash between the people that believe in a Non-Local Universe versus those that believe in a Local Universe.

Local people believe in the direct push pull, cause and effect action, and they do not believe in the power of the mind to effect things at a distance without a direct connection. They look for repeatability and worship statistics.

Non-Local believers see a universe where there is prayer, spirit, a collective unconscious and a connection of all things . They know that there is a power of the mind to effect things and a level of connection of all things.

The Steps of the Proof are :

Step 1. The test of time: Humans have always felt the connection of mind and spirit. Every race of people and every tribe has had those who have greater abilities to use these powers of the mind. They know that there is a subtle but undeniable force of

connection.

The Bible, Koran, Bagavad Gita, the analects, and all of the religious beliefs are filled with every page referencing the power of spirit, prayer, faith, hope and God.

This belief is Ageless , Universal, and Omnipresent. The test of time is met and if we had a vote on the conflict of Non-Local versus Local there would be landslide 99.9% for a Non-Local universe.

Step 2. Quantum Theory : Physicists were shocked when they found that a very small quantic experiment could be influenced by the observer. This was called the observer effect and thus the world of science was changed forever when **the Observer Effect was PROVED!!!!!**.

Step 3.Medicine's Paranoiac need for Double Blind. Medicine was shocked when they discovered the placebo effect. The mind of the researcher was able to effect the results of an experiment. The mind of a doctor can effect the patient. The mind of a patient can effect himself.From then on a double blind experiment was required. Proof of the powers of the mind.

Step 4. **Fractal Complexity**: What we do not know is so vast that it should be humbling. Fractal complexity has shown that reductionism is now no longer a valid process of examining complex situations. Non-Linear chaos mathematics are needed. When we use this type of analysis we can see that a small change might produce a large change. This is known as the 'Butterfly Effect" and it allows for the powers of the mind.

Step 5. Bell's Theorem. This basic theorem of Quantum Electro Dynamics has shown that twin photons can have instantaneous effects on each other even when light years apart. This has been PROVED theoretically and experimentally to the utmost level of science.

Step 6 . PEAR.= Princeton's Engineering Anomalies Research :. After over a decade of research on the effects of the mind in a prestigious American university Princeton, there is undeniable proof of the power of the mind to effect things. The evidence is astounding for it's quality and quantity and is without doubt **PROOF**. See the PEAR studies.

Step 7. The disbelievers always get test results that deny the proof: The hypothesis of our theory is that **the mind can effect things.** This means that those who disbelieve or scoff at the theory will only be able to get tests results that confirm there own disbelief. Why is it that when a researcher does a study that it usually confirms his original belief is because there is an effect of the mind.

Step 8. The resistance to accepting the powers of the mind is great, in fact it is too great. The resistance is so incredibly great that it becomes PROOF : There appears that this resistance comes from such closed minded people and often psychologically unstable people. These critics will often shake and flush and get over compassionate in their attempt to dispel the powers of the mind. Their actions and reactions are so contrived and insecure that they cause wonder that perhaps there is an ulterior motive. Is there perhaps a plan to keep the powers of the mind away from the general public**.**

This study will now more fully discuss Bell's Theorem.

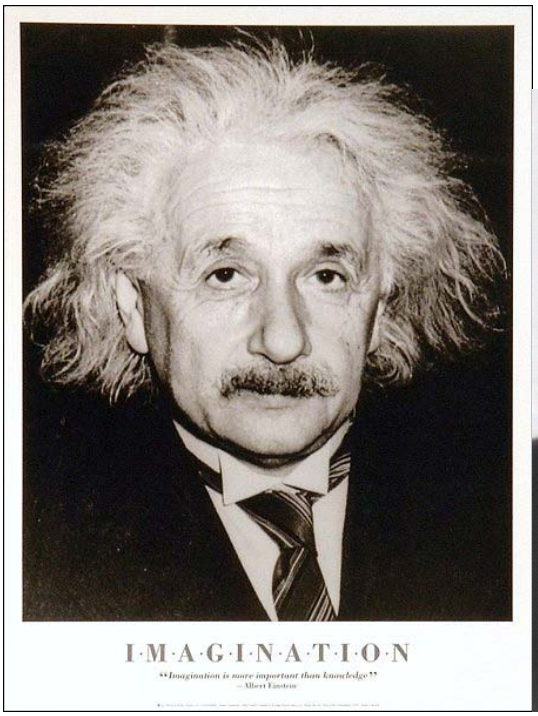
The basis of Bell's theorem is this: ***if no local model of reality can explain the results of any particular experiment.*: *then reality is non-local, if there***

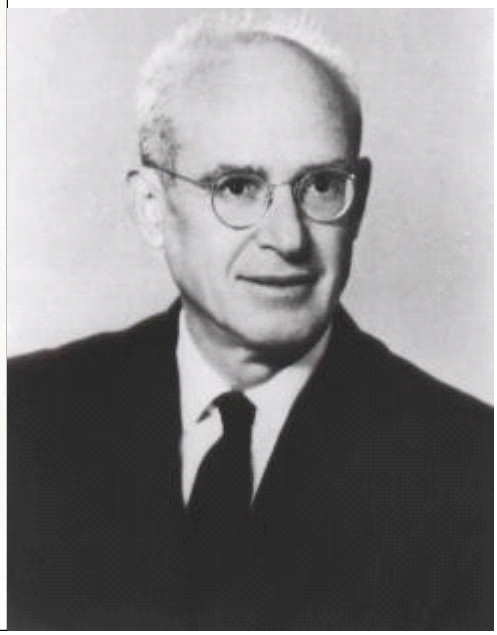
is non-locality anywhere then there is some nonlocality everywhere . To prove that white crows exist we only have to produce one white crow. All of the black crows are not proof that white crows do not exist. All we need is one. with non-locality it is even more of the same, because if there is non-locality somewhere then there is some non-locality everywhere. Just how much is the part of the mystery of life.

Before we study what "non-locality" means, let's take a look at this particular experiment, called the **EPR** experiment (**Einstein-Podolsky-Rosen Paradox**), which is the factual basis for Bell's fantastic result. Like so many other innovations in twentieth-century physics, the EPR experiment was conceived by Albert Einstein.

Although he helped put it together, Einstein was never satisfied with quantum theory. He didn't like its intrinsic randomness ("I cannot believe that God plays dice with the universe"), but most of all he disliked the fact that quantum theory (as interpreted by Bohr and Heisenberg) implies that reality is observer-created. "I cannot imagine," Einstein once said, but as Nelson has said "What if God is the Dice? What if God is in the indeterminancy? Could this indeterminancy be the subspace? Could God be the subspace glue that penetrates the essence of the universe? Answer to all : Yes"

Albert Einstein





Nathan Rosen

"that a mouse could drastically change the universe by merely looking at it."

Einstein accused Bohr and Heisenberg of attempting to restore man (and mouse) to the center of the cosmos from which Copernicus had ousted them nearly five hundred years ago. "The belief in an external world independent of the perceiving subject," Einstein maintained, "is the basis of all natural science." **But man (and mouse) are the center of their own cosmos, relativity revisited, or at least the maximum twist of relativity.**

Bohr responded by comparing Einstein to the critics of his own relativity theory. He pointed out that thanks to Einstein's work, physicists have come to realize that space and time are not absolute but relative to an observer's state of motion. In quantum theory we simply take this way of thinking one step further and recognize that reality itself (or at least its dynamic attributes) is also observer-dependent. Why did Einstein find it so difficult, Bohr wondered, to accept this natural extension of his own ideas?

"A good joke should not be repeated twice," Einstein quipped.

Niels Bohr and Albert Einstein debated the quantum reality question for as long as they lived: **Einstein failed in his attempts to assault quantum theory head on, and reluctantly agreed with Bohr that quantum theory describes correctly all presently conceivable experiments—a conclusion that remains uncontested today**. Einstein resorted instead to criticizing quantum theory on the grounds that it is *incomplete.*

Quantum theory may be sufficient to explain experiments, Einstein confessed, but experiments are only part of what goes on in the world. Because quantum theory makes only statistical predictions, it cannot help but leave out certain "elements of reality" which a more adequate theory of the world must include.

Niels Bohr, on the other hand, claimed that although quantum theory does give only statistical predictions, it is still complete. Quantum theory's indefiniteness is a virtue, not a weakness, because it corresponds to an indefiniteness that actually exists in the world. It is foolish to seek a precise description of an imprecise world; such misplaced precision is bound to miss the mark.

Einstein put forth his best argument for quantum theory's incompleteness in the form of a thought experiment involving two correlated quons. He devised this experiment at Princeton in 1935 with the help of two American physicists: Boris Podolsky, originally from southern Russia, and Brooklyn-born Nathan Rosen. The original Einstein, Podolsky, and Rosen (EPR) experiment concerned two *momentum-correlated electrons,* but physicists today repeat EPR's argument using David Bohm's conceptually simpler experiment involving two *polarization-correlated photons.*

If we compare a light beam to a series of balls (photons) thrown by a baseball pitcher. The two-valued photon polarization attribute was compared to a batter holding his bat at a certain angle 0 and getting either a hit or a miss. In the laboratory, photon polarization is measured with a calcite crystal which splits a light beam into up and down channels depending on whether its photons are polarized along or across the calcite's optic axis.

The EPR experiment is only slightly more complicated than this two-man ball game. The EPR source emits *pairs of photons* (Green and Blue) which travel in opposite directions to two *distant detectors* (also labeled Green and Blue) where their polarization P(¢) at a particular angle 0 can be measured. To visualize this EPR arrangement we imagine a pitcher who throws *two balls at a time.* First he throws a Green ball to home plate; then, without breaking rhythm, he turns and fires a Blue ball to second base where a second batter is waiting.

As in the previous game, the batters at home and at second can each measure the "polarization" of the baseball by holding their bats at a particular angle. A hit shows the ball to be polarized at the bat angle; a miss means polarization at right angles to the bat.

The pitcher fires off a pair of balls, rests for a moment, then throws another pair. For each pair of balls, the Green player measures his Green ball's polarization at some Green angle, while the Blue player measures her Blue ball's polarization at some Blue angle. To understand the EPR experiment, it's not necessary actually to know what polarization really is —what polarization "really is" is a mystery to physicists too—but only the particular results of each pair of polarization measurements. Encoded in the pattern of these results is the gist of the EPR paradox as well as the core of Bell's theorem.

The EPR photon pairs are pitched in a special way; they come out of the light source in a particular phase-entangled state called the "state of parallel polarization." Because their phases are entangled with each other, each photon's phase depends on what the other photon is doing. Consequently, neither photon by itself is represented by a definite waveform; hence (according to quantum theory) neither photon possesses a definite polarization.

Observationally, not possessing a definite polarization means that no measurement of polarization will always give the same result. In fact, for this particular two-photon state the Green light and the Blue light are *completely unpolarized—the* maximum indefiniteness possible for a two-valued attribute. For each photon at any angle *0,* a polarization measurement P(~) gives 50 percent up/50 percent down, results which occur at random, like flipping a coin.

Although *each photon by itself* does not possess a definite proxy wave, *the two-photon state as a whole is* represented by a definite wave, which means that certain *two-particle attributes* (which belong to the Green and Blue photon together) have a definite value. For photons in the state of parallel polarization, one such definite attribute is the photons' *paired polarization.*

To measure paired polarization *PP*,* at a particular angle 0, set both Green and Blue calcites at the same angle ˇ and look at their polarization values (up or down). Like polarization itself, the *PP* attribute can take two possible values: either both photons have the same P (match) or they have opposite P (miss).

Both quantum theory and quantum fact agree that for photons in the parallel polarization state, PP(() *at all angles 0,* always has the same value, namely match. This means that if you measure the Green polarization at angle 0 and the

Blue polarization at the same angle, both polarizations are always the same. Furthermore the *P of* C will be the same as the *P* of *B* no matter how far apart the photons fly or which polarization happens to be measured first. For instance, you can measure the polarization of the Green photon immediately after it leaves the source and measure the Blue photon a year later (when it is one light year away from its source): the polarizations of both photons will be identical.

According to quantum theory, in the state of parallel polarization each photon by itself has no definite P. However, the *PP* of C and *B* together is definite: it's match in every direction. The polarization attributes of unmeasured photons in this state resemble the attributes of identical twins before conception. Each twin's attributes (sex, hair color, and so forth) are undecided but the status of their *paired attributes is* already known: the same for both. **For this reason I call the state of parallel subspace polarization "the twin state."**

In terms of the two baseball players, the results of a long series of plays against a pitcher who always throws pairs of balls in the twin state is this:

I. At no matter what angle ø either player holds the bat, he/she always gets a 50-50 mixture of hits and misses;

II. If both players agree beforehand to hold their bats at the same angle (I call this move "measuring the *PPO* attribute), whatever happens to one player's ball (hit or miss) also happens to the other player's ball.

III. shared subspace interaction allows for a non-locality, "*what God hath joined together let no man set apart*"

QUANTUM THEORY AS A PARTIAL OR COMPLETE DESCRIPTION OF REALITY

"Obstacles occur only in the Mind" Helen Keller

One difference between human twins and a pair of photons in the twin state is that before conception the human twins are nonexistent, while before measurement the photons already exist. We know that they were emitted at a certain time from their source and are traveling with a certain velocity toward their respective detectors.

For a pair of photons in the twin state, Einstein asked the question, "Is the P of photon G, after it's emitted but before it's actually measured, *truly indefinite* as Bohr's interpretation of quantum theory requires, or is it, like identical twins in the womb, *really definite* but unknown?" In other words, "Is our uncertainty concerning the unobserved polarizations a mat-ter of *quantum* or *classical* ignorance?"

According to Bohr, the P of photon C does not even exist before we measure it. G's so-called attributes belong not to the photon itself but reside partly in "the entire experimental arrangement." Like the position of a rainbow, polarization is a

relational attribute and does not come into existence until Green observer decides how he will deploy his apparatus at location G (and possibly elsewhere as well). It's nonsense to suppose that before a measurement, photon G has some definite polarization. Einstein argues that, on the contrary, not only does photon G have a definite P in some direction, it has a definite *P in every direction.*
To dramatize the difference between Bohr and Einstein, let's imagine that Blue player moves closer to the mound so that she gets her Blue ball before Green player gets his. Suppose she holds her bat at zero degrees (vertically) and gets a hit, which means that her photon is V-polarized. We now switch our camera to home plate where the spirits of Bohr and Einstein are discussing the reality status of the as-yet-to-be measured Green photon presently hurtling toward the Green batter at the speed of light. To allow the great men time for debate, we imagine the usual passage of time to be temporarily suspended.

BOHR: When I say that quantum theory is "complete," I mean that QT says everything that can possibly be said about the reality of that Green photon. If it's not in the theory, it's not in the photon either.

EINSTEIN: If complete, What, then, does quantum theory say about this Green photon now approaching the Green batter?

BOHR: In the first place, given that Blue's already measured a V photon, coupled with the fact that this pitcher throws nothing but twin-state photon pairs, quantum theory predicts that if Green chooses to hold his bat vertically, he will certainly get a hit; furthermore it also predicts that if he holds his bat horizontally, he will certainly get miss.

EINSTEIN: I agree with you concerning what quantum theory predicts if Green makes either a horizontal or a vertical polarization measurement. Now, what is supposed to happen if Green holds his bat at some other angle?

BOHR: For Green bat angles other than zero or ninety degrees, quantum theory gives no certain results, but only the relative *probability* of a hit. For instance, if Green should hold his bat at 45 degrees, the odds are 50-50 that he will get a hit.

EINSTEIN: Yes. Quantum theory indeed **gives** only **statistical** predictions for intermediate angles. We seem to agree concerning the predictions of the theory and about the facts of the matter—namely, that quantum theory has never made a single incorrect prediction. We agree, as Kant would have put it, about the appearances and about the theory. But what, my dear Bohr, are you willing to say about the *reality* of this particular Green photon magically suspended before us?

BOHR: Because I believe that quantum theory describes all physical situations

completely, I must say that before it is actually measured, this photon really has a definite polarization only in the *V* and *H* directions, but no others. To speak of a definite polarization in any other directions would be to talk nonsense. Thus I say that, in reality, this Green photon does not possess polarization attributes except perhaps at these exceptional angles.
Even at these special angles, for which quantum theory gives certain results, I am not entirely convinced that these results represent a definite attribute belonging solely to the photon. I believe that all attributes are joint creations of photon and measuring device and do not belong to one or the other.

EINSTEIN: Concerning this matter of completeness…As you know, my friend, I cannot refute your opinion that quantum theory is *a complete theory of phenomena:* it indeed seems to describe correctly the results of every experiment my poor head has been able to imagine. But I do not share your faith that quantum theory is a *complete theory of reality . I* believe that certain elements of reality exist in the world that are not described by the quantum formalism. In the case of this Green photon, for example, I say that it possesses a definite polarization attribute for every possible angle, not just for the *V* and *H* directions.

BOHR: No, my friend, you are mistaken. Except perhaps in certain special situations where the outcome is not a matter of chance—such as the V and II directions in this case—the photon's polarization is a joint production of the entire experimental arrangement, and does not inhere in the photon by itself independent of a particular measurement context.

EINSTEIN: Forgive me, Bohr, but I have never been able to understand your subtle reasoning in this matter. Indeed, for situations like this twin-state baseball game, I have, with my colleagues Podolsky and Rosen, devised a simple argument which convinces us that this Green photon hovering in front of us possesses a definite (but unknown) polarization attribute *at every angle.* Permit me to show you this argument.
Our reasoning depends on a certain plausible assumption, which physicists nowadays call "the locality assumption": we assume that the real factual situation of the Green photon, after it's left the source, is not affected by how the Blue player chooses to hold her bat. In other words, we assume that *Blue's batting stance does not affect the Green photon.* This supposition seems reasonable since both photons are traveling in opposite directions at the speed of light. Therefore one photon cannot learn about the other's measurement situation except via signals that travel faster than light.

BOHR: I am suspicious of this locality assumption but please continue.
EINSTEIN: Here is our argument. For this present situation, Blue chose to hold her bat vertically and she got a hit. But if she had held her bat at some other

angle, say 45 degrees, she would also have measured *some-thing,* either a hit or a miss, we do not know which. Because this photon pair is in the twin state we know that Green photon would be obliged to show the same polarization that Blue got at 45 degrees. In like manner Blue could have held her bat at any angle X and measured a certain polarization; Green photon is compelled to have an identical polarization at angle X.

If Green photon must have a definite polarization for each Blue measurement choice, and if (by the locality assumption) Blue's measurement choice does not physically affect the Green photon, then *the Green photon must already possess a definite polarization for each angle*—polarizations that exist regardless of Blue's actual choice.

Thus we believe we have shown that before it strikes the Green bat, this Green photon has already "made up its mind" as to how it will act no matter how Green might choose to hold his bat. This Green photon must possess a sort of hit/miss list which tells it what to do for every bat angle. Quantum theory, on the other hand, certainly does not recognize any such list: except for the *N* and *V* directions, it considers these results to be "random," utterly unknown except in a probabilistic sense. Quantum theory is therefore "incomplete" because it leaves out some attributes—this hit/miss list, for example—which this photon seems to possess.

BOHR: Your argument is clever but I cannot accept your conclusion. Of course there is no question of any *mechanical influence* traveling from Blue's bat to the Green photon, but *there is essentially the question of an influence on the very conditions which define the possible types of predictions regarding the future behavior of the Green light.*

EINSTEIN: Yes, I remember your making that very statement in 1935 in response to our original EPR paper. I did not understand it then, and despite considerable effort, I must confess that I still cannot grasp the subtlety of your thought on this matter.

Since the author seems to have frozen our intellects, like that time-suspended Green photon out there, into our ancient philosophical positions, I will answer your old quote with two of my own which sum up my thinking on the EPR experiment:

"We are forced (via the EPR argument) to conclude that the quantum-mechanical description of physical reality given by wave functions is not complete".

"One can escape from this conclusion only by either assuming that the measurement of B (telepathically) changes the real situation at C, or by denying independent real situations as such to things which are spatially separated. Both alternatives appear to me entirely unacceptable".

Bohr, Einstein, and numerous other thinkers struggled with the EPR paradox but no generally acceptable solution could be found until Bell focused attention on the

fragility of the locality assumption. Let's take a closer look at this locality assumption so essential to the argument of Einstein, Podolsky, and Rosen.

LOCALITY ASSUMPTION

"Circumstances are like objects, they are not alive, you bring life to them" *Nelson*

The locality assumption does not mean that *what happens* at the Green bat has nothing to do with *what happens* at the Blue bat. Since the photons are correlated at the light source, the results at the Green and Blue measurement sites will likewise be correlated. What locality means is that no action on Blue's part (as she detects her Blue photon) can affect what Green player sees (when he detects his Green photon). Locality means that what happens at home plate is unaffected by how Blue holds her bat at second base.

The locality assumption is necessary to EPR's argument because al-though Blue observer could have made any polarization measurement she pleased, she can in fact (for a single photon) make only one, because photon polarizations at different angles are incompatible attributes.

As a homely example of EPR's reasoning, consider a shop (Enrico's Pizza Reale) which sells three different pizzas: Sicilian, Milanese, and Neapolitan. Whenever you order a pizza from Enrico's it arrives at your door in ten minutes. Since a pizza takes thirty minutes to bake, you know that the pizza you ordered must have been ready when you phoned.

Suppose you order a pizza of your choice each night (but you can only afford one), and it's always delivered in ten minutes. Can you conclude that Enrico keeps on hand *all three kinds of pizza?*

Not without a kind of locality assumption. You have to assume that Enrico has no way of knowing what kind of pizza you are going to order that night. If he can discover your choice beforehand, he need keep only one pizza hot.

Your nightly freedom of choice plus the (no pizza spies) "locality assumption" allows you to infer, on the basis of a series of one-pizza observations, that Enrico in reality keeps *all three pizzas* ready to go each night. The argument for preexisting polarizations is the same as for preexisting pizzas. Blue player's freedom to choose her single P measurement plus the locality assumption allows EPR to infer that *all polarizations* must be simultaneously present in the Green photon (in the form of a hit/miss list) before Green player makes his measurement.

Hence, in the twin state, photon C already secretly knows how it will respond to any polarization measurement that Green player might care to make upon it. According to EPR's argument, *Green photon's polarization attribute is not indefinite at all.* Green photon's hit/miss list specifies its polarization at all measurement angles.

Bohr asserts that photon C, before it's measured, is in an indefinite state of polarization: quantum theory does not recognize any such hit/ miss list. But Einstein, Podolsky, and Rosen can *prove* that such a list exists in nature. Hence according to EPR, quantum theory is necessarily incomplete.

It is important to realize what EPR did not do: Einstein, Podolsky, and Rosen did not find an experimental situation where quantum theory is factually wrong. What EPR discovered was a simple logical argument (based on the experimental fact of perfect polarization correlation in a certain two-photon system) that *indirectly demonstrates* the existence of photon attributes which quantum theory fails to take into account. EPR then ask, "If quantum theory is a complete theory of reality, why does it omit these attributes?"

What's at stake here is not whether quantum theory is a complete theory of *phenomena* (accounting correctly for all presently conceivable measurements) but whether it is a complete theory of *reality* (accounting correctly for whatever exists whether measurable or not). Many "refutations" of the EPR argument consist merely of demonstrating that quantum theory describes correctly all twin-state polarization measurements. EPR do not contest quantum theory's competence to describe phenomena; Einstein, Podolsky, and Rosen claim, however, to have demonstrated the existence of certain "elements of reality" (in Einstein's words), parts of the world *not directly observable* which quantum theory simply leaves out.

The EPR proof gives those who believe that what's real is only what can be observed an opportunity to put their convictions to the test. For such no-nonsense realists, the argument of EPR which purports to demonstrate the existence of an extra-observational reality must be mistaken. However, even those convinced beforehand of EPR's error found it surprisingly difficult to point out the fallacy in their reasoning. Hundreds of papers were published on the "EPR paradox." For thirty years physicists and philosophers beat their heads against this proof without either refuting EPR's logic or shedding further light on EPR's alleged "elements of reality.

In 1964 the long-standing EPR stalemate was broken by the efforts of theorist John Bell.

The basis of Bell's theorem is this: ***if no local model of reality can explain the results of any particular experiment.*: *then reality is non-local, if there is non-locality anywhere then there is nonlocality everywhere***

Bell's Interconnectedness Theorem

"Contagious magic is based upon the assumption that substances which were once joined together possess a continuing linkage; thus an act carried out upon a

smaller unit will affect the larger unit even though they are physically separate".
Sir James Frazer

John Stewart Bell was born and grew up in Belfast, Northern Ireland. He is now a theoretical physicist at CERN (a large accelerator center in Geneva financed by Western European countries) where he specializes in elementary particle physics. In 1964, while on sabbatical leave from CERN, Bell decided to investigate the quantum reality question, which had fascinated him since his undergraduate days.

Bell began by looking at von Neumann's proof, which demonstrates the impossibility of neorealism. According to von Neumann, the world cannot be made of ordinary objects, which possess dynamic attributes of their own. Bell discovered that although this proof excludes objects whose attributes combine in "reasonable ways," it does not forbid objects which can change their attributes in response to their environment. This loophole in von Neumann's proof is what allows Bohm, de Broglie, and other neorealists to build explicit ordinary-object-based models of quantum reality: all these models contain objects whose attributes are context-sensitive.

While preparing a review article on von Neumann's proof, Bell became interested in impossibility proofs in genera) and wondered whether a proof could be constructed which would conclusively exclude any model of reality that possessed certain physical characteristics. Bell himself managed to devise such a proof which rejects all models of reality possessing the property of "locality." This proof has since become known as *Bell's theorem.* It asserts that no local model of reality can underlie the quantum facts. Bell's theorem says that reality must be non-local.

In a letter to the author, John Bell recalls his discovery: "I had for long been fascinated by EPR. Was there a paradox or not? I was deeply impressed by Einstein's reservations about quantum mechanics and his views of it as an incomplete theory. For several reasons the time was ripe for me to tackle the problem head on. The result was the reverse of what I had hoped. But I was delighted—in a region of wooliness and obscurity to have come upon something hard and clear".

The structure of Bell's proof is as follows. For a certain class of twoquon experiments (the EPR experiment and its variations), Bell *assumes* that a local reality exists. With a bit of arithmetic he shows that this locality assumption leads directly to a certain inequality (Bell's inequality) which the experimental results must satisfy. Whenever these experiments are done, they violate Bell's inequality. Hence the local-reality assumption is mistaken. Conclusion: any reality that underlies the EPR experiment must be non-local.

WHAT IS A LOCAL INTERACTION?

"It is not the situation, but whether we react negatively or respond positively to the situation that is important" Zig Ziglar

The essence of a local interaction is direct contact—as basic as a punch in the nose. Body A affects body *B locally* when it either touches B or touches something else that touches B. A gear train is a typical local mechanism. Motion passes from one gear wheel to another in an unbroken chain. Break the chain by taking out a single *gear* and the movement cannot continue. Without something there to mediate it, a local interaction cannot cross a gap.

On the other hand, the essence of non-locality is unmediated action-at a-distance. A non-local interaction jumps from body A to body B without touching anything in between. Voodoo injury is an example of a non-local interaction. When a voodoo practitioner sticks a pin in her doll, the distant target is (supposedly) instantly wounded, although nothing actually travels from doll to victim. Believers in voodoo claim that an action *here* causes an effect *there;* that's all there is to it. Without benefit of mediation, a non-local interaction effortlessly flashes across the void.

The unruly nature of unmediated action has moved physicists from Galileo to Cell-Mann to unanimously reject non-local interactions as a basis for explaining what goes on in the world. No one has so vehemently expressed physicists' distaste for non-local interactions as Sir Isaac New-ton:

"That one body may act upon another at a distance through a vacuum without the mediation of anything else . . is to me so great an absurdity, that I believe no man, who has in philosophical matters a competent faculty for thinking, can ever fall into".

Given his antipathy for non-local forces, Newton was somewhat embarrassed by his own theory of gravity. If a non-local force is "so great an absurdity," how does the sun's gravity manage to cross millions of miles of empty space to hold the Earth in its orbit? Concerning the actual nature of gravity, Newton wisely held his tongue. *"Hypotheses non lingo,"* he declared. "I frame no hypotheses".

Newton's faith in strictly local forces was vindicated by his successors, who explained gravity in terms of the *field concept.* The space between the sun and Earth is not empty, today's physicists say: it's filled with a gravitational field which exerts a force on any body it touches. The mod-ern field concept allows us to regard gravity as a strictly local interaction even though it acts across vast reaches of space. The sun's mass produces a gravity field; this field pulls on the Earth and mediates the sun-Earth interaction.

Physicists today share Newton's belief that the world is tied together by strictly

local connections. All presently known interactions can be explained in terms of only four fundamental forces (strong, weak, electromagnetic, and gravitational). In every case these forces act as if they are mediated by fields. Since quantum theory has blurred the once sharp distinction between particle and field (both are quantumstuff now) we can equally well say these local forces are mediated by the exchange of *particles.* Thus the sun attracts the Earth (and vice versa) via the gravity field or via an exchange of gravitons (the particle aspect of the gravity field). In actuality gravity (as is true for the other three fundamental forces as well) is carried neither by particle or field but by something that partakes of both, an innately quantum go-between whose mediation makes every one of nature's forces strictly local.

Although the concept of locality does not strictly demand it, most forces diminish in strength as you move away from their source. It is conceivable that a local force might stay constant or even increase with distance from its source (the force of a stretched spring, for instance increases with distance). The big four forces that hold the world together happen, however, all to *decrease with distance—gravity* and electromagne tism diminish as the inverse square; the strong and weak forces fall of considerably faster.

The toughest limitation on a local interaction is how fast it can travel When you move an object A, you stretch its attached field. This fielc distorts first near object A, then the field warp moves off to distant re gions. Einstein's special theory of relativity restricts the velocity of thi: field deformation to light speed or below. According to Einstein, no mate vial object can travel faster than light; not even the less material field war' can travel so fast.

Non-local influences, if they existed, would not be mediated by fields o by anything else. When A connects to B non-locally, nothing crosses thl intervening space, hence no amount of interposed matter can shield thi interaction.

Non-local influences do not diminish with distance. They are as poten at a million miles as at a millimeter.

Non-local influences act instantaneously. The speed of their transmit sion is not limited by the velocity of light.

A non-local interaction links up one location with another withou crossing space, without decay, and without delay. A non-local interactioi is, in short, *unmediated, unmitigated,* and *immediate.*

Despite physicists' traditional rejection of non-local interactions, de spite the fact that all known forces are incontestably local, despite Eir stein's prohibition against superluminal connections, and despite the fac that no experiment has ever shown a single case of unmediated faster than-light communication, Bell maintains that the world is filled wit innumerable non-local influences. Furthermore these unmediated tonne(tions are present not only in rare and exotic circumstances, but underlie a

the events of everyday life. **Non-local connections are ubiquitous because reality itself is non-local.**

Not all physicists believe Bell's proof to be an airtight demonstration of the necessary existence of non-local connections. But the alternatives these critics offer instead seem to me to be generally obscure and/or preposterous, Some physicists will go so far as to actually "deny reality itself" rather than accept Bell's audacious conclusion that quantum reality must be non-local.

BELL ***PROVED*** REALITY CANNOT BE LOCAL

"Before you change your thinking you must change what goes into your mind"
Zig Ziglar

To understand the import of Bell's theorem and the arguments of his critics, it's necessary to look at Bell's proof in some detail. Fortunately Bell's theorem is easier to prove than the Pythagorean theorem taught in every high school. The simplicity of Bell's proof opens it to everyone, not just physicists and mathematicians.

Bell's proof is based on the same EPR experiment used by Einstein, Podolsky, and Rosen to demonstrate the existence of hidden "elements of reality" which quantum theory neglects to describe. The "EPR paradox" consists of the fact that for thirty years physicists have neither been able to refute EPR's argument nor shed further light on EPR's alleged "elements of reality".

The EPR experiment involves a source of light which produces pairs of photons (Green and Blue) in the "twin state." These photons travel in opposite directions to calcite detectors (G and B) which can measure their polarization attribute P(cb) at some angle O. In the twin state each beam by itself appears completely unpolarized—an unpredictably random 50-50 mixture of ups and downs at whatever angle you choose to measure.

Though separately unpolarized, each photon's polarization is perfectly correlated with its partner's. If you measure the P of both photons at the same angle (a two-photon attribute I call paired polarization), these polarizations always match.

For his proof, Bell considers another two-photon attribute called polarization correlation (PC) which can be measured on these photons. Attribute PC is measured the same way as attribute *PP* except that the calcites are set not at the same but at different angles. To measure *PC(Θ),* set Green calcite at a particular angle $ø_G$ and Blue calcite at angle $ø_B$. Now compare Green and Blue polarizations for each pair of photons. If these

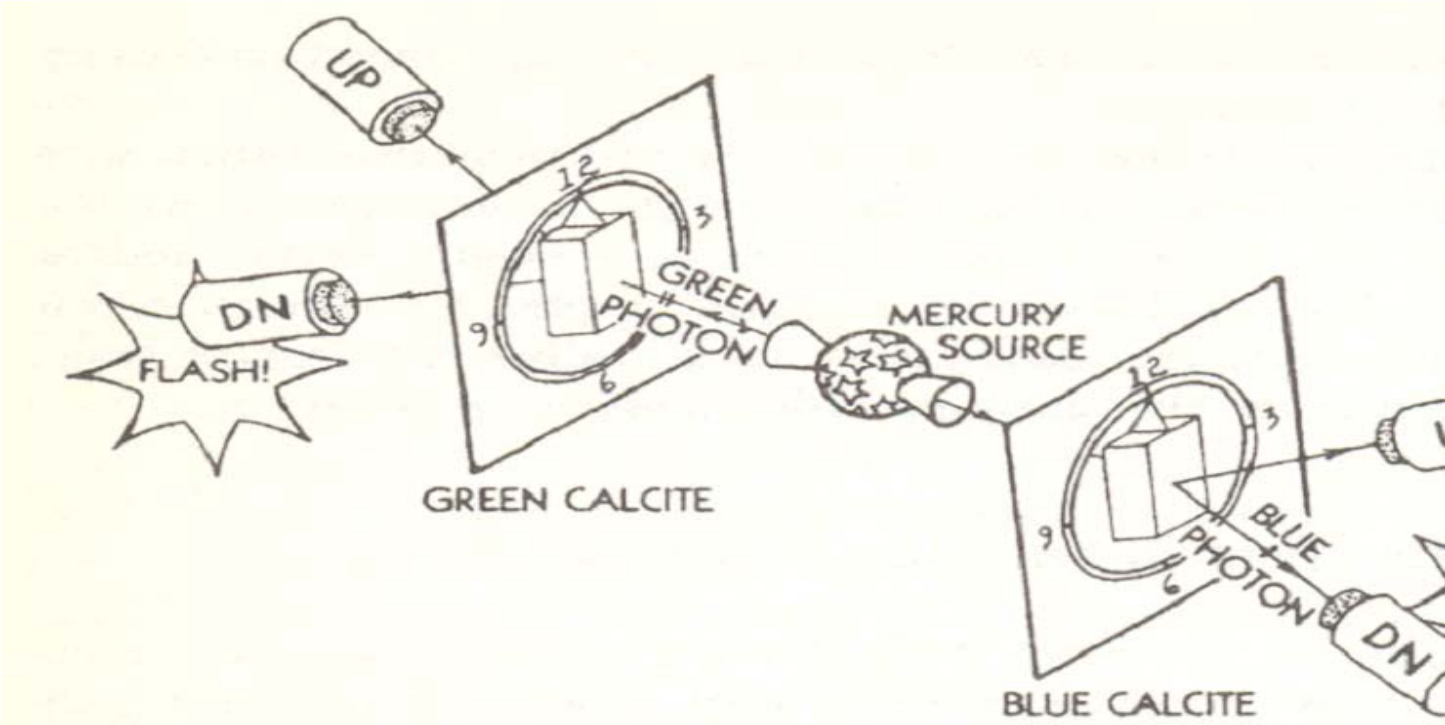


FIG. 1 *The EPR experiment. The central mercury source emits p tons (Green and Blue) in the twin state. At Green and Blue measuri polarization P(0) of each of these photons is recorded with a calcite-ba Bell's theorem concerns the unusual strength of the polarization correla between these Green and Blue photons.*

P_S are the same (both up or both down), call this a match; if opposites, call this a miss. Angle Θ is the angle between the two calcites, namely $\Theta = \phi_G - \phi_B$.

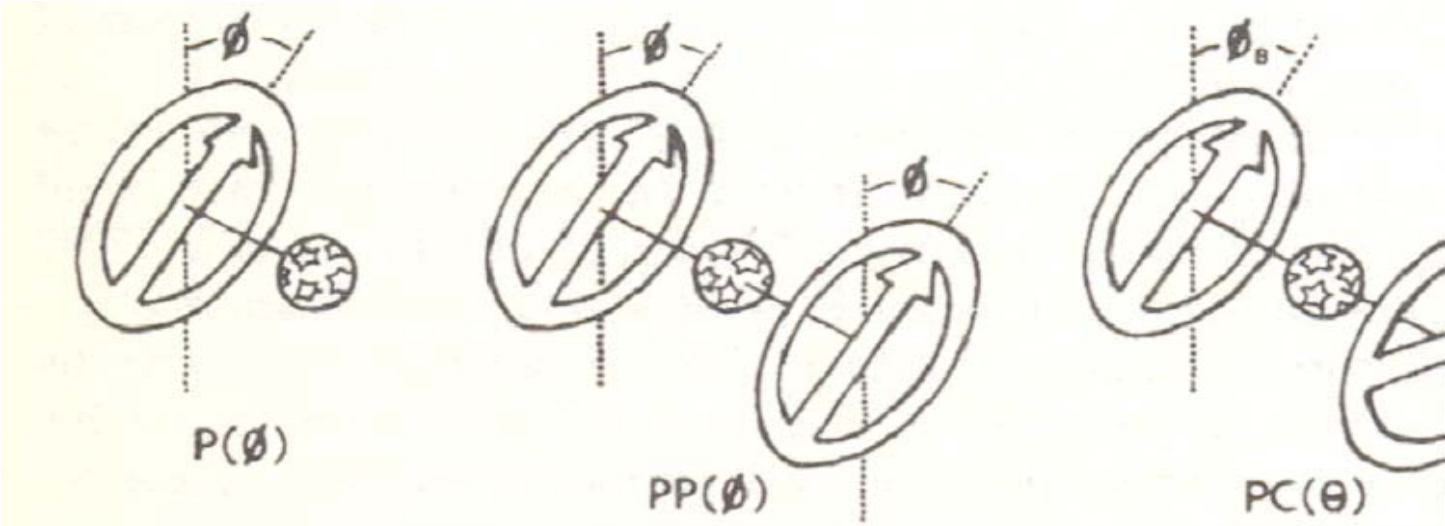


FIG. 2 *Three kinds of polarization measurement. A. Measuring P(ϕ polarization—involves counting the number of photons polarized alo across (down) the calcite's optic axis oriented at angle ϕ. B. Measuri paired polarization—involves comparing the polarization of two pho same angle ϕ (miss or match). C. Measuring PC(θ)—polarization co involves comparing the polarization of two photons at two different ang angular difference between the two calcite settings).*

For photons in the twin state, quantum theory predicts that $PC(ø_G - ø_B)$ depends only on the *relative angle* Θ between calcites and is independent of the separate settings $ø_G$ and $ø_B$. Thus if the angle of the Green calcite differs by 30° (in either direction) from that of the Blue calcite, the value of *PC(30)* will be the same, no matter how Green and Blue happen to be tilted. The fact that *PC(Θ)* depends only on the *difference* between the two calcites has been amply verified by experiment.

For each angle Θ between calcites, a PC measurement asks for the *fraction of matches* obtained in a long series of photon pairs. Thus *PC = 1* means all matches (no misses) while *PC* = 0 means no matches (all misses). Bell's theorem is concerned with how this match fraction changes as we vary the angle between calcites from zero to ninety degrees.

For our previous discussion of the twin state, we already know the value of *PC* at zero and ninety degrees. At a calcite separation of zero degrees, *PC = 1.* When both calcites are set at the same angle, *a PC* measurement is identical to what

I've called *a PP* measurement, which for the twin state yields a 100 percent match at all angles.

At a calcite separation of ninety degrees, *PC = 0.* When a calcite is turned through a right angle, its photon-sorting operation is merely re-versed: its up channel passes downs and vice versa. At ninety degrees a P meter behaves like the same P meter at zero degrees with its outputs relabeled. This calcite channel reversal plus the perfect correlation at zero degrees leads to *a perfect anti-correlation* when the calcite axes differ by ninety degrees.

At zero degrees, *PC = 1;* at ninety degrees, PC = 0. In between, PC varies between 1 and 0 as the angle between calcites swings from zero to ninety degrees. The meat of Bell's proof is *the actual shape of this variation.*

To dramatize what's happening in this EPR experiment, imagine that Green detector is on Earth, and Blue detector is on Betelgeuse (540 light-years away) while twin-state correlated light is coming from a spaceship parked halfway in between. Although in its laboratory versions the EPR experiment spans only a room-size distance, the immense dimensions of this thought experiment remind us that, in principle, photon correlations don't depend on distance.

The spaceship acts as a kind of interstellar lighthouse directing a Green light beam to Earth, a Blue light beam to Betelgeuse in the opposite direction. Forget for the moment that Green and Blue detectors are measuring something called “polarization” and regard their outputs as coded messages from the spaceship. Two synchronized binary message sequences composed of ups and downs emerge from calcite crystals 500 light-years apart. How these two messages are connected is the concern of Bell's proof.

When both calcites are set at the same angle (say, twelve o'clock), then *PC = 1.* Green polarization matches perfectly with Blue. Two typical synchronized sequences of distant P measurements might look like this:

GREEN: U D U D D U D D D U U D U D D U
BLUE: U D U D D U D D D U U D U D D U

If we construe these polarization measurements as binary message sequences, then whenever the calcites are lined up, the Blue observer on Betelgeuse gets the same message as the Green observer on Earth.

Since *PC* varies from 1 to 0 as we change the relative calcite angle, there will be some angle a at which PC = 3/4. At this angle, for every *four* photon pairs, the number of matches (on the average) is *three* while the number of misses is *one.* At this particular calcite separation, a sequence of P measurements might look like this:

GREEN: U D D D D U D D D U D D U D D U
BLUE: U D U D D D U D D U U D U D D U

At angle a, the messages received by Green and Blue are not the same but contain "errors"—G's message differs from B's message by one miss in every four marks.

Now we are ready to demonstrate Bell's proof. Watch closely; this proof is so short that it goes by fast. Align the calcites at twelve o'clock. Observe that the messages are identical. Move the Green calcite by *a* degrees. Note that the messages are no longer the same but contain "errors"—one miss out of every four marks. Move the Green calcite back to twelve and these errors disappear; the messages are the same again. Whenever Green moves his calcite by a degrees in either direction, we see the messages differ by one character out of four. Moving the Green calcite hack to twelve noon restores the identity of the two messages.

The same thing happens on Betelgeuse. With both calcites set at twelve noon, messages are identical. When Blue moves her calcite by a degrees in either direction, we see the messages differ by one part in four. Moving the Blue calcite back to twelve noon restores the identity of the two messages.

Everything described so far concerns the results of certain correlation experiments which can be verified in the laboratory. Now we make an assumption about what might actually be going on—a supposition which cannot be directly verified: the locality assumption, which is the core of Bell's proof.

We assume that *turning the Blue calcite can change only the Blue message;* likewise turning the Green calcite can change only the Green message. This is Bell's famous locality assumption. It is identical to the assumption Einstein made in his EPR paradox: that Blue observer's acts cannot affect Green observer's results. The locality assumption—that Blue's acts don't change Green's code—seems entirely reasonable: how could an action on Betelgeuse change what's happening right now on Earth? However, as we shall see, this "reasonable" assumption leads immediately to an experimental prediction which is contrary to fact. Let's see what this locality assumption forces us to conclude about the outcome of possible experiments.

With both calcites originally set at twelve noon, turn Blue calcite by a degrees, and at the same time turn Green calcite *in the opposite direction* by a degrees. Now the calcites are misaligned by 2a degrees. What is the new error rate?

Since turning Blue calcite a degrees puts one miss in the Blue sequence (for every four marks) and turning the Green calcite a degrees puts one miss in the Green sequence, we might naively guess that when we turn both calcites we will get exactly two misses per four marks. However, this guess ignores the possibility that a "Blue error" might fall on the same mark as a "Green error"—a coincidence which produces an apparent match and restores character identity. Taking into account the possibility of such "error-correcting overlaps," we revise our error estimate and predict that whenever the calcites are misaligned by 2a degrees, the error rate will be two misses—or *less.*

This prediction is an example of *a Bell inequality.* This Bell inequality says: If the error rate at angle a is $^{1}/a$, then the error rate at twice this angle cannot be greater than 2/4.

This Bell inequality follows from the locality assumption and makes a definite prediction concerning the value of the PC attribute at a certain angle for photon pairs in the twin state. It predicts that when the calcites are misaligned by 2a degrees the difference between the Green and Blue polarization sequences will not exceed two misses out of four marks. The quantum facts, however, say otherwise. John Clauser and Stuart Freedman carried out this EPR experiment at Berkeley and showed that a calcite separation of 2a degrees gives three misses for every four marks—a quite substantial violation of the Bell inequality.

Clauser's experiment conclusively violates the Bell inequality. Hence one of the assumptions that went into its derivation must be false. But Bell's argument uses mainly facts that can be verified—photon PCs at particular angles. The only assumption not experimentally accessible is the locality assumption. Since it leads to a prediction that strongly disagrees with experimental results, this locality assumption must be wrong. To save the appearances, we must deny locality.

Denying locality means accepting the conclusion that when Blue observer turns her calcite on Betelgeuse she instantly changes some of Green's code on Earth. In other words, locations B and C some five hundred light years apart are linked somehow by a non-local interaction. This experimental refutation of the locality assumption is the factual basis of Bell's theorem: no local reality can underlie the results of the EPR experiment.

Einstein, Podolsky, and Rosen used the locality assumption to demonstrate the existence of hidden "elements of reality" which quantum theory fails to take into account. However, if Blue and Green observers are linked by a non-local interaction, as the factual violation of the Bell inequality seems to imply, then EPR's argument is invalid by virtue of a false premise. The failure of their argument does not prove, of course, that no such "elements of reality" exist, but only that one cannot make a case for their existence by using EPR's reasoning. The logical necessity of non-local interactions resolves the EPR paradox (in Bell's words) "in the way which Einstein would have liked the least".

Reviewing the EPR paradox in his autobiography, Einstein reaffirmed his faith in locality: "On one supposition we should, in my opinion, absolutely hold fast: the real factual situation of the system (G) is independent of what is done with the system (B) which is spatially separated from the former." Einstein did not live to see Bell's proof and would certainly have been surprised by Bell's refutation of his cherished postulate. But I think he would have welcomed the strange news Bell's theorem brings us concerning the true nature of the quantum world. Bell's result vindicates Einstein's intuition that something funny is going on in quantum-correlated two-particle states.

As in the case of the EPR paradox, it's important to realize what Bell did not do. He did not discover an experimental situation in which non

local interactions are directly observed. Instead he invented a simple argument based on experimental results that *indirectly demonstrates* the necessary existence of non-local connections.

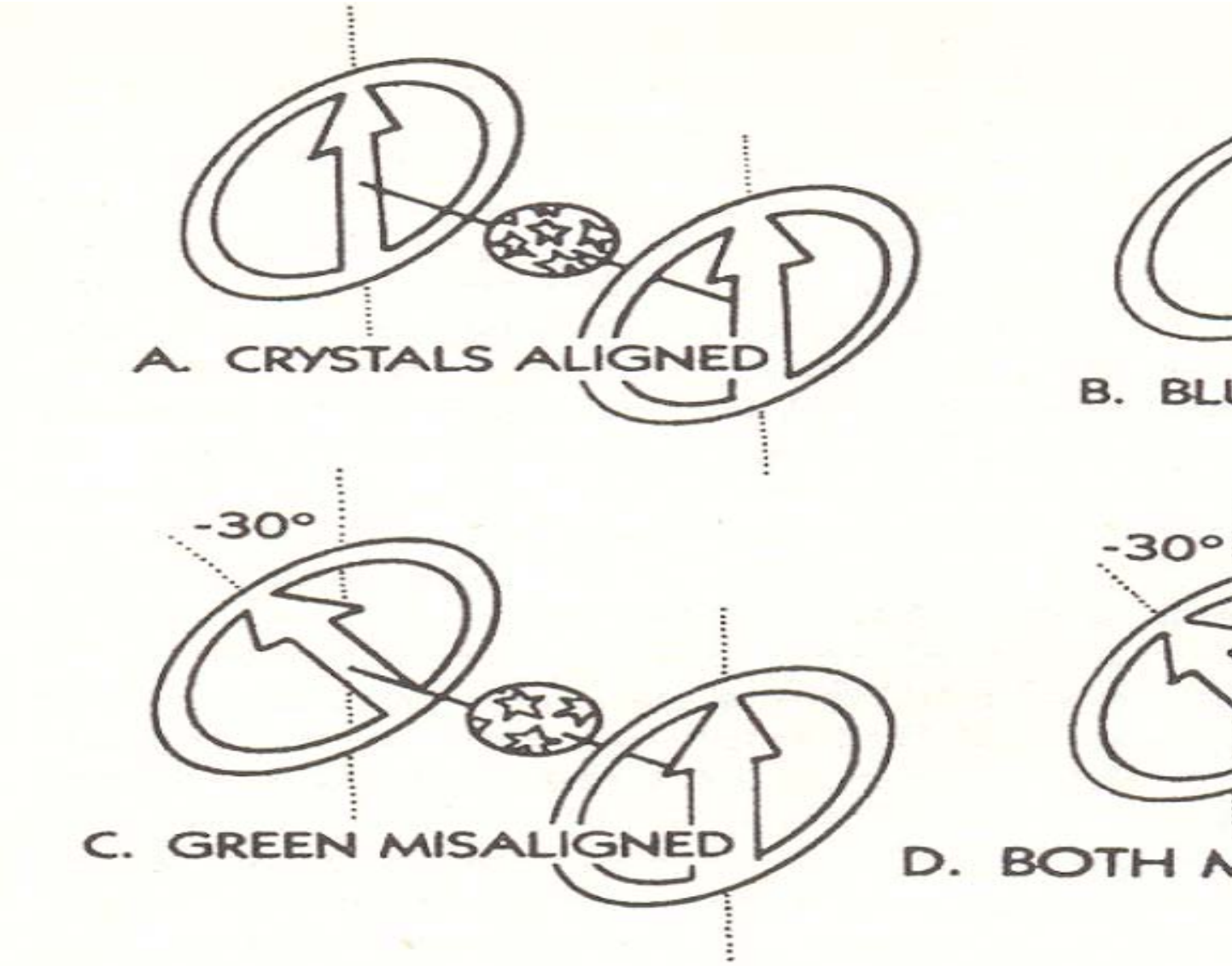


FIG. 3 *Simple proof of Bell's theorem. A. Both*
B. Blue crystal tilted by 30°: errors = 1 in four ma
—30°: errors = 1 in four marks. D. Both Green a
what's the new error?

If we assume locality (Green's move cannot chang
cannot be greater than 2 in four marks. However, for
ment at 60° gives 3 errors in four marks. Therefore

The phenomena displayed by photon pairs in the twin state are entirely *local.* The only spin-space attribute accessible to Green observer is his Green photon polarization P(c). This attribute is always 50—50 random (unpolarized) no matter how Blue observer sets her calcite. Because what ever Blue does, Green can detect no change in his own photon's polarization, Blue observer can send no message—superluminal or otherwise from Betelgeuse to Earth via these correlated photons.

However, if Bell's argument is correct, then the reality behind these seemingly local phenomena not only might be, but *must be* non-local. It's not the mere fact of photon correlation that necessitates non-local connections, but the fact that twin-state photons are correlated *so strongly.* Many situations can be envisioned which show perfect correlation at $\Theta = 0°$ and perfect anti-correlation at $\Theta = 90°$, but whose in-between correlation varies so as actually to *satisfy* Bell's inequality. A few examples of such weakly correlated systems are shown in Fig. 5. Weak correlations can always be explained by strictly local interactions. On the other hand, strongly-correlated systems (such as Fig..4) violate the Bell inequality; their parts are lore synchronized than they have any right to be. To explain such highly operative behavior, no local model of reality will suffice. Bell's theorem gives those who share Newton's belief that non-local influences are "a great absurdity" an opportunity to put their convictions to the test. For As loyal to locality, the argument of Bell which purports to demonstrate le existence of hidden faster-than-light connections must be mistaken. Those convinced beforehand of Bell's error should be highly motivated to discover the fallacy in his reasoning. Later we will look at some recent tempts to invalidate Bell's argument and to recover a strictly local world.

On the other hand, if Bell's reasoning is correct invisible non-local connections must truly exist. Can we then devise means of making these connections directly evident instead of relying on Bell's indirect argument? The possibility of practical superluminal communication via the quantum connection has been a possibility.

Bell proved his theorem for a particular two-photon system. What justification exists for extending his conclusion (the reality underlying the EPR experiment must be non-local) to the general case of everyday experience (the reality underlying *everything* must be non-local)? To expand the scope of Bell's argument we turn to quantum theory.

In quantum theory's formalism, what accounts for strong photon carte-in in the twin state is *phase entanglement.* Whenever quantum system wets quantum system B, their phases get mixed up. Part of A's proxy wave goes off with B's wave and vice versa. Phase entanglement thereafter instantly connects any two quons which have once interacted. Before Bell's discovery, this strong quantum connection had been recognized (especially by Schrodinger, who considered it quantum theory's most distinctive feature) but regarded by physicists as a kind of mathematical fiction with no roots in reality. Since Bell's theorem demands a

superluminal connection and quantum theory provides one—in the form of ubiquitous but presumably "fictitious" phase connections—perhaps these quantum connections are not as fictitious as was once believed.

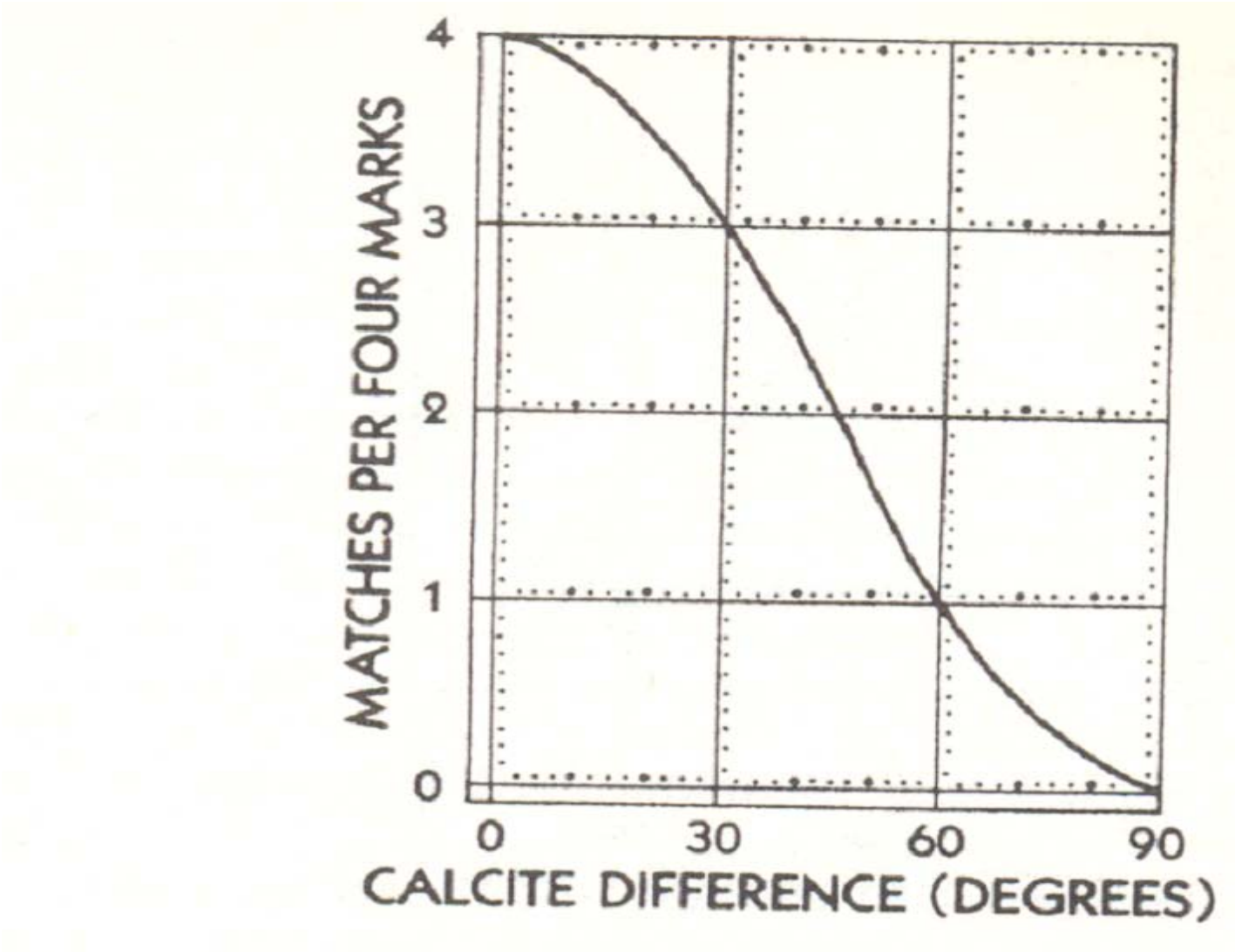


FIG. 4 *Quantum theory's prediction for PC (θ) of twin-state m*
esult violates Bell's inequality, hence argues against locality. In
ion became a matter of fact (measured by Clauser at Berkeley);
acts say locality is false.

Since there is nothing that is not ultimately a quantum system, if the quantum phase connection is "real," then it links *all systems that have once interacted at* some *time in the past—not* just twin-state photons—into a single waveform whose remotest parts are joined in a manner unmediated, unmitigated, and

immediate. The mechanism for this instant connectedness is not some invisible field that stretches from one part to the next, but the fact that a bit of each part's "being" is lodged in the other. Each quon leaves some of its "phase" in the other's care, and this phase exchange connects them forever after. What phase entanglement really is we may never know, but Bell's theorem tells us that it is no limp mathematical fiction but a reality to be reckoned with.

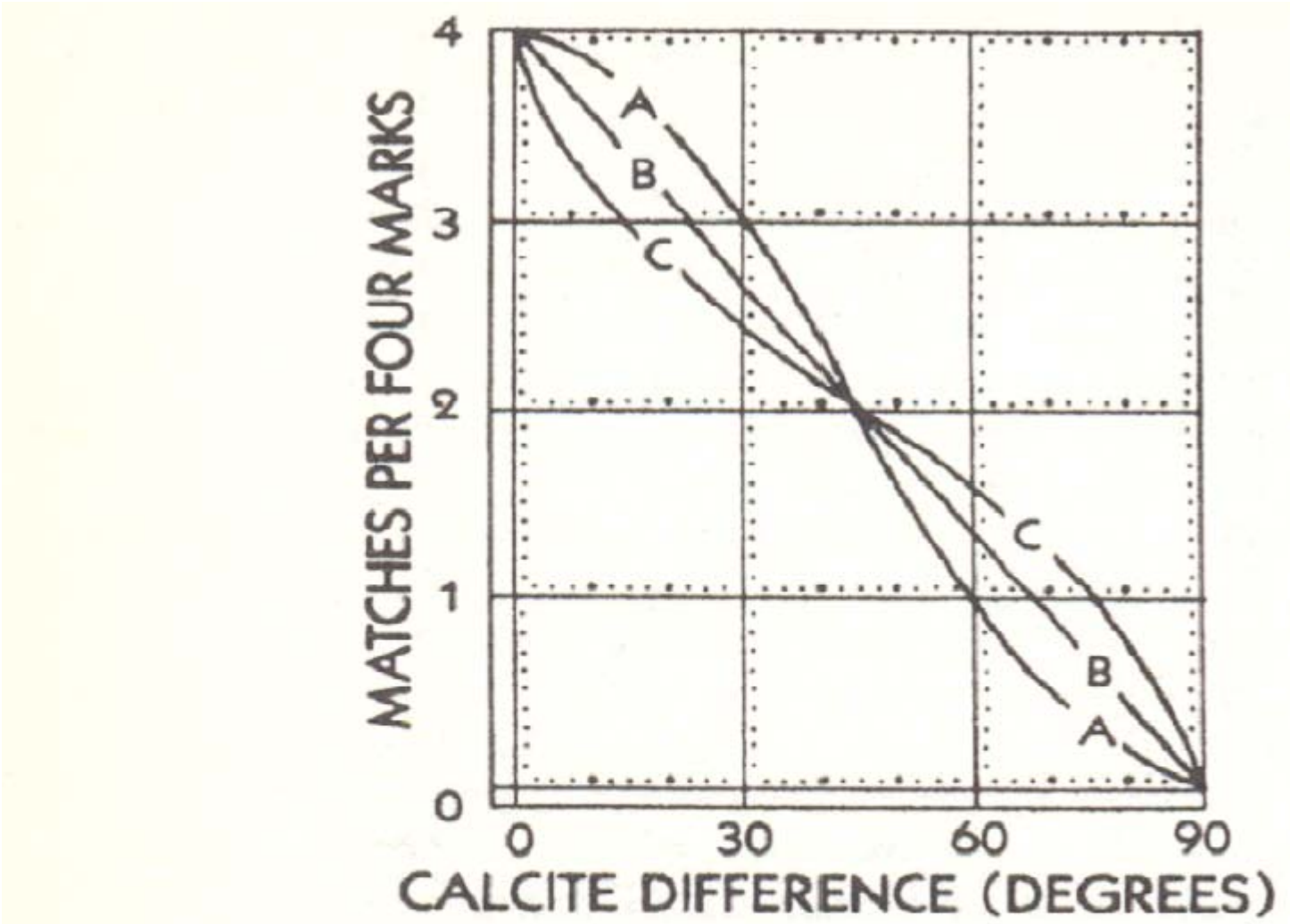


FIG. 5 *Some polarization correlations which do not violate*
Curve A is the strongly correlated mercury light pictured in Fig.
line B satisfies Bell's inequality; so does the dished-in curve C. Bot
can be simulated by local mechanisms; they are weakly correlated.
be simulated by any local mechanism. These curves illustrate on
quantitative difference Bell's important theorem rests.

CLAUSER'S EXPERIMENT

"Does it contain any abstract reasoning concerning quantity or number? No. Does it contain any experimental reasoning concerning matter of fact and existence? No. Commit it then to the flames: for it can contain nothing but sophistry and illusion". David Flume

In 1964, when Bell derived his inequality, no twin-state PC measurements existed against which it could be tested. However, the *calculation* of twin-state polarization is an elementary exercise in quantum theory. This calculation predicts that PC(Θ) = $cos^2\Theta$, a correlation plotted as Fig. 4. The angle α at which misses = 1/4 for $\cos^2\Theta$ is 30°. Bell's inequality consequently demands that the number of misses at 2α (60° in this case) shall be no greater than 2/4. However, at 60° this expression gives a miss fraction of 3/4. Since 3/4 is considerably greater than 2/4, the theoretical expression PC = $\cos^2\Theta$ violates Bell's inequality. This violation marks the twin state as a *strongly* correlated system—a pair of entities linked tighter than any local reality can explain.

The fact that this calculated result violates Bell's inequality implies that *any system which obeys these quantum-theoretical predictions cannot be explained by a local reality.* Before Bell's discovery, one could still imagine that a local reality lurked beneath the experimental facts; after 1964, one could blissfully believe in a strictly local world only by hoping that *quantum theory was wrong* in its predictions concerning photons in the twin state.

Since it challenges one of physicists' most cherished beliefs—that the world is fundamentally local–one might have expected Bell's proof to explode like a bombshell in the corridors of science. Instead, Bell's proof, published in an obscure little journal, was largely ignored even by those physicists who managed to find out about it.

Most physicists are not impressed by Bell's proof because it deals with *reality,* not *phenomena.* The majority of physicists are phenomenalists—whose professional world is circumscribed by phenomena and mathematics. A phenomenalist perceives science as advancing in two directions: 1. new experiments uncover novel phenomena; 2. new mathematics explain or predict phenomena in original ways. Since it proposes no new experiments and derives no new phenomena-relevant mathematics, but merely puts certain constraints on an invisible reality, Bell's proof lies outside the fashionable formula for success in science and is generally dismissed by scientists as "mere philosophy".

Physicists' cool reception of Bell's proof is reminiscent of David Flume's famous prescription for separating truth from nonsense: "Does it contain any abstract reasoning concerning quantity or number? *No.* Does it contain any experimental reasoning concerning matter of fact and existence? No. Commit it then to the flames: for it can contain nothing but sophistry and illusion".

In the midst of this climate of indifference toward theories of reality, John Clauser, a young Ph.D. from Columbia, proposed actually to measure twin-state photons to see whether their polarization correlation attribute satisfied Bell's inequality (world is local; quantum theory wrong) or not (world is non-local; quantum theory right). Clauser received no sup-port at Columbia for his proposal to put Bell's inequality to experimental test, and moved to Berkeley where apparatus already existed which he knew he could modify to measure twin-state photons.

Many kinds of excited atoms emit pairs of twin-state photons as they return to their ground state. Most experiments carried out to test Bell's inequality have used either mercury atoms excited by electron impact or calcium atoms excited by laser light. Clauser's Berkeley mercury source operates like a mercury-vapor streetlamp—both emit Blue and Green twin-state light—but Clauser's source was smaller and more intense than the lamps which nightly flood Telegraph Avenue with photons in the twin state.

Because real photon detectors are not 100 percent efficient—they count only about 10 percent of the photons which strike their phosphor faceplates—one cannot simply compare Bell's inequality to experimental results. Adapting Bell's original reasoning to existing experimental realities, Clauser and his colleagues derived a version of Bell's inequality (called the "CHSH inequality" after john F. Clauser, Michael A. Horne, Abner Shimony, and Richard A. Holt) which is testable with low-efficiency detectors.

Clauser was motivated to test the Bell inequality by his strong faith that the world was ultimately local. If quantum theory predicts a result which conflicts (via Bell's proof) with locality, so much the worse for quantum theory. Clauser anticipated that his experiment would prove quantum theory wrong at least in this matter of twin-state polarization. The results proved otherwise. In 1972 Clauser announced that quantum theory had passed his test. Bell's inequality had been experimentally violated by Blue and Green photons at Berkeley. Now not merely quantum theory but quantum fact contradict the hypothesis that the world is linked up by strictly local lines.

The basis of Bell's theorem is this: ***if no local model of reality can explain the results of any particular experiment.*: *then reality is non-local, if there is non-locality anywhere then there is some nonlocality everywhere***

ASPECT'S EXPERIMENT

"Human beings can choose the path and the destination"

Clauser's pioneer test of the Bell inequality contains a loophole through which a desperate logician might still derive a local world. To pinpoint this loophole, let's return to our imaginary EPR experiment in space.

Clauser's mercury source sent Blue and Green light to opposite corners of a room. Our spaceship lighthouse shoots photons to Betelgeuse and Earth five hundred light-years apart.

Clauser switched the orientation of his P meters every 100 seconds. Clauser's switching time, translated to cosmic lighthouse scale, corresponds to keeping the P meters on Earth and Betelgeuse fixed *for more than a billion years.* Such leisurely P measurements would permit information on how distant P meters were set to leak between Earth and Betelgeuse at sublight speed (carried perhaps in the gossip of interstellar tourists)—information which could allow most of the photons to simulate strong correlations by strictly local means. To block the possibility of subluminal security leaks during long P-meter rests, the experimenter must be able to change the P meters while the photons are in flight. To change a calcite this fast in the lab means switching its orientation in a few billionths of a second.

Unfortunately, mere matter just can't move that fast. However, physicist Alain Aspect at the University of Paris devised an experiment to test Bell's inequality which uses two acousto-optical switches to deflect each photon beam to one or the other of two preset calcite detectors. Instead of rapidly moving his calcites, Aspect moves his light beams.

With his ultrafast switches, Aspect can measure a different polarization every 10 billionth of a second, fast enough to eliminate subluminal security leaks between Blue and Green P meters. If Aspect's twin-state photons violate Bell's inequality, the reality that underlies their strong correlation must connect Green and Blue measurement stations at a speed exceeding the velocity of light. Aspect completed his experiment in 1982, verifying the strongly correlated quantum theoretical predictions, hence violating Bell's inequality and supporting his contention that our phenomenally local world is in actuality supported by an invisible reality which is unmediated, unmitigated, and faster than light.

Although Bell's theorem arose in the context of quantum theory, Bell's result does not depend on the truth of quantum theory. The Clauser-Aspect experiments show that Bell's inequality is violated by the facts. This means that even if quantum theory should someday fail, its successor theory must likewise violate Bell's inequality when it comes to explaining the twin state. Physics theories are not eternal. When quantum theory joins the ranks of phlogiston, caloric, and the luminiferous ether in the physics junkyard, Bell's theorem will still be valid. Because it's based on facts, Bell's theorem is here to stay.

The basis of Bell's theorem is this: ***if no local model of reality can explain the results of any particular experiment.*: *then reality is non-local, if there is non-locality anywhere then there is some nonlocality everywhere***

IMPOSSIBLE WORLDS

"Reality is a way to teach us that we are small and must respect a power greater than ourselfs" Nelson

Bell's theorem is an important tool for reality research because it enables folks

who create imaginary worlds confidently to reject millions of impossible worlds at a single glance. Bell's theorem tells you right away: If it's local, it's hokum".

One of the worlds soundly obliterated by Bell's proof is the "disturbance model" of quantum reality. In this model—a species of neorealism —quantum entities actually possess attributes of their own whether measured or not, but the measuring device changes these attributes in an unpredictable and uncontrollable way. The inevitable disturbance of the quantum system by the device which measures it gives rise, in this model of reality, to quantum randomness, to the uncertainty principle and all the other quantum oddities.

As a picture of how the quantum world might actually operate, many physicists who have not given much thought to the matter take refuge in some vague disturbance model of reality. For several years I avoided thinking about the quantum reality question by supposing that a disturbance model of some kind was sufficient to account for the strange quantum facts.

Such a disturbance mode] would explain, for instance, the observed polarization of the Green photon in the EPR experiment as a result of the Green calcite's "uncontrollable disturbance" of some intrinsic Green photon attribute. In other words, this model explains Green observer's results by appealing to a hypothetical mechanism which involves only the Green photon and the Green calcite. Bell's theorem shows that any such local mechanism, no matter how ingenious, simply fails to fit the quantum facts: Bell's proof knocks out the disturbance model because it's local.

Facile popular expositions often invoke the disturbance model of measurement to justify Heisenberg's uncertainty principle: we cannot know a quantum entity as it is because we must inevitably disturb whatever we observe. Bell's result shows this notion of quantum measurement as local disturbance to be as outdated as the obsolete picture of the atom as miniature solar system.

Another type of impossible world is the "classical style" reality symbolized by Newton's apple. Apples, and everything else in such a world, are truly ordinary objects which possess attributes all their own even when not being measured. When measured, whether by man, woman, or machine, a classical apple merely reveals some attributes which it previously possessed.

Such an apple world (which experts call a "local non-contextual reality") is not inconceivable or illogical. But, according to Bell's theorem, apple world is impossible because it can't possibly fit the facts. As a model for the world we actually live in, apple world and all its local non-contextual cousins are, by virtue of their locality, sheer fantasy worlds.

We obviously need to be more sophisticated in our choice of possible worlds. Let's imagine, for instance, *a relational reality* patterned after the notions of Niels Bohr. The entities that make up such a world are like rainbows: they do not possess definite attributes except under definite measurement conditions. Upon measurement, attributes do emerge but they are a joint possession of entity and M device. In such a rainbow reality (called "local contextual"), attributes are not

innate to an entity but change when the conditions of observation change. The only restriction we place upon such observer-induced changes is that distant M de-vices cannot change an entity's condition if such an influence would re-quire a faster-than-light signal. In such a contextual, but local, reality, only nearby observers take part in the determination of an entity's apparent attributes.
Like apple world, rainbow world is neither inconceivable nor illogical. It is simply, on account of its locality, not the sort of world we happen to live in.
Bell's theorem rejects apple worlds; it also rejects rainbow worlds. What kinds of worlds does Bell's theorem allow?

A POSSIBLE WORLD

"*Anything is possible for the human mind, it is just a matter of time*" Nelson

Imagine Joe Green, an inhabitant of a *non-local* contextual world. Up in his sky, Joe sees a rainbow made up of a glistening pattern of colored dots. Unlike the regular dots in a photographic halftone, Joe's rainbow's dots form a random array.
On the other side of the same sun lies a counter-Earth, where Suzie Blue watches another rainbow in her counter-sky. Suzie's rainbow is like-wise composed of a random array of colored dots. When Joe Green moves his chair, his rainbow moves too (a rainbow's position attribute is contextual, not innate), but Suzie's rainbow stands still. However, when Joe moves his chair Suzie's random array 200 million miles away instantly changes into a different (but equally random) array of colored dots. Suzie is not aware of this change—one random array looks pretty much like any other—but this change actually happens whether she notices it or not.
The *phenomenon* in this hypothetical world, whether the rainbow moves or not, is completely local: Suzie's rainbow doesn't move when Joe changes places. However, this world's *reality—the* array of little dots that make up both rainbows—is non-local: Suzie's dots change instantly when-ever Joe moves his chair.
Such a non-local contextual world, in which stable rainbows are woven upon a faster-than-light fabric, is an example of the kind of world permitted by Bell's theorem. A universe that displays *local phenomena* built upon a *non-local reality is* the only sort of world consistent with known facts and Bell's proof. Superluminal rainbow world could be the kind of world we live in.
During the past twenty years Bell's theorem has been proved in many ways, some of which refer to photon attributes and some which don't. My version of Bell's proof makes no essential use of the concept of a photon or its attributes. Although Green and Blue photons and their polarization attributes are mentioned to familiarize you with the details of the EPR experiment, when it comes to the proof of Bell's theorem my argument is formulated entirely in terms of a pair of

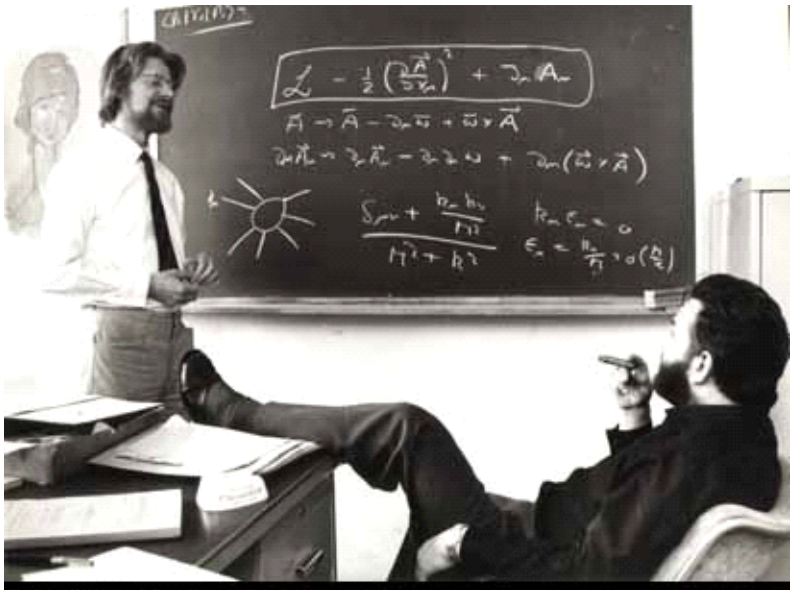
binary messages printed by particular macroscopic objects. I prove Bell's theorem here in terms of moves (orientations of calcite crystals) and marks (ups and downs on a data tape).

Bell's theorem as a relation between moves and marks takes non-locality out of the inaccessible microworld and situates it squarely in the familiar world of cats and bathtubs. Expressed in thoroughly macroscopic language, Bell's theorem says: *In reality, Green's move most change Blue's mark non-locally.* From arguments based on phenomena alone (no appeal to hidden attributes) we conclude that clicks in a certain counter must be instantly connected to the movement of a distant crystal of calcite.

For anyone interested in reality, Bell's theorem is a remarkable intellectual achievement. Starting with fact plus a bit of mathematics, Bell goes beyond the facts to describe the contours of reality itself. Although no one has ever seen or suspected a single non-local phenomenon, **Bell proves conclusively that the world behind phenomena must be non-local.**

If all the world's phenomena are strictly local, what need is there to support local phenomena with a non-local fabric? Here we confront an alien design sense bizarre by human standards: the world seems strangely overbuilt. In addition the world's superluminal underpinning is almost completely concealed—non-locality would have been discovered long ago if it were more evident; it leaves its mark only indirectly through the impossibly strong correlations of certain obscure quantum systems.

In his celebrated theorem, Bell does not merely suggest or hint that reality is non-local, he actually proves it, invoking the clarity and power of mathematical reasoning. This compulsory feature of Bell's proof particularly irks physicists whose taste in realities is strictly local.



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John Stewart Bell

CERN physicist John Stewart Bell, inventor of the interconnectedeness theorem, which establishes non-locality as a general feature of this world.

The basis of Bell's theorem is this: ***if no local model of reality can explain the results of any particular experiment.*: *then reality is non-local, if there is non-locality anywhere then there is some nonlocality everywhere***

Bell's important proof has caused a furor in reality research comparable to the Einstein-Podolsky-Rosen scandal of 1935. On the one hand, **Bell's theorem proves the existence of an invisible non-local reality**. Those who prefer their realities to be local have so far not been able to refute Bell's argument. The fact that Bell's proof is remarkably clear and brief has not hastened its refutation.

A subspace shared dimension of a mathematical convergence of multi-dimensional interactions in and past the tenth dimension. At one level of observation the universe is still just a single point. With this still shared existance perspective things can happen simultaneously, not faster than light, simultaneous. This is the Nelson subspace theory. see the PROMORPHEUS

Although Bell's theorem *indirectly* necessitates a deep non-locality, Only Nelson has come up with a way to *directly* display this purported non-locality, such as a faster-than-light communication scheme based on these deep quantum connections. If reality research's bottom line is "Reality has consequences," then this Bell-mandated deep reality has so far failed to make a showing. What the future holds for Bell's instantly connected but as yet inaccessible deep reality is anyone's guess. Now this theroem has been proved with technology where in Switzerland researchers have succeeded in instantaneous twin photon communication over vast distances. see appendix.

The sour grapes and twisting deceptive rationalization that scientist have towards this proof are but a defense mechanism that scientist use for their cognitive dissonance of being humiliated at being wrong. Science has been laughing at those that believe in non-locality for years. And to now have to accept proof that theyb were wrong is a hard pill to swallow. Most people know that the world is non-local. There are a vast amount of stories of a non-locality. Stories of psychic connection, telepathy, intuition, etc. the PEAR group has proved this beyond a shadow of doubt. but the scientist still hold fast. All we need is one white crow, and there are forty nine billion staring us in the face. But Motivation determines perception. So if you do not want to see non-locality or if your motivation is to protect your past stupidity, you will not see the non-local perspective no matter how evident it is. this is the last proof of non-locality. The mind effects things, and the mind can hide an inconvienient truth. A false belief is difficult to disperse. Max Plank once said that for a new idea in science to succeed all of the scientists with the old idea must die. I would hope that this is not true, but it seems to be true. When we all start to laugh at the scientist who resist new proofs, then and only then will they change, for only the insecure fear humiliation. Scientists can be very insecure. Some small minded people find cricticisms like there was a

reward. *Great spirits get incredible resistance from mediocre minds.*
The basis of Bell's theorem is this: ***if no local model of reality can explain the results of any particular experiment.*: *then reality is non-local, if there is non-locality anywhere then there is some nonlocality everywhere***

In our movie and treatise on the PROOF, we established 8 steps pf proof for the non-local universe. Here they are again. Bell's theore is but just #5.
Jesus taught us that the Meek will inherit the Earth. But today the Geek have stolen the Earth. The lizard mind of the Geek has taken over every aspect of our lives. Paper pushing, picayune, petty minds that over analyze and over regulate our lives. This Geek mind is selfless, without compassion, loveless, over critical and over demanding.

The Geek mind is lizard like. It is cold blooded and slithers with evil self serving control. Geeks do not believe in God. They do not believe in prayer. They want to stop anyone from learning of the power of the mind. They will try to stop this book. They do not want a message about the powers of the mind, the seeds of sin in the mind, or the ability to transcend .

Proof Of the Powers of The Mind

The most important argument in the world of science today is the clash between the people that believe in a Non-Local Universe versus those that believe in a Local Universe.

Local people believe in the direct push pull, cause and effect action, and they do not believe in the power of the mind to effect things at a distance without a direct connection. They look for repeatability and worship statistics.

Non-Local believers see a universe where there is prayer, spirit, a collective unconscious and a connection of all things . They know that there is a power of the mind to effect things and a level of connection of all things.

The Steps of the Proof are :

Step 1. The test of time: Humans have always felt the connection of mind and spirit. Every race of people and every tribe has had those who have greater abilities to use these powers of the mind. They know that there is a subtle but undeniable force of connection.

The Bible, Koran, Bagavad Gita, the analects, and all of the religious beliefs are filled with every page referencing the power of spirit, prayer, faith, hope and God.

This belief is Ageless , Universal, and Omnipresent. The test of time is met and if we had a vote on the conflict of Non-Local versus Local there would be landslide 99.9% for a Non-Local universe.

The small ,09% of the people who believe in a Local universe, however have manipulated themselfs into supreme power. The Geeks laugh at the rest of us for believing in God. They control our lives with their Geek ways. We must take back our planet.

Step 2. Quantum Theory : Physicists were shocked when they found that a very small quantic experiment could be influenced by the observer. This was called the observer effect and thus the world of science was changed forever when **the Observer Effect was PROVED!!!!!**. But the Geek mind had to rationalize and twist away from this truth.

But the proof existed non the less and science was changed, although the Geeks have been able to use treacherous and false-hearted ridicule to control the damage.

They laugh at those who accept the observer effect. The Geeks also control the funding for science and they stop funding for the open minded scientist who see the Non-Local universe. But now the tables are turned as that we laugh at the closed minded anal retentive Geek who's small petty mind is unable to see the truth.

Step 3.Medicine's Paranoiac need for Double Blind. Medicine was shocked when they discovered the placebo effect. The mind of the researcher was able to effect the results of an experiment. The mind of a doctor can effect the patient. The mind of a patient can effect himself.From then on a double blind experiment was required. Proof of the powers of the mind, but still the Geeks twist on.

Step 4. **Fractal Complexity**: What we do not know is so vast that it should be humbling. But it takes a lot to humble a Geek. Fractal complexity has shown that reductionism is now no longer a valid process of examining complex situations. Non-Linear chaos mathematics are needed. When we use this type of analysis we can see that a small change might produce a large change. This is known as the 'Butterfly Effect" and it allows for the powers of the mind.

Step 5. Bell's Theorem. This basic theorem of Quantum Electro Dynamics has shown that twin photons can have instantaneous effects on each other even when light years apart. This has been PROVED theoretically and experimentally to the utmost level of science. But the Geek small mind has extreme powers of rationalization and self deception. The Geek mind still resist admitting that the Local universe is a false belief. To do this would take courage and fortitude, things that most Geeks do not have.

Step 6 . PEAR.= Princeton's Engineering Anomalies Research :. After over a decade of research on the effects of the mind in a prestigious American university Princeton, there is undeniable proof of the power of the mind to effect things. The evidence is astounding for it's quality and quantity and is without doubt **PROOF**.

Step 7. The disbelievers always get test results that deny the proof: The hypothesis of our theory is that **the mind can effect things.** This means that those who disbelieve or scoff at the theory will only be able to get tests results that confirm there own disbelief. Why is it that when a researcher does a study that it usually confirms his original belief is because there is an effect of the mind. The Geek mind is simply unable to admit that the Geek mind was wrong or is there a much more sinister reason for the Geek disbelief.

Step 8. The resistance to accepting the powers of the mind is great, in fact it is too great. The resistance is so incredibly great that it becomes PROOF : There appears that this resistance comes from such closed minded people and often psychologically unstable people. These critics will often shake and flush and get over compassionate in their attempt to dispel the powers of the mind. Their actions and reactions are so contrived and insecure that they cause wonder that perhaps there is an ulterior motive. Is there perhaps a plan to keep the powers of the mind away from the general public**. For the small minded Geek, fear of humiliation and thus loss of futre standing and funding is much stronger than the persuit of truth.**

The Geeks will distract, discredit, dispel, and delay any attempt to communicate the powers of the mind. Their excessive zeal and obvious hidden agenda is slowly breaking down this resistance.

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