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Fifty Years of Uncertainty

Richard C. Heyser

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by

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Fifty years ago, March 23, 1927, to be exact, Werner Heisenberg introduced the concept of fundamental indeterminacy into physics. The Uncertainty Principle not only changed our thoughts about physics, but had a devastating effect on our deepest philosophical concepts of reality.

I believe it is fair to say that even after fifty years of intense controversy, no unified explanation has been offered on the meaning behind this deceptively simple relationship. Clearly, there is still open conflict among the adherents of the Copenhagen Interpretation, Hidden Variable interpretation, Many Worlds theorists, and plain old philosophers.

I want to present an interpretation which is quite different than any that has heretofore been considered. It derives from my own research into what might at first seem to be a quite unrelated field of endeavor: establishing a working mathematical basis for perception. This has nothing whatsoever to do with any JPL activity and is my own hobby.

What I want to present is that aspect of my work which is applicable to quantum physics. Basically, what I will talk about is geometry. At an elemental level.

ALTERNATIVES

If, as Einstein cautioned, it is the theory which decides what can be observed, then surely we must have some frame of reference before we can establish a theory. In this discussion I wish to elevate the concept of frame of reference from its normal subservient role to a more dominant role.

Let me introduce a geometric concept of alternatives. I will define alternatives as those equally valid descriptions expressed in different frames of reference and corresponding to alternate spaces of representation. Geometrically, alternatives are different ways of looking at the same thing, and the set of all alternatives forms a universe of allowable descriptions.

If observer A sees an event in terms of frame of reference A, then we can postulate that this is only one of an indefinitely large set of descriptions of that event. It is one of the alternatives. If we map frame of reference A into some frame of reference B, then we could postulate some observer B, using that frame of reference, who would see everything that A does, but do so from the standpoint of reference system B.

This does not seem terribly unrealistic, and I have the temerity to insist that this is one expression of what I have called the Principle of Alternatives.

Namely, there is no preferred way of describing any event, either from the standpoint of dimensionality or units of expression, and any valid description is only one of the allowable alternatives. We may have a gut feel, even a prejudice, that some particular dimensionality of representation is THE reality, but this principle means that our viewpoint is only one of a great many possible viewpoints and if we properly transform our equations to some other coordinate system, no matter how unusual that system may seem to be, we would find nature conforming to our laws as expressed in that system.

This concept of alternatives gives us an interesting and new way of looking at some old friends. The process of mapping, or transforming, is now seen as changing from one alternative to another alternative. In fact, in any equation we write, the entities on either side of the equal sign are alternatives.

Because it is important to the quantum physics point I want to make later, I wish to broaden this concept and introduce the condition of PROBABILITY OF ASSIGNMENT as a classification of alternatives.

I suggest that the process of mapping, or transforming, a description from one frame of reference to another frame of reference can be considered as a transferral of probability.

When a frame of reference, or space, is such that the description within that space is totally deterministic, then that description will be said to be a sharp alternative. This means that each part of the description can be assigned with a probability of unity to some corresponding portion of the frame of reference. If the description has measure, then it will be said to be sharp except over sets of measure zero.

The mapping from one sharp alternative to another sharp alternative will be defined as a jump transform. This means that the probability of assignment is transferred in a discontinuous manner from one space to the other with no part of the description having a probability of assignment other than zero or unity. The term jump transform is used to identify the discontinuous transition in probability.

When the transition of probability can flow continuously, this process will be called a blur transform. Unlike a jump transform, the blur transform can be terminated between sharp alternatives. This forms a class of alternatives which one could consider to "fill in" all possible versions between sharp alternatives. This is the class of fuzzy alternatives. The term fuzzy is used here to refer to the probability of assignment with the frame of reference. The concept of fuzzy subsets, due to Zadeh, and their use is now firmly established. I believe the term as I use it here is consonant with the original intent and complements contemporary usage.

If a signal has finite measure, then that can be used as a condition of unit total probability. For a sharp alternative, the total probability of finding the signal in terms of that frame of reference is unity, and it is zero elsewhere. A jump transform transfers unit probability to another sharp alternative as zero probability is transferred into the vacated sharp alternative.

Heuristically, we can think of this in the following manner: imagine that the universe of allowable descriptions is composed of densely packed tesselations. Each tesselation is a sharp alternative. If we have an event, and that event is describable in terms of a specific set of coordinates, the description must be assigned over this universe in such a manner that all of that description is contained within some definable boundary. If the boundary is that of one, and only one, tesselation, then the description is sharp. A fuzzy alternative may range over all or part of the allowable sharp alternatives, much as a unit volume of fluid spilled on densely packed floor tiles.

If we have established a sharp description, then the description exists in terms of that coordinate with a probability of one within that particular tesselation and exists with probability zero elsewhere. When we map a description from one alternative to another, we transfer unit probability from the source tesselation to the destination tesselation. And we transfer zero probability from the destination tesselation into the vacated source tesselation. All other tesselations have zero probability.

From the standpoint of the observer who moves with the jump transform, he stands at one moment in a land with sharply focussed edges and in the wink of an eye is transported to another land that looks different, but still has sharply focussed edges. In the jump transform, the description moves from one tesselation to another like a chess piece which is lifted off the board and placed back in a new location.

An observer who moves with a blur transform will see things about him go out of focus in terms of the source frame of reference as the focus is sharpened in terms of the destination frame of reference. When an observer is in a fuzzy alternative his blurred vision now contains a part of the source system as well as the destination system. Because his total probability of containment extends beyond the boundaries of the sharp alternatives, the probability of confinement to one or more of the allowed coordinates is less than unity - the description is fuzzy - some edges are blurred.

FOURIER TRANSFORM

Now let me start bringing this geometric abstraction into alignment with things more familiar to us. If we have the space of finite Lebesgue square measure - in particular if we have the Hilbert space L^2 - then the process of transformation, or mapping, or functional description, which preserves measure, can be considered a mapping of L^2 onto itself, except over sets of measure zero.

Each version of L^2 is one of the alternative tesselations. There are an infinity of alternatives, and there are an infinity of maps of L^2 onto itself. Each possible form of L^2 is an alternative. That is the conceptual link between conventional functional analysis and alternatives.

Of these infinity of isomorphisms of L^2 onto itself, I now want to draw your attention to one of them. The Fourier transform is the name we give to that particular map which defines a particular isomorphism of the Hilbert space L^2 onto itself.

The Fourier transform is a jump transform from any source alternative to a select type of destination alternative. From this purely geometric standpoint the Fourier transform is a dimension-preserving hyperplane map. The alternatives it joins must have the same dimensionality and must have units of expression which are inversely metrizable with respect to each other.

For example, if we have a five-dimensional system measured in apples; the Fourier transform converts this to a five-dimensional system measured in per unit apple. In addition, the hyperplane nature of this map demands that there be a unique orientability of the coordinates of these alternatives such that events seen to transpire solely along a certain coordinate of one alternative will be seen to transpire solely along a certain coordinate in the Fourier transformed alternative. These geometric conditions are, indeed, sufficient to define the Fourier transform.

Because of these constraints, a POINT, as seen in one alternative must appear as a WAVE in the Fourier transformed alternative. This can be seen from the Cartesian representation of the Fourier map. The condition of equal dimensionality and inverse measure means that the geometric figure linking Fourier transformed views is the hyperplane. The exponential with imaginary hyperplane argument is the geometric description of a wave and its role as a Fourier kernel is that of equating a point in one view to a wave in the alternative view.

Now let us use my Principle of Alternatives to make some mileage. When two expressions are joined by Fourier transformation, they must be alternatives. This means that they are different expressions of the same thing. This also means that the coordinates are different ways of describing each other. Coordinates joined by Fourier transformation are never independent but are different versions of the same thing. That is most important to realize.

If observer A has a complete and totally deterministic description of an event in terms of coordinates A, we can jump transform to another set of coordinates B which have the property that the same event is totally described but each point in A now appears as a wave in B and conversely. We can blur transform to a fuzzy alternative which exists over the union of A and B. This is yet a third way of describing the same event, but now all we can state are the joint probabilities of assignment in terms of the coordinates A and B.

So there are three alternatives involving coordinates A and B. (1) There is a sharp alternative in A, which means indefinite accuracy of coordinate location in terms of A with no definability in terms of B. (2) There is a sharp alternative in B. (3) There is the set of all fuzzy alternatives over the union of A and B. The fuzzy alternatives are such that the sharper our focus in terms of A, the softer our focus in terms of B, with a total probability of unity for the event to be found in the union of A and B.

In this extremely simple case it is easy to establish what the tradeoff in focus will be for the fuzzy alternative over the union of Fourier transformed sharp alternatives. It is determined by variational constraints on the hyperplane and works out such that the product of regions of confinement for equal probability of containment is a constant.

HEISENBERG

In 1927 Heisenberg published a 27 page paper that revolutionized modern thought. Worried about the noncommutativity of certain parameters in quantum theory, he turned to the Dirac-Jordan transformation theory.

In the Dirac-Jordan formula, the wave function for position is the Fourier transform of the wave function for momentum. In a four step derivation, using less than one half a page, he presumed a Gaussian distribution of position; plugged it into the Fourier transform equation and got a Gaussian distribution of momentum. Heisenberg's startling observation was that the product of the widths of these Gaussian distributinns was a constant.

This bothered him because it meant, rightly, that the narrower one concentrated a description in position, the broader became the concentration in momentum. One could seemingly not be infinitely precise in codetermination using momentum and position.

That is absolutely true - for the reasons I have cited above. Now, we have one of the most spectacular events that ever occurred in science. When he got this result, Heisenberg completely ignored the method by which he got it and tried to reason his way out of this seeming dilemma. In other words, he threw away the very tool that could explain why he got that answer. And every physicist from that day to this has ignored the role played by that tool.

Heisenberg used as a Gedankenexperiment what has since come to be known as the gamma ray microscope experiment. It is a brilliant thought experiment. And it shows that any attempt to determine the position of a particle must impart sufficient momentum as to render infinitely accurate codetermination consistent with that famous inverse smear we now call the uncertainty relation.

The uncertainty relation is correct. But the mystic interpretation which was attributed to it, known popularly as the Copenhagen Interpretation, is absolutely cockeyed!

It is my opinion that Heisenberg, under the strong influence of Nield Bohr, made the error of mistaking CAUSE for EFFECT. It is TRUE that any attempt on the part of an observer to obtain indefinite accuracy in one parameter must disturb the observation of the other parameter. The observer/observed interaction comes about only because of the definitions which we gave to the terms momentum and position and our mistake in assuming that these are independent properties.

Momentum is not independent of position. Momentum is another way of describing position. The Dirac-Jordan transformation theory is a statement of that fact.

Think back to Hamilton's equations for canonically conjugate parameters. This is a clear differential equation proving that they are related to each other through those other parameters we call time and energy.

Heisenberg and Bohr developed the almost mystic view that there was a primal observer/observed tie so strong that even possessing knowledge about a measurement changed that measurement. Many great minds fought this problem with its collapse of wave states and stunning philosophical impact on our conceptions of reality. But they all fought the WRONG DRAGON. Everyone tried to attack the uncertainty relationship. That does absolutely no good because the uncertainty relationship is not the cause - IT IS THE RESULT - and, as a result, is absolutely correct if you play the game and use the conventional definition of the parameters involved. The cause of this tragic misunderstanding is our own definition of these terms, coupled with the inconsistent assumption that the terms we thus defined could be independent.

GEOMETRIC RESULTS

If it seems I am ripping out the entrails of modern physics, relax. Here is the consequence of what I am saying:

The Uncertainty Principle is correct. All of the math relations we now use are correct. However, we have foolishly limited ourselves in the type of problems we can solve and in the grander picture behind the so-called modern physics.

Let me go back to the geometric concept of alternatives. Suppose it is 1899 and Planck had not worried about radiation laws. What could we have predicted then?

* Any expression of an observation is only one of an infinite possibility of equally valid alternatives. Here is a bit of mind-stetch: alternatives can have differing dimensionality. Our sacred four-dimensional universe could just as easily be somebody else's sacred two-dimensional universe. Nothing happens in one that does not happen in the other. But if we pursue the geometry we find that continuity and "betweenness" are NOT geometric invariants of alternatives. In other words, quantizing, with allowed and unallowed states is something we can expect to have happen when we look at the same thing from a different dimensionality. So, from this, the concept of quanta could have been anticipated.

* If we blur transform from a higher-dimensional frame of reference to a lower-dimensional frame of reference we will never encounter any discontinuity or step. This is a geometric version of what we call the Correspondence Principle if one alternative is what we call classic physics and the other is what we call the microcosm.

* Point-wave duality is something we can predict MUST happen. If we are careless, and forget that the sharp point-wave alternatives are oriented, we might assume that the corresponding fuzzy alternative parameters are combined together. For example, an observer using a point-oriented frame of reference will see corpuscular behavior along a particular direction. An observer using a wave-oriented frame of reference, will see the same thing as waves, apparently along the same direction. A fuzzy observer will see WAVELETS depending on the class of fuzzy alternative he uses. The fact that one can see something as either waves or particles is understandable if we realize the change of reference used when we blur from wavelike to placelike.

* Bohr's Complementarity Principle, wherein there is an apparent need for both momentum and position yet each complements the other in any description, makes much more sense once we regard the alternatives which are involved. Position and momentum are complementary because they are alternatives of each other.

The same is true for particleness and waveness. But each of these is a lower-dimensional alternative to a higher-dimensional description which we can associate with the macrocosm. And in this higher-dimensional structure we have sufficient dimensional flexibility to support both location and change of location as properties.

* And what about this magic thing we call Planck's constant? Somehow, there is a weak glue binding canonically conjugate parameters such that when we strive toward the microcosm we are stopped by the uncertainty relationship which involves this small constant. Let me make you angry and suggest that the quantity we call Planck's constant is that fudge factor which we must put in so that the equations will come out correct for the definition of parameters we used.

Look at the Dirac-Jordan kernel, which Heisenberg used. The expression in the exponential is an angle, and as such must be dimensionless of a certain magnitude. If, in the beginning, we had used a distance measure of different magnitude and/or different momentum measure, the proportionality constant, h, would have been unity.

Chase back to Hamilton's equations. What are the units we must use for this proportionality constant to make the angle measure dimensionless? It is erg-seconds. In fact if we take this partial differential equation, dating back to the early 1800's, and play some games, it is apparent that the dim sounds of the uncertainty principle for momentum-position and energy-time could have been heard a century before Heisenberg made it formal.

* And if we allow our minds some freedom, we do not have to stop here. There is a primal tie between energy-time and position-momentum. The tie exists because that is how we defined these things - not that nature gave them to us. There is the further structuring such that if momentum-position are jump transformable, so also are energy-time.

Look at the conceivable four-space sharp alternatives: position-time and momentum-energy. We do not have a Planck fudge factor to make our experiments numerically consistent with our equations. But we do have some new fudge factor, which we can call c. What would be the interpretation of c - from this purely geometric standpoint? It might be that having defined the units of position we cannot arbitrarily define the unit of time and be geometrically consistent. What we can do is define a thing we call time and determine that the geometry requires that we multiply this by the number c so as to align it with the units for position. If we try to fool mother nature and tie things together with some other constant, such as twice c, we would discover, as in Heisenberg's gamma ray microscope, that any observation attempting to link position and time will be perturbed by our efforts such that the proportionality constant c was still involved.

If we are classic types we could interpret c as a number having the units of speed - meters per second - just as Planck's constant had to have units of action - energy-time or position-momentum. In fact we would notice that this same geometric constant already appeared in our classic equations and was identified as the speed of light. This would make a lot of sense, even geometrically, since any attempt to communicate from one place to another in a defined interval of time would be under this geometric constant. This constant would then be the speed of influences capable of causal results.

A position-time four-space could be an allowed sharp alternative. A momentum-energy four-space could be another sharp alternative. A fuzzy alternative, formed over the union of these sharp alternatives, could begin to take on the aspects of many of the things familiar to us in classic physics; yet, in detail, be subject to the limitations which we now attribute to the microcosm and to special relativity.

The lesson to be learned from this geometry, however, is that there are many other sharp and fuzzy alternatives we may use. And that is the exciting promise which it brings to physics.

CONCLUSION

Let me now summarize what has been presented:

For the past fifty years, the uncertainty principle has stood as a challengable, yet never defeated, statement. An entire view of physics has arisen which offers this principle as proof of the assertion that the observer must ultimately disturb what is being observed. Schroedinger's Cat, Double Slit experiments, and spin cancelling photon experiments give results sensibly in agreement with equations based on the probabilistic interpretation of quantum physics. Yet the helpless feeling of a noncausal universe, based on probabilities, is so repugnant to our inner convictions that we accept the proof but rebel at the philosophy.

I submit that the math is correct, the indeterminacy relation is correct, and the role of probability is correct. But we made one assumption which is not correct. We assumed that the property called momentum and the property called position have the same meaning in the higher-dimensinnal geometry we call the macrocosm as in the reduced-dimensionality geometry we call the microcosm; and that these properties are wholly independent.

I have introduced alternatives as a geometric concept. Probabi lities are associated with the process of mapping and establish the class of alternative, whether fuzzy or sharp. All I have discussed here are those special types of alternatives which are Euclidean. If we identify the concept of alternatives with the concept of space, it is possible to have nonEuclidean as well as Euclidean spaces. In the greater sense, this probabilistic relationship which we call the indeterminacy relationship - or uncertainty principle - is an interspace mapping rule for fuzzy spaces. And is only a special case of far more general interspace probability relationships governing fuzzy spaces.

I want to impress the fact that starting solely from this geometric structure of alternatives we can predict, a priori:

* why things may appear quantized
* particle-wave dualism
* correspondence relationships
* indeterminacy relationships
* complementarity interpretation
* the role of probability in observation

In other words, the geometry was not developed with the intent of "explaining" these things but being developed from quite a different standpoint, these things were seen to fall out of the geometry.

There is much more that has been, and I am sure will be, developed from even this primitive geometry. But if I have settled fifty years of uncertainty in your minds, I will be satisfied.