SLAC-PUB-2264
February 1979
(T/E)

THE ETERNAL TRIANGLE EFFECT*

Pierre Noyes

Stanford Linear Accelerator Center
Stanford University, Stanford, California 94305

(To be published in Nonverbal Communication Today: Current Research, edited by Mary Ritchie Key and Donald Preziosi.)

*Work supported by the Department of Energy under contract number EY-76-C-03-0515.

Communication, whether verbal or non-verbal, is often analyzed as the flow of information between sender and recipient. This causal model, drawn from classical physics, is all too often thought to be the whole story. But we have learned from quantum mechanics that, at least in physics, the entire past history of a system is needed to interpret the present, and that even with such knowledge we cannot guarantee the absence of novelty. In this paper we present a specific example of this general feature of quantum mechanics which has, we believe, a profound analogy to a well-known behavioral situation. We offer this analogy, not as a model, but rather in the hope that it will stimulate a different type of thinking about non-verbal communication and related phenomena.

Conventional quantum mechanical theory, and its relativistic extension, are embedded in the continuous space-time of classical physics. Within this framework the theory is "non-local" in the sense that the whole space-time region of events described by the wave function has to be included in the calculation. There is no way to make any clear causal separation between "past" and "future" that satisfies all physicists who discuss the problem. Although most physicists do not consider fundamental revision of quantum mechanics to be needed, or even desirable, this extreme non-locality and acausality leaves many of them uncomfortable when they are confronted with specific examples. Physicists are accustomed to believe that they can manipulate apparatus freely in an experiment and then measure the result of the manipulation--even though they may have to content themselves with a statistical result obtainable only through many trials. Consequently, though physicists accept the extreme non-locality I describe below, they shrink from drawing physical, let alone metaphysical or cross-disciplinary consequences from it.

The wave function of quantum mechanics describes the process of "preparation of a system" and its absolute square the probability of detecting the various particles in the system at various places with various correlations. The effect on which I base this essay uses this conventional interpretation for the specific case of three structureless particles which, pairwise, scatter (or "interact") only when their distance of separation is within some finite range. We also assume that this "interaction" is not modified by the presence of a third particle, or in technical terms that there is no "three body force". Then, as I showed some time ago,[1] the three body equations predict that--in spite of the fact that the model of the interaction contains no forces in this region due to the third particle--the behavior of any pair can be radically altered by the presence of the third particle, no matter how far away that third particle is!

Discovery of this quantum mechanical effect led me to think of a behavioral analogy. Imagine two people in a room with a closed door. We study them (or in this thought experiment think of their behavior) by means they cannot detect. Their behavior patterns exhibit regularities we are accustomed to meet in pairwise conversations. Yet we all know that these regularities change abruptly if they come to believe (correctly or not) that there is a third person outside the door. This I find exactly analogous to the change in the behavior of a pair of particles when we modify the system by considering it to contain a third particle, even though the interactions are of finite range and the third particle is indefinitely far away. For obvious reasons I call this the "eternal triangle effect".[2,3]

When I first ran across this effect in my study of the quantum mechanical three body problem, I was startled. It is an obvious effect, and as already said, I could find no way to limit the region over which the effect must take place, even in the extreme case of strictly finite range pairwise interactions. Indeed, I found the effect so bizarre that I thought I must have made a mistake. This mistaken conviction held up my work on the three body problem for two years. But the physics is correct, and has been independently established by others. For example, Efimov[4] showed that for three identical particles this effect can, in a particular limit, lead to an indefinitely large number of three particle bound states of indefinitely large size. It was subsequently shown that Efimov's effect is not restricted to identical particles, as my independent line of reasoning had already made clear must be the case.

It is instructive to see how the causal analysis of classical physics would describe the three particle system with the same finite range interactions. In classical physics, if the masses and forces between the pairs are specified then given the angles and velocities with which a pair come together, we can predict the angles at which they emerge. Alternatively, we could determine these angles experimentally. With this knowledge, we can then predict, in the situation shown in the figure, what will happen when first one pair scatters, and then the other, in all cases. This is, of course, just a specific example of the causal nature of classical physics.

At first glance the quantum mechanical situation is not very different. Again we can study the scattering of pairs, and determine from them a unique function (the "differential cross section") which predicts the angles of scattering. In this case, the prediction is only statistical, so we must make many trials in order to determine the function, or to check a prediction based on it, but this can also be the practical situation when a classical model is appropriate. The difference begins with the fact that, in the classical situation we can, in principle, go uniquely from the observed scattering (if we can follow the motion of the particles along the entire path) to the force which "causes" the motion. But in the quantum mechanical case we are debarred in principle from making such a detailed study of the trajectory, and it can be proved that there are an infinite number of force laws all of which will give precisely the same fit to the two body scattering data. Consequently, within the range of forces, the models are arbitrary empirically, and in practice must be constructed from other theoretical considerations. This leads to the second situation presented in the figure. In the first scattering, there will be some (unknown--but the same for all cases) specific wave function within the range of forces. This leads now not to emerging particles travelling in unique directions but to a probability amplitude wave. When this wave strikes the region within the range of forces in the second scattering it interferes with the process. Consequently the distribution inside the range of forces is <u>not</u> the same as it would have been for an isolated pair. Thus, empirically, we cannot predict what will happen in the second scattering because of the arbitrariness of our model. In consequence, no matter how precise our knowledge of the past, novelty can emerge. Even if we have what we believe to be a trustworthy model for what goes on within the range of force, we see that just where the first scattering takes place will have an effect on the second, and that consequently we must know the entire past history of the situation in order to perform the calculation. In contrast, for the classical calculation all we need know is the positions and velocities of the particles at any one instant of time.

This time dependent analysis of the situation makes the behavioral analogy profound, rather than trivial. Two people change their behavior when they anticipate the presence of a third because of past cultural experience. In order to make even an educated guess about what form this change will take, we need to know their individual histories, and be familiar with their culture. In principle, we might need to know about the evolution of those cultures, of the planet on which they occur, and of the cosmos in which the planet finds its place. Thus the quantum mechanical analogy takes on aspects like that of Jung's "collective unconscious" once we take seriously the quantum mechanical proposition that the present emerges from the past via coherent, interfering statistical processes.

Turning back to the question of what this quantum mechanical analogy might tell us about the three person communication with which we started, it is important to distinguish two situations. In the first we have a part that can be analyzed partly in terms of a "signal" which the pair in the room receive indicating the presence of the third vertex of the triangle--a sound, heat, a current of air, what have you. This signal may be below the threshold of conscious awareness, and hence difficult to be certain of experimentally. But the situation is still a conventional aspect of non-verbal communication involving the usual complicated interplay between unconscious, preconscious and explicit thoughts and behaviors which make the study of the subject so difficult. The second case is more interesting. In the absence of a signal, the pair change their behavior, and sometimes correctly anticipate the arrival of the third person. When physical means of communication have been ruled out, this might be called a "paranormal" phenomenon.

I wish I had at hand a well documented example to show that I am dealing with a real event. But such examples are hard to come by, and notoriously difficult to make convincing to much of the scientific community. So the event I describe must be treated as illustrative and anecdotal, although I hope it will call to mind for at least some readers items from their own experience. I believe that the event was indeed real. It was described to me by a distinguished scientist, who also stated that he had the documentation to back it up. But in spite of his international reputation, and the fact that he could support the case with evidence, he had delayed (still has so far as I know) publishing the evidence for fear of his professional standing being affected.

The incident involved an anthropologist who had, after many months, gained the confidence and friendship of a shaman in the group with which he was working. One day the shaman asked him out of the blue whether he would like to know what the anthropologist's friend (at that time many thousand miles away) was doing at that moment. The anthropologist took down the description in writing, had it notorized, and wrote his friend asking him (without explaining why) to describe the friend's actions at that time. The result was startlingly accurate.

It is not necessary for you to believe the story in order to ask the question, as I do, of how such a remarkable "communication" might occur. After much rumination on the event, and after the discovery of the eternal triangle effect and its behavioral analog, I have come up with a tentative model, or rather explanatory framework. Since the anthropologist and the shaman had reached a mutual level of confidence and trust, they could to a certain extent "share each others thoughts"--a phenomenon known to all of us, and not necessarily involving any paranormal phenomena. Further, the anthropologist knew his distant friend well, and might by similar process anticipate (unconsciously) what his friend would be doing at that time. We know of many instances where such unconscious deductions come to us in dreams--sometimes accurate and sometimes not. For the shaman to "pick up" this knowledge or conjecture from the anthropologist need involve only the types of "non-verbal communication" which are discussed in this volume, and which, though often difficult to understand, model, or demonstrate, are again familiar aspects of human behavior. Thus, granted only the postulate that a human mind makes many accurate deductions about present happenings from past experience--which would shock no psychoanalyst--the whole incident can be fitted into the framework of explanatory models, that, separately, are often accepted.

It is interesting to speculate on whether many phenomena which are called "paranormal" might not fit into such an explanatory framework. The framework does not really "explain" anything, of course. To account for an unexplained occurrence by saying that a human mind can make, unconsciously, very accurate deductions about what will occur ("precognition"), what another person is thinking ("telepathy"), or how an unstable system will behave (predictive "telekinesis") is only to replace one problem with another--namely how to explain this extraordinary computational ability. But it does have the aspect of explaining a fact that is troublesome in "paranormal research", namely that the ability is not 100% and closely tied to the emotional state of the individual. This is what we would expect, from psychoanalytic theory, of a process deeply buried in the unconscious. Coming back to the theme of this volume, such unconscious processes clearly can have an important bearing on non-verbal communication of more conventional sorts, and it is perhaps reassuring that the underlying physics warns us we should include them in our thinking about how such communications work.

My intention in this essay is not to say that quantum mechanics "explains" paranormal phenomena by some such route. What I do claim is that quantum mechanics, in the simplest case where the phenomenon can occur (the three particle problem with finite range interactions), *does* require both an extreme non-locality of description when forced into an "instantaneous" or "static" form, and the inclusion (in principle) of *all* past events in the discussion of the current situation. I hope that this fact can provide an "explanatory framework" within which it is easier to contemplate correlations between events so distant in space and time from each other as to make models drawn from classical physics seem inadequate or implausible.

BIBLIOGRAPHY

1. H. Pierre Noyes, "Exterior Three-Particle Wave Function," Physical Review Letters 23, 1201 (1969).

2. H. Pierre Noyes, "Some Spontaneous Remarks," in Three Body Problem in Nuclear and Particle Physics, J.S.C. McKee and P. M. Rolph, editors, North Holland, Amsterdam, 1970, p. 494.

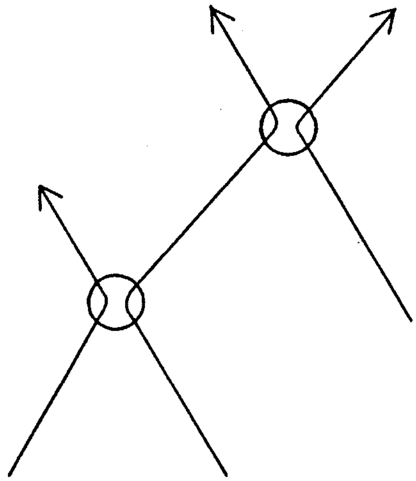
3. H. Pierre Noyes, "The Eternal Triangle," Bulletin of the American Physical Society 16, 20 (1971).

4. V. Efimov, Yad. Fiz. 12, 1080 (1970) (English translation in Soviet Journal of Nuclear Physics (U.S.A.) 12, 589 (1971)). For recent work and references to earlier work, see A. C. Fonseca, E. F. Redish and P. E. Shanley, University of Maryland, Department of Physics and Astronomy preprint ORO 5126-51 (November 1978).

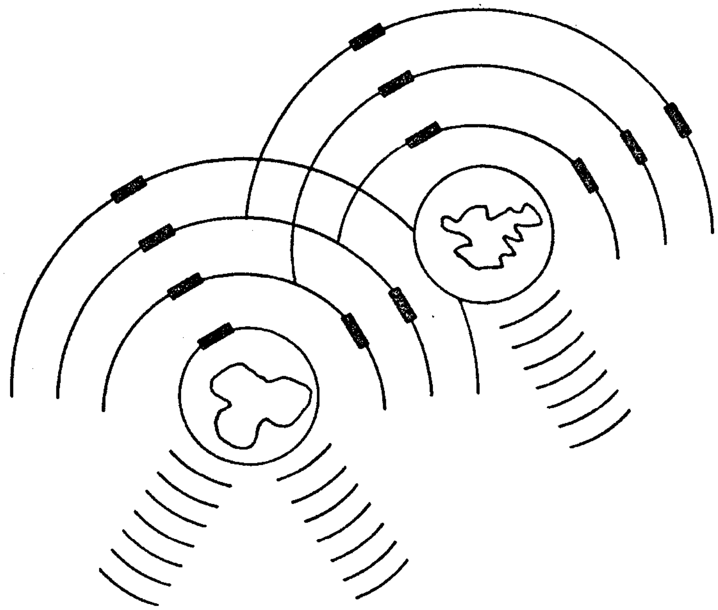
FIGURE CAPTION

For classical finite range systems, study of the scattering of pairs allows a unique prediction of double scattering in a three particle system. For the quantum mechanical three body problem, the scattered wave from the first scattering interferes with the second scattering, making the result not only statistically unpredictable but also novel. Thus, the future cannot be unambiguously predicted from the past, and systems evolve. The effect does not fall off with the range of forces R, but instead depends on the dynamical scattering length a and its ratio to R.

ETERNAL TRIANGLE EFFECT



Classical Determinism



Quantum Mechanical Irreversibility
+
Statistical Prediction

8–79
3038A4

Fig. 1