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**SPECULATIONS AND INQUIRIES REGARDING THE POSSIBILITIES FOR  
AND LIMITATIONS TO PRACTICAL INTERSTELLAR TRAVEL**

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**ABSTRACT**

The existence of superluminal phenomena have now been independently confirmed by physicists working in several different laboratories, most notably by the team of Alain Aspect in Paris. The two major variants of these experiments are described and their implications for superluminal communication and superluminal travel are discussed. It is noted that while the original suggestion for these experiments is due in part to Albert Einstein (Einstein, Rosen, and Podolsky, 1935), their recent empirical validation presents a significant anomaly within the theoretical framework of the special theory of relativity, although they are predicted within the framework of quantum mechanics. How a newly emerging paradigm broadly encompassing the empirical sciences, and informed by both the social sciences and general systems theory may resolve this theoretical crisis is discussed. With the impasse to further elaboration of these effects for possible superluminal applications removed, the discussion concludes with a research proposal.

**INTRODUCTION**

Until recently even the possibility of interstellar space travel has been limited by the result of the special theory of relativity due to Albert Einstein that the velocity of light "cannot be exceeded by any form of propulsion that relies on the expulsion of mass to obtain reactive thrust... moreover, every scientific experiment, designed within the last half-century to test Einstein's hypotheses concerning relativity, has consistently added verification to his postulates" (ref.15).

In the brief course of this paper, I will attempt to state not only the observations which lead to the conclusion that practical interstellar travel ("practical" in the sense that travel times will be at least on the same order of magnitude as the multi-month peregrinations of the sailing ships of the Great Age of Exploration) is at least now thinkable, but also the process by which such a "possibility" may proceed to "practicality." Scientist-science fiction author Arthur C. Clarke has made the observation that every great idea, invention, or discovery comes about through a three-step process as shown in Figure 1. Dubbed Clarke's Law, the experts, as illustrated above, have already amply supplied the first step.

#### Figure 1. Clarke's Law

**From the viewpoint of experts, any great idea, invention, or discovery comes about in a three-step characterization process:**

1. "It's impossible"... "It can't work"... "It can't be!"
2. "It's impractical"... "It won't work"... "It'll never make you any money."
3. "I thought it was a great idea all along!"

But these same experts evidently will not allow themselves to be cast in the roles of historical curmudgeons. British Interplanetary Society fellow James Strong as one such expert quoted above in nearly the same breath stated that "to be so positive that it was impossible—after a mere century of industrial progress— is surely defeatist, and most men would be more guarded in their statements. There is always room for speculation concerning the future, but none for evasion." (ref.13). To quote the admonition of Hamlet, "There are more things in heaven and earth, Horatio, than are dreamt of in your philosophy." Einstein himself said "Imagination is more important than knowledge."

Now, perhaps ironically, but more likely consistent with Einstein's latter observation, a ludicrous prediction made by quantum mechanics that Einstein elucidated in the 1935 paper with Rosen and Podolsky to demonstrate the incompleteness of quantum theory has turned out to be true.

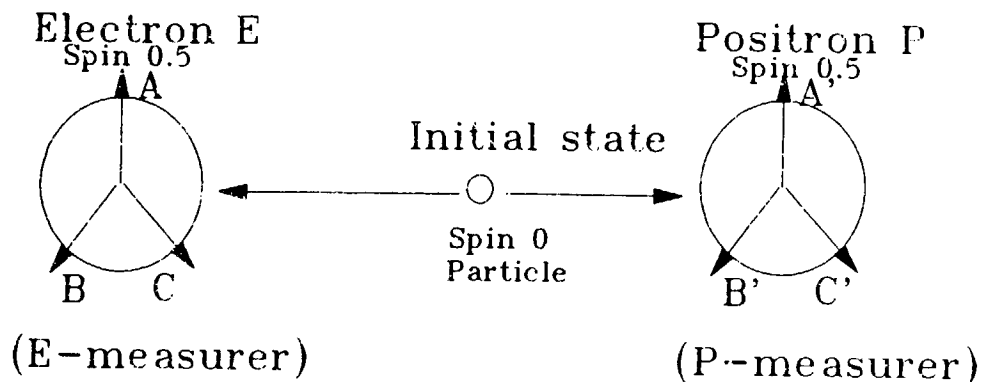
## THE ENSTEIN-ROSEN-PODOLSKY (ERP) EXPERIMENTS

The original challenge to quantum theory devised by ERP was a thought experiment that relied on the conservation of momentum of two interacting elementary particles to show that the position and momentum of one of the particles could be determined exactly by measuring the momentum and position of the other particle even if they had already separated by a large distance (ref. 5). This result is required by the putative conditions of the experiment, which was to be conducted in such a way as to avoid any interaction with other particles or systems. As momentum, like energy, could neither be created nor destroyed, the position and momentum of the particle "in London" could be instantaneously determined by measurement of these properties of the particle "in New York." But the Heisenberg uncertainty principle, which, like the conservation of momentum law, had already been experimentally verified, stated that the position and momentum of a single particle could not be ascertained without uncertainty. But most distressing was the result that the principle of local causality— that distant events cannot instantaneously influence local objects without mediation— was also violated! According to physicist Heinz Pagels writing about ERP 50 years later, "This finding startled most physicists, because they held the principle of local causality sacred" (ref.14).

As the conditions necessary to isolate the particles in the ERP thought experiment from other influences would prove to be difficult, physicists such as David Bohm (ref. 2) and J.S. Bell devised other, practical experiments that nonetheless had the property in common with the original thought experiment that a conservation principle would allow the state of one, remote part of the system to be determined "instantaneously" by the measurement of the state of another part of the system separated by some sensible distance from the first. (Note that it is important to bear in mind as we describe these experiments that they all are applied to the "microworld" of elementary particles such as fermions and photons). The two major types of experiments that have been proposed to date involve 1) decay of a spin-zero particle into two spin-one-half particles, viz., an electron and a positron (see ref. 14); 2) decay of "positronium," an atom consisting of a single electron bound to a positron (positive electron), into two photons that travel in opposite directions (see refs. 2,3,8,14). (In the discussion of all such experiments it is important to bear in mind that while we talk about individual particles, the observations are actually being made on macroscopic agglomerations of the source particles and the resulting decay products, and that the actual occurrences of decays happen in the "chaotic" or random manner typical of all radioactive decay processes).

Figure 2 illustrates ERP experiments of the first kind. At the

Figure 2. An ERP experiment involving pair production. A spin-zero particle decays into an electron E and a positron P. Measurement of the spin of any one of the particles fixes the spin state of the other instantaneously.



time of decay, both positrons and electrons fly off in opposite direction and spinning with their axes of spin oriented more-or-less randomly. Instruments can be set up in such a way in advance of any series of spontaneous decays as to determine the number of respective particles spinning in any of the directions A, B, C for the electron observations and A', B', C' for the positron. The directions A', B', C' are to be made parallel to A, B, C as shown and in the same plane. When the measurements are conducted, sometimes the electron-measurer will register YES whenever the spin is in the A, or B or C direction and NO when the spin is NOT in the A, B, or C direction. Similarly, the positron-measurer counts up his YES's and NO's for his A', B', C' settings.

Now quantum theory predicts, according to Penrose (ref. 14), that 1) whenever the A, B, or C measurement is YES, the corresponding A', B', or C' measurement is always NO, and vice versa, i.e. the results by the two measurers always disagree; 2) whenever the dials for the spin directions are spun and set at random and independently of one another, then the two measurers are equally likely to agree as disagree. Penrose goes on to prove logically that the results cannot be explained in terms of any set of conditions hidden from observation whereby the electron and positron spins are prepared in advance, as the conservation condition stated for this experiment (i.e. opposing spins) leads to a false prediction (at best a 5 to 4 agreement/disagreement ratio) when condition 2) is imposed. Hence there is no set of prepared answers which can produce the quantum mechanical probabilities.

Penrose states that the above experiments have not actually been performed, but that the second type using the polarization of pairs of photons has. Here the conservation principle states that the opposing photons must be plane-polarized in the same direction whenever they are measured. He quoted the work of Alain Aspect (1986) and his colleagues in Paris as having performed the "most accurate and convincing of the experimental results" (ref. 14). Aspect added the additional feature that the "decision" about which direction to measure the polarization in was only made after the photons were emitted. Thus, if we think of some influence traveling from one photon detector to the one on the opposite side, signalling the direction in which it intends to make the measurement so that the opposing photon can "align itself" in the same direction, then the effects must be able to travel faster than light!

However, all these researchers are quick to point out that there is no known way to actually set the direction of spin or polarization of the electron/positron or photon, respectively or to predict in advance how a particular particle or photon will be oriented— only that when A is "UP" then A' is "DOWN" or that when photon A is found to be polarized at 60 degrees, then photon A' must also be polarized at 60 degrees. Within the framework of current quantum mechanics, Penrose quotes Ghirardi, Rimini, and Webber 1980 as having made a general demonstration that such putative superluminal influences can't be used for signalling.

We have thus seemingly come round to where we started, with no superluminal communication, let alone superluminal transportation possible. Have we merely generated "a lot of sound and fury, signifying nothing..." as MacBeth lamented? I think not. In the next section I will state why the situation is still better than before the revelation of the EPR experiments.

### DIRECTIONS FOR RESEARCH

Thomas S. Kuhn over 25 years ago wrote his now-famous "Structure of Scientific Revolutions" in which he concluded from his historical study of major scientific "revolutions" that when major anomalies occur while practitioners are working within a given scientific body of knowledge or "paradigm", "something's got to give". Either the

Kuhn's characterization of this progression.

**Figure 3. T. S. Kuhn's Structure of Scientific Revolutions**

**Stage 1. Normal science: puzzle-solving**

**Stage 2. Anomaly and emergence of scientific discoveries**

**Stage 3. Crisis and the emergence of scientific theories**

**Stage 4. Resolution of crisis and change of world-view**

From what we have described above, we are well into Stage 2, and we have evidence that we have already moved into stage 3 with respect to the quantum mechanical/relativistic paradigm. References 1, 2, 3, 6, 8, 10, 13, 14 are all major scholarly works that both grapple with the anomalies stated above and engage in major philosophical discussions of the history, personalities, motivations, and metaphorical content of the paradigm in question. In this brief space I can only mention these treatises, but I wish to bring out two major conclusions from these works that seem implicit but are not stated in any one place.

First, that the observations that lead to the anomalies, whether simply "thought" experiments or actual observations, are "real" and that therefore either quantum mechanics, special relativity, or both are fundamentally limited and must be corrected or replaced with a new paradigm that explains and/or predicts all existing data properly.

Second, that "a process of metaphor" is under way now that involves an intensive search for familiar objects, images, and concepts that can serve as the bases for a new model or set of models that will explain these phenomena. Psychologist Julian Jaynes can be credited with the realization that the "history of thought" and intellectual development is a process by which familiar phenomena (which he calls "metaphiers") are sifted through to give meaning to the unfamiliar-or anomalous- which he refers to as the metaphrands. (Thus a metaphor always is composed of two parts- the metaphier:"the familiar", and the metaphrand: "the unfamiliar") (ref. 7).

I hereby suggest that a conscious search for the appropriate

"metaphiers" will be the speediest way to resolve the anomalies, and to arrive at either a new paradigm or a re-vamped version of the old. I am confident that such a development will remove the impasse to further research into superluminal phenomena and allow the concomitant technology to develop. Finally, I list in Figure 4 an agenda for research:

**Figure 4. Proposed Areas of Research for Superluminal  
Communication and Transportation**

- 1. Identify a quantum system whose decay phenomena can be externally influenced. Such a system could be used for superluminal communication.**
  
- 2. Re-conduct the Michelson-Morley experiment at higher levels of sensitivity both on earth and in the space environment to determine the presence of "luminiferous" and even "super-luminiferous" media"**

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