The Impossibility of Large-scale Retrocausal Signalling

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Abstract

Following an earlier paper, an argument is presented that sets up a causality paradox with signals that are claimed to be retrocausal. This is not to be dismissive of claims of retrocausality over small scales by the mechanism of advanced and retarded waves, just that it is not possible over timescales greater than the energy-time uncertainty relationship.

1. Introduction

Relativity, with its maximum speed of transit for mass-energy (but not quantum state information) and the banishment of simultaneity, gives us the notion of the past, present and future happening at the same time by the literal Relativists. Quantum entanglement introduced a problem with this viewpoint[1-3], as well as obviously correct communications schemes[4] (and appendix 1) which may hint at a return to an almost Newtonian view of space-time, certainly with a universal absolute present[5]. However this is not the focus of this paper but a paradox generated by relativity and fitting EPR phenomena into that framework with notions of retrocausality.

The Lorentz transform does not easily permit faster than light travel, requiring as yet unproven physical effects such as imaginary mass particles (tachyons), space warps or space bridges. It is to this system of thought that the notion of Retrocausality[6] has been introduced to explain EPR effects, through advanced and retarded waves known since the 19th century. EPR effects are considered explained by Post-Quantum Mechanics and a two-state vector formalism[7-9] where the "pre-ordained" end states of a quantum process in a "block-universe" are communicated backwards in time, with initial states propagating forward, in a mathematically consistently manner. The advanced and retarded waves are precisely the solutions of wave equations and so are automatically relativistically covariant. The author feels that this a conflation of EPR effects with Retrocausality but to *that* community, this is all so fitting and just-so; as is the general time symmetric nature of mechanics, apart from wavefunction collapse, which is banished.

That aside, we shall concentrate in this paper on showing the impossibility of large-scale retrocausal signalling within the framework of Relativity; in other words, it is impossible to engineer a retrocausal "radio transmitter" sending definite classical signals such as a binary code. Retrocausality may be possible on the scale of the energy-time uncertainty relationship for fundamental quantum processes, wherein there is a window of possibility that the direction of time could be said to be uncertain. In the conclusion we discuss how it may be possible for a quantum predictor computer to compute various scenarios for the evolution of a classical system it models; though this is probabilistic and in no sense a definite communication from the future to the past.

2. The Paradox

Following the author's earlier paper[10], two parties, A and B, are initially together and aim to synchronise clocks by the following procedure: A and B synchronise clocks. A sets out slowly so that the minimal time resolution unit of the clocks is not affected by time dilation. A achieves a separation from B of many time units such that A is separated from B by a space-like interval.

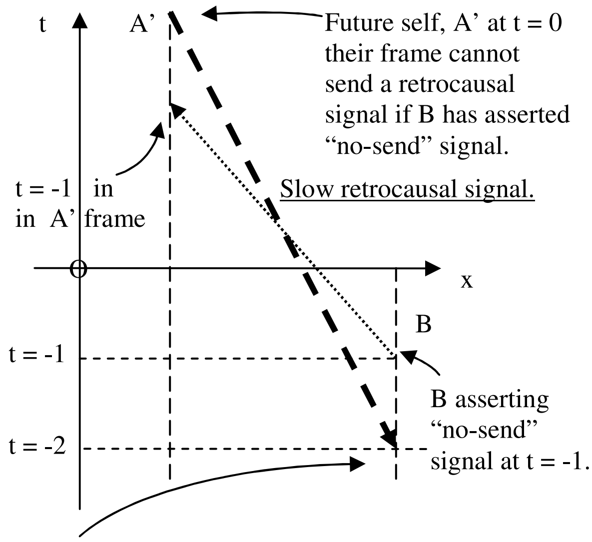

Figure 1 – Retrocausality Free-will Paradox

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A, at time zero (which is A' in figure 1 from the point of view of B), will send a *slow retrocausal signal* (that is one that travels backwards in time more slowly than a retrocausal light-speed signal, such as by an advanced matter wave) to B at time t = -2, unless prior to t = 0 in A's frame, B has sent a "no-send" signal. Does B receive A's signal at t = -2 despite sending a "don't send" signal at t = -1? If it is a fait-accompli and the retrocausal signal was sent, does B have any free-will in asserting the "don't send" signal?

3. Discussion, Conclusion and "Quantum Clairvoyance"

How does one resolve a paradox like this? There seems to be three possible resolutions:

- Have an Everettian[11] fork into different universes, where in one universe A did send the slow retrocausal signal and B definitely didn't send the no-send signal and vice versa. Still, in all of this, why can't B be a rebel? Besides by the Principle of Parsimony, that's an awful lot of spare universes for every nano-second, fleeting quantum event that leads to collapse. Where do they happen to be? If they can't be measured or show their influence, then the debate is metaphysical.

- Admit that Retrocausality is impossible on such a large scale, though it might still be for processes within energy-time uncertainty.

- (Still keeping the door open to a more limited, small-scale form of retrocausality) Admit that large-scale EPR type signalling *is* superluminal and B definitely can tell A not to send[10] if enough time is allowed for B's light-speed limited signal to transit the space between them (figures 2a and 2b). In other words, B sends their signal early enough.

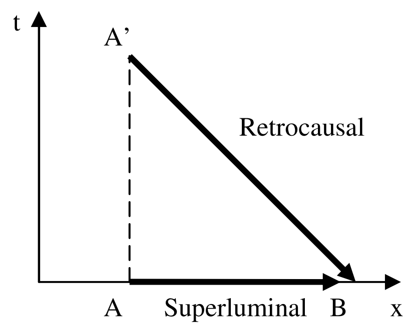

Figure 2a – Superluminal or Retrocausal?

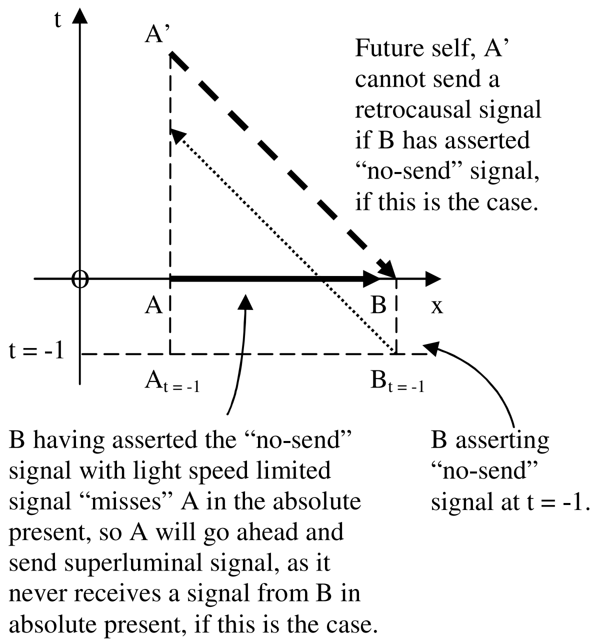

Figure 2b – Resolving the paradox

To the latter, large-scale retrocausality is ruled out by the paradox: if a large-scale classical protocol can be transmitted over an EPR signalling arrangement[4] (appendix 1) then *it has to be superluminal and furthermore, it exposes the absolute present in abeyance of Relativity*. It is Relativity that gives the notion of the past, present and future all happening at the same time with the banishment of simultaneity. The author believes in a revamped Newtonian view with the absolute present with "relativistic effects"[5].

As an aside, for those still not comfortable with the notion of a superluminal signal, who saw retrocausality as a means of preventing such an "abomination", one can make an effective superluminal signal (horizontal signal on space-time diagram) with a series of relay stations with a positive time delay (or it could simply re-transmit with a wave moving forward in time). Figure 3 shows the construct:

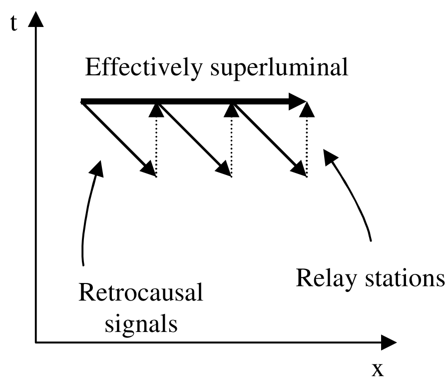

Figure 3 – A de-facto superluminal signal from a retrocausal signal

Notions of retrocausality can still be admitted on the small-scale, as observed say in Feynman diagrams between matter and anti-matter (with provisos). Quoting the energy-time uncertainty relation guardedly[12]:

$$\Delta E \Delta t \geq \frac{\hbar}{2}$$

It might be correct to consider a quantum process happening over an interval, Δt, as hidden beneath a veil. We can only speak of initial and final states but in between, time could well be moving forwards, backwards or even multi-dimensional. It is on this scale that the graceful description of the two-state vector approach[7-9] perhaps resides. Perhaps then the objections to a "block universe", with its restriction of free-will and quantum super-determinism can then be dismissed.

One then might wonder, does a quantum computer with low energy processes (the brain, as quantum mystics might have us believe?) that is continually fed real world (classical level processes, figure 4) state information, look into the future of the classical system?

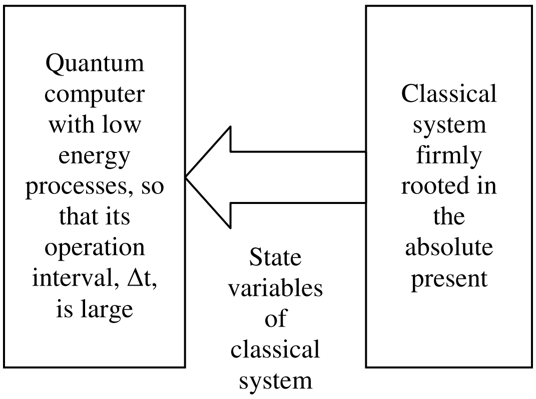

Figure 4 – "Quantum Clairvoyance" or just a State Predictor?

It may be a moot point but we think it easier to say that the quantum computer predictor can solve a range of problems that a classical computer predictor can't in principle and it simply is a better computer, a better predictor, not a clairvoyant.

References

1. Einstein, Podolsky, Rosen, *Can Quantum-Mechanical Description of Physical Reality Be Considered Complete?* Phys. Rev., 1935. **47**(777).

2. Bell, J.S., *On the Einstein-Podolsky-Rosen Paradox.* Physics Letters A, 1964. **1**: p. 195-200.

3. Aspect, Grangier, Roger, *Experimental Realization of Einstein-Podolsky-Rosen-Bohm Gedankenexperiment: A New Violation of Bell's Inequalities.* Phys. Rev. Lett., 1982. **49**(91).

4. Cornwall R.O., *The misuse of the No-communication Theorem.* 2016 (https://www.academia.edu/29296558/The_misuse_of_the_No-communication_Theorem).

5. Cornwall, R.O., *A Mechanism for the effects of Relativity* 2014 (https://www.academia.edu/11587819/A_Mechanism_for_the_effects_of_Relativity).

6. Sheehan D. P. *Quantum Retrocausation III.* 2016. University of San Diego, C.A.: AIP.

7. Watanabe, S., *Symmetry of physical laws. Part III. Prediction and retrodiction.* Reviews of Modern Physics, 1955. **27**(2): p. 179-186.

8. Cramer, J.G., *The Transactional Interpretation of Quantum Mechanics.* Reviews of Modern Physics, 1986. **58**(3): p. 647-688.

9. Sutherland, R., *Lagrangian Description for Particle Interpretations of Quantum Mechanics.* 2014 (https://arxiv.org/ftp/arxiv/papers/1509/1509.02442.pdf).

10. Cornwall R. O., *Outline of an Experiment to test Retrocausal versus Superluminal Interpretations of a Digital Protocol over a Quantum Channel.* 2017(https://www.academia.edu/34430077/Outline_of_an_Experiment_to_test_Retrocausal_versus_Superluminal_Interpretations_of_a_Digital_Protocol_over_a_Quantum_Channel).

11. Everett H., *Relative State Formulation of Quantum Mechanics.* Reviews of Modern Physics, 1957. **29**: p. 454-462.

12. Baez J., *The Time-Energy Uncertainty Relation.* 2010; Available from: http://math.ucr.edu/home/baez/uncertainty.html

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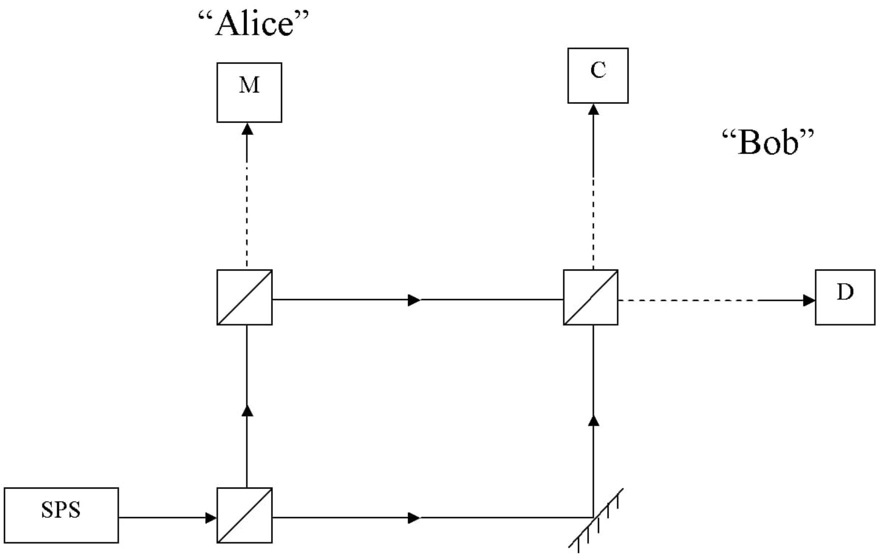
Appendix 1

A single photon source (SPS) is incident on a Mach-Zehnder type interferometer with 50:50 beamsplitters. Alice's measurements discerned over space-like separations by Bob at his detectors C (constructive) or D (destructive). Many single photons (a spot from a beam-expander is used with an attenuator on a laser source) are used to represent one bit.



This is the fundamental law of Quantum Mechanics:-

If the paths can be distinguished then add probabilities

else if the paths can't be, then add amplitudes before calculating probabilities

Thus when Alice measures, both of Bob's paths to his detectors become distinguishable.

Alice sends	Bob receives
Binary 0: No measurement	Binary 0: Min signal, destructive interference from pure state at D
Binary 1: Measurement	Binary 1: Max signal from mixed state at D

$$P\left(Bob\ few\ photons, binary\ 0 \mid Alice\ no\ measurement\right) = \left|\frac{i}{\sqrt{2}}\right|^2 + \left|\frac{e^{i\theta}}{\sqrt{4}}\right|^2 + 2\left|\frac{i}{\sqrt{2}}\right|\left|\frac{e^{i\theta}}{\sqrt{4}}\right|\cos\theta$$

$$= 0.5 + 0.25 + \frac{1}{\sqrt{2}}\cos\theta$$

$$\simeq 0.75 \pm 0.707\cos\theta$$

$$\simeq 0.043 \text{ minimum}$$

$$P\left(Bob\ lots\ of\ photons, binary\ 1 \mid Alice\ measurement\right) = \left|\frac{i}{\sqrt{2}}\right|^2 + \left|\frac{i}{\sqrt{4}}\right|^2$$

$$= 0.5 + 0.25$$

$$= 0.75$$

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