Retrocausality and the directions of time

Austin J. Fearnley
Manchester
England
5 December 2023

Abstract

The mystery for the last century at the heart Of Bell's Theorem is quantum entanglement. This paper explores issues with entanglement and explains that the success of Bell's Theorem experiments depends upon some particles/photons travelling backwards in time. It is also argued that QED electric charge and QCD colour charge are both directly related to time's arrow for individual particles.

Introduction: retrocausality and quasi-retrocausality

The idea of retrocausality has been around for decades (Reference [1]) and most proponents appear not to believe that an elementary particle can actually travel backwards in time. What is generally agreed is that Special Relativity removes the existence of absolute time of an event or particle. In general, there is no ability of an observer to say certainly which of two events occurred first as the time ordering of events depends on the position and speed of the observer in relation to the positions of the two events. In this context, retrocausality can be modelled by advanced and retarded waves where the temporal ordering is relative and within the bounds of special relativity.[2] More recently, Aharonov adopted weak measurements with particles/waves which have both forwards and backwards-in-time components.[3] These effects are not considered to arise from particles travelling backwards in time in their own frames; in other words, particles still obey the thermodynamic arrow of time of the universe. I call this quasi-retrocausality and l argue in this paper that, on the other hand, there are particles with proper retrocausality which can travel absolutely backwards in time defying the thermodynamic arrow of time of the universe.

Bell's Theorem and the incompleteness of quantum mechanics

The question arose in the 1930s of whether Quantum Mechanics (QM) is a complete theory or an incomplete one (Einstein, Podolsky and Rosen (EPR) paradox). This issue was carried forward by Bell's Theorem from the 1950s until the present. QM shows clear signs of incompleteness. For example, Born's Rule gives a probabilistic outcome for a measurement of position rather than an exact position of a single particle. Bell's Theorem, QM and nature appear to show that there are no hidden variables which could explain the results of a Bell's Theorem experiment. In my preon model, I speculate that there is a fifth level of matter below the four established levels of particles: 1 molecules, 2 atoms, 3 nuclei and 4 elementary particles of the Standard Model. The existence of a fifth level, of preons, gives a clue as to why QM is incomplete. No model can be certain to be complete as we cannot be sure if a deeper or preon level exists. This is reminiscent of Gödel's Incompleteness Theorem where a self-contained model cannot answer every internal question but can be augmented by adding extraneous layers in order to answer more questions. Although Nobel prizes were awarded in 2022 to physicists who devised the loophole-free Bell experiments in or about the year 2015, understanding of the reason for the results of Bell experiments remains open to differing interpretations.

Matter and antimatter

My papers ([4] [5]) showing retrocausality works to bypass Bell's Inequalities was based on a simulation of a Bell experiment using paired partners of electrons and positrons. The same result applies if photon and antiphoton pairs are used instead of electrons and positrons.[4] I have since had comments that most actual Bell experiments do not involve antiparticles. That is answered below in an explanation of what an antiphoton structure is in my preon model and why it is a serious misunderstanding to believe that antiphotons are not involved in a photonic Bell experiment, for example when using parametric down-conversion to produce photon pairs.

An antiparticle has reversed properties of electric charge, colour charge, spin, weak isospin and chirality compared to its partner particle. Reversal of the above properties is not controversial. It is usually said that a photon is its own antiparticle. A photon has as its only net quantum state property one of the two quantum states: spin 1 or spin -1. A photon has no net electric charge and it is the electric charge which is primarily reversed in an antiparticle. An electron, for example, has electric charge -1 while its antiparticle, the positron, has reversed electric charge +1. My preon model shows that a spin -1 photon, despite having no net electric charge, has the exact opposite structure to the spin +1 photon.[6] So a photon

has no antiparticle in a strict sense of no photons having opposite electric charges but a photon does fulfil the retrocausal property at preon level of an antiparticle for gaining correct results in a Bell experiment.

The antiparticle situation is rather complicated in terms of my preon model as spin and electric charge are innately independent properties but are associated in my model by being held within preons such that the associations between spin and charge can be different for different preons. The A preon has negative charge and negative spin; the B preon has negative charge and positive spin; the C preon has negative charge and zero spin; and the fourth and last preon, preon E, has negative charge and positive spin. (There is no preon D as it was withdrawn from an earlier model and replaced by preon E.)

The left-handed electron contains preon A, thus it has negative charge and negative spin. The right-handed electron has negative charge and positive spin. The electron's own, personal arrow of time, being normally described as matter, moves in the same time direction as the universal or thermodynamic arrow of time. This is because an individual particle's arrow of time is controlled by its electric charge, not its spin. Spin direction, at least within my preon model, is theoretically independent of arrows of time but in practice depends on my particular arrangement of preons within elementary particles. Electric charge is the direct cause of the direction of a particle's arrow of time (see later Section).

A photon has no net electric charge but it contains either preon B or antipreon B'. Antipreon B' has positive charge and negative spin. The positive charge makes the photon containing B' travel backwards in time, at least for the antipreon B' component of the photon, that is, the part of the photon containing spin -1. That means that the spin components of photons with spin -1 travel backwards in time while those in photons with spin +1 travel forwards in time, merely because of the way charge and spin are combined within preon B. This fulfils the requirement that particles travelling backwards in time are needed to bypass the Bell Inequalities in a Bell Experiment. In a photonic Bell experiment the spin polarisation is passed from the spin -1 photon, which is travelling backwards in time, from say Alice's measurement, to the source of the photon pair and then its polarisation state is passed to the partner photon as spin +1 to go forwards in time to the second measurement.

This is not a complete description as an up quark is a particle, not an antiparticle, and so it is generally assumed to travel forwards in time despite having a positive charge. The important property for this paper is that negative charges in individual preons travel forwards in universal time. There is uncertainty whether it is positive charge or negative charge which actually travels forwards in time. Perhaps increasing entropy is more associated with atomic nuclei than with their electrons and maybe it is positive, rather than negative, charge which is associated with the thermodynamic arrow of time.

In its structure, the photon has four preons of which two travel forwards in time and two travel backwards in time. So the photon in its net motion travels equally forwards as

backwards in time, though the spin within a single photon only travels in one direction: negative spin travelling backwards in time, carried along with the positive charged preons, while positive spin travels forwards in time, carried along with the negatively charged antipreons.

A hindrance to understanding antiparticle problems is that matter was described and defined in the classical era. In the twentieth century the discovery was made that matter annihilated with antimatter. Since matter did not self-annihilate, this confirmed erroneously that QM matter was identical with classical matter. It is merely the case that classical matter contains particles not in the correct format of constitution to self-annihilate.

Clearly, this paper cannot re-define the long established nature of matter and antimatter but my earlier papers misleadingly associated all antimatter with travelling backwards in time. It is the sign of electric charge which instead is associated with travelling backwards in time and as matter and antimatter fermions do have opposite charges they are hence travelling in opposite time directions.

Effect of reversed time direction on interpretations of Bell Experiment results

The effect of the reversed-time direction is to restore locality to interpretations of Bell experiments by circumventing, rather than breaking, Bell's Inequalities. It is shown in References [4] and [5] that with reversed time direction, and reversed-time causality, that measurements in a Bell Experiment are not carried out on pairs of particles that were entangled at the instant of measurement. The particles are entangled at one stage, and that entanglement is important, but the measurement of the time-reversed particles is carried out when entanglement is not present and the Bell's Inequalities are avoided. The Bell Experiment then defaults to measurements on polarised beams. Alice first measures a beam of time-reversed photons and the subsequent entanglement enforces the beam of time-forward photons measured by Bob to be polarised in or opposite to the direction of Alice's detector setting; and, similarly, Alice measures photons polarised in the direction of Bob's detector setting. The measurements of polarised of beams give results compliant with Malus's Law, and Malus's Law leads to correlations which give an apparent but false impression of breaking the Bell Inequalities: because the constraint of measurement of entangled pairs is removed from a central role in the experiment. The particle pairs are not entangled at their time of measurement.

Electric charge is associated with the Arrow of Time

Just over a hundred years ago, the Kaluza-Klein (KK) formulae were announced which produced both Einstein's equations of General Relativity and Maxwell's electro-magnetic equations in one process. The main drawback was that a fifth, spatial dimension was required in which the electromagnetic content existed. More recently a modified KK formula has been produced and referred to as a KKD formula, where the D refers to the incorporation of Dirac's equations.[7] Whereas the approach to KK was contravariant the approach in KKD used covariant results. The KKD approach requires a fifth, time-like, open dimension.

This adds a new factor to the issue of time. Is the KKD time dimension really open or is it a tightly curled up compactified dimension? Is the KKD time dimension genuinely extra and different from the thermodynamic arrow of time?

This issue also concerns the building blocks within my preon model.[8][9] My preon model was designed to have as few preons as possible which could be combined to give all the Standard Model fundamental particles and their interactions and decay paths. This was achieved with four preons and those sufficed to describe all particles and also all interactions of particles. The key properties of fundamental particles are quantum states of electric charge, colour charge, spin and weak isospin. These quantum states take quantised magnitudes which indicate that they arise from measurements on compactified dimensions. If the KKD time dimension were to be compactified, this would imply that the measurements on it are measurements of its time direction. As in string theory, speeds at or near the speed of light can compactify size from near infinity to near zero so we have no knowledge of what would be the size of the KKD dimension if it could be observed in its own frame.

The KKD time dimension for electric charge is one of the basic constituents from which the preon model is built up and occupies a deeper layer than the preons. The idea was based by analogy on L.L.Thurstone's poles of the mind (from the 1930s) where mental decisions are based on aggregates of Thurstone's elementary poles or vectors. In the preon model, particle net quantum properties are based on an additive model of aggregates of compactified dimensions which are contained in the particles. My preon model has hexarks as a sixth layer within the preons, and septarks as a seventh layer, as deeper layers before one arrives at the individual compactified dimensions.[8][9]

There is a circular aspect to the relationship between electric charge and the thermodynamic or entropy arrow of time. What causes the electric charge dimension to have its own internal arrow of time? The electric charge dimension might need to have its own internal entropy direction.

Colour charge is related to electric charge

Time is not explicitly referred to in my Preon Model. Time is, however, implicit in the structures upon which the preon model is based. Fundamental particles of the Standard Model are here suggested to be composed of preons where the preons are themselves composed of hexarks. Colour charge is hypothesised also to be dependent on the direction of time (say red time) in a three dimensional (say red) space. So an antired colour is a property of entities travelling in the reverse direction of red time within red space. Further, in Preon Model #9, electric charge is directly dependent on colour charge so that negative electric charge is an aggregate of one red, one green and one blue QCD charge while positive electric charge is an aggregate of one antired, one antigreen and one antiblue charge. A complexity is that a left-handed red up quark is denoted by preons A' Cr C'g' C'b' where the apostrophe denotes 'anti' matter or 'anti' colour. Preon A' is net neutral with respect to colour and has electric charge +0.5. The three C preons are actually one-third preons and have electric charges of -1/6, +1/6 and +1/6, respectively. The total charge on that quark being 0.5 - 1/6 + 1/6 + 1/6 which is +2/3. So the complexity is that any quark, and indeed any fundamental particle in this model, is a mixture of matter and antimatter preons. Which means that properties are based on net charges and the reality of matter versus antimatter is much more complicated than in the Standard Model.[10] The definition of antimatter in the Standard Model is, however, adversely affected by a hangover from the classical idea of what the nature of matter is.

The relationship of weaker QED forces to the much stronger QCD forces explained here is perhaps strange given that the Yang-Mills nature of QCD is not present in QED. An analogy is that common salt is fairly neutral in interactions whereas the two components of sodium and chlorine, of salt, are highly reactive when alone. Similarly the three independent colour forces of QCD are strong when separate but, when all three colours are combined in a particle, the overall result is the much weaker electric force.

Time's arrow

Because of spacetime there is a give and take, or virement, between space and time, so that a particle's speed through space decreases its 'speed' through time. At any instant a particle has a vector in spacetime representing its time direction but over a time period that vector can vary in its time direction but limited such that it does not reverse its forwards-in-time travel in its own frame. As an analogy, if a particular time direction must be 'not southerly'

on a compass, then it can point anywhere between West, through to North, through to East. That is, free to point within the two northern quadrants. This attribute is similar to the trivector in three dimensional geometric algebra which can take values of +1 or -1. Effectively, a +1 trivector could represent forwards-in-time travel within the entire 3D and -1 would represent backwards-in-time travel within the 3D.

The arrow of time of a particle is similar to the spatial hidden variable of a particle. In References [4] [5] the precession of an electron or photon was compared to the precession of a gyroscope. A gyroscope spinning on a table top never has its axis pointing below the horizontal level of the table top. Over time, the gyroscope's axis points on average perpendicularly upwards. By analogy with the electron, upwards is the direction of the polarisation vector of the gyroscope. The direction the axis points towards at any particular time is the (spatial) hidden variable. For an electron, as for the gyroscope, the opposite of up is down, that is, opposites are rotations through 180 degrees. For a photon, the opposite of up is along the table, or the opposite of north is a 90 degrees rotation, say, east (or west). By analogy with a gyroscope the photon precesses in a tighter proximity to the average position of the axis or polarisation vector than occurs for the electron. Therefore, the relationship of the time vector of a particle at an instant to the trivector is a temporal equivalent to the relationship between the spatial hidden variable at an instant to the polarisation vector or average over time of the spatial hidden variable vectors.

Decoherence in quantum computers

Decoherence is a current problem for quantum computing. Decoherence can be, for example, a failure to maintain the Bell states of photons in a quantum computer circuitry long enough to reach the final measurements. The maintenance of coherence in my retrocausal model requires maintaining a pathway, in an optical circuit, for every spin -1 photon to be allowed to travel back in time and transmit its spin to a spin +1 photon travelling forwards in time. This may or may not be possible currently for all four Bell states to be maintained coherently.

Summary

It has been shown experimentally (Nobel prize in physics in 2022) that nature appears not to obey Bell's Theorem or, rather, that Bell's Theorem does not apply to nature as nature appears not to allow the use of Local Hidden Variables. The use of retrocausality (my References [4] and [5]) shows that Hidden Variables can explain the experimental results but

only at the expense of introducing backwards-in-time properties of some particles/photons. In my model, these retrocausal effects are proper or fully backwards in the particles' own frames. Most retrocausal models only allow a quasi-retrocausality where retro effects lie entirely within the bounds of Special Relativity where there is no universal absolute time. One absolute even in Special Relativity is that time for a particle in its own frame does not reverse time direction. In my model, particles which travel backwards in time can never travel forwards so that the Special Relativity rules are divided between the two groups of particles so that each group separately obeys Special Relativity within its own time direction.

The issue of the difference between matter and antimatter is explored here. The current idea of antimatter in the Standard Model is adversely affected by a hangover from what matter was taken to be in the classical era. The fact that an everyday classical object does not self-annihilate does not mean that the object is entirely made of matter. As also occurs with various other physicists' preon models, there is in my preon model an exact balance between amounts of matter and antimatter present at the preon level. The imbalance of matter/antimatter for atoms is caused by spontaneous symmetry breaking of positive charge entering the structure of the nuclei and negative charge forming electrons outside the nuclei.

Kaluza-Klein equations introduce a fifth dimension alongside the four of spacetime. This fifth dimension contains all the electric content. Because of compactification of dimensions, measurements on the fifth dimension are quantised into + and – quantities which are also indicative of the time direction within that fifth dimension. Electric charge is hence associated with a time direction. It is electric charge rather than matter/antimatter which determines the direction of travel in time of particles. For electrons and positrons, their electric charge signs agree with their matter/antimatter charges. The position is more complicated for photons in my preon model. Photons have an equal number of forwards-in-time preons as they have backwards preons, but the forwards in time preons (BB) contain spin +1, so a photon with spin +1 has that spin travelling forwards in time because it is associated with the positive electric charge of the B preons.

Colour charge of Quantum Chromodynamics directly causes the electric charge of Quantum Electrodynamics, at least in my preon model.[10] So the causation of time's arrow is also an effect of colour charge in addition to an effect of electric charge. Further, weak isospin is also a form of electric charge. Spin itself is the only quantum property not identified in my preon model as having an independent effect on time's arrow for particles. This lack of an independent effect of spin on time direction is probably the result of spontaneous symmetry breaking such that at an even deeper level of matter there is an independent effect which has been lost within preons by the symmetry breaking.

Some of the decoherence in optical quantum computers is possibly an effect of quantum circuitry not taking into account spin signs, and hence time directions, of the photons within the four Bell states which define entanglement.

5 December 2023
Manchester
England

References

[1] *Time Symmetry and the Einstein Paradox*. Costa de Beauregard, Olivier (1977). Il Nuovo Cimento.

[2] *Feynman's Thesis. A New Approach to Quantum Theory.* L. M. Brown (2005) World Scientific

[3] *The Two-State Vector Formalism: An Updated Review.* Aharonov, Yakir & Lev Vaidman. (2008) Time in Quantum Mechanics, Vol 1., Lect. Notes Phys. 734, 399

[4] *Malus's Law and Bell's Theorem with Local Hidden Variables.* Fearnley, A.J. (June 2020) https://vixra.org/abs/2006.0160

[5] *Bell's Theorem and Retrocausality.* Fearnley, A.J. (2022) viXra:2205.0140

[6] *Leptoquarks and Charged Higgs Using Preon Model #9.* Fearnley, A (2019) viXra:1907.0038https://vixra.org/abs/1907.0038

[7] *Theory of Fermion Masses, Mixing, Lagrangian Potentials and Weak Beta Decays, based on Higgs Bosons arising from the Scalar Fields of a Kaluza Klein Theory with Five-Dimensional General Covariance Provided by Dirac's Quantum Theory of the Electron.* Yablon, J. R. (2018) Researchgate. DOI: 10.13140/RG.2.2.10103.68007

[8] *Hexark and Preon Model #8 and the Unification of Forces: a Summary.* Fearnley, A.J (2017) https://vixra.org/abs/1907.0021

[9] *Hexark and Preon Model #8 and the Unification of Forces*. Fearnley, A.J (2017) https://vixra.org/abs/1709.0438

[10] *Hexark and Preon Model #6: the Building Blocks of Elementary Particles. Electric Charge is Determined by Hexatone and Gives a Common Link Between QED and QCD.* Fearnley, A.J (2015) https://vixra.org/abs/1505.0076

[11] *Bell Experiment Results Explained by Retrocausality: Implications for Quantum Cryptography, Quantum Computers and Action at a Distance*. Fearnley, A.J. (2022) https://vixra.org/abs/2210.0011

[12] *Antiparticles and the Nature of Space.* Fearnley, A.J. (2021) https://vixra.org/abs/2101.0179

[13] *Models for Quantum Gravity, Dark Matter and Dark Energy Using the Hexark and Preon Model #7*. Fearnley, A.J (2015) https://vixra.org/abs/1510.0338