

Future is not separate from the present or the past: Can temporal nonlocality in Quantum Entanglement explain Retrocausality (effect preceding the cause), Precognition and Déjà vu?

Jai Paul Dudeja

Professor and Director, Amity University Haryana, Gurgaon 122413, India.

ABSTRACT

According to the ancient wisdom in the scriptures reinforced by the assertions of Albert Einstein, the future is not separate from the present or the past, but all are one extending in multiple directions and dimensions until perceived by a conscious mind. So there could be effects in the present where the causes are hidden in the future and vice versa. This leads to phenomena like retrocausality, precognition, déjà vu etc, as areas in parapsychology. Leaving a few exceptions, even today parapsychology is considered as pseudoscience by a vast majority of mainstream scientists. But the times are changing fast. Many reputed physicists, neuroscientists, psychologists etc. are now joining hands and removing the 'classical view glasses' from their mental eyes and switching over to the 'quantum view glasses' to narrow down the gap between actual science and 'paranormal science'. The current paper is one such attempt in this direction. It takes the help of quantum entanglement to explain some of these paranormal experiences.

Keywords: Retrocausality, Precognition, Déjà vu, Temporal nonlocality, Quantum entanglement.

1. Introduction

Parapsychology is the study of paranormal and psychic phenomena, including telepathy, precognition, clairvoyance, psychokinesis, déjà vu, retrocausality, regression, near-death experiences, synchronicity, reincarnation, apparitional experiences, and other paranormal claims. Leaving a few exceptions, even today parapsychology is considered as pseudoscience by a vast majority of mainstream scientists. But the times are changing fast. Many reputed physicists, neuroscientists, psychologists etc. are now removing the 'classical view glasses' from their mental eyes and switching over to the 'quantum view glasses' to narrow down the gap between actual science and 'paranormal science'. The current paper is one such attempt in this direction. It takes the help of quantum entanglement to explain paranormal experiences.

1.1 About Link between Past, Present and Future: Circle of Time

According to ancient Hindu scriptures, Vedic time is not just a linear progression of seconds, minutes, hours, days and years. Within the cosmos, there are time cycles of differing lengths for each planetary system. Time is also a coordinate, and all events; past and future are to be found in different realms of the four dimensional space-time matrix. This understanding differs from the conventional view of space as being three dimensional, and it being impossible to visit the past or the future.

There are a variety of conceptions as to the nature of the universe: curved, flat, finite, infinite, and so on. Einstein's relativity predicts a curved universe, the curvature being due to gravity which in turn creates a lumpy universe with waves, valleys, vortexes, eddies, and innumerable geometric contortions, all of which affect the trajectory of light and the fourth dimension known as space-time. In a curved universe anyone traveling in a "straight line" across the cosmos would eventually return to where they started. Einstein's field equations predict that time is a circle and that the future leads to the past.

Einstein argued that the distinctions between the past present and future are an illusion and that the past, present and future differ according to location, gravity, and speed of movement. Like a flowing river, the "present," "past" and "future" are relative to the location of observer along the banks of that river; whereas in fact, the river has no present, past, future, or upstream or downstream, it just flows as its own unity. If space-time is curved as predicted by Einstein and if time is a circle, then the river of time is also a unity as predicted by quantum physics. However, in a curved universe, the future leads to the present and then the past. The past affects the present, the present affects the future and the future affects the pasts, and so on, in a cyclic way. The future is not separate from the present or the past, but all are one extending in multiple directions and dimensions until perceived by a conscious mind.

In the philosophical terms, it is identical to birth-to-death, the rebirth-to-death in the labyrinth of life [1]. By walking through the labyrinth, we trace the path of a long and difficult life on earth, beginning with birth, at the entrance, and ending with death at the centre and walking the labyrinth again and again. This point was discussed by this author [2] while interpreting the 'delayed choice quantum eraser' experiment, in which it appeared as if the photon generated in future (8 ns later) it could influence the interference with the photon that reached the interference screen at an earlier time. But the role of 'temporal nonlocality' was not introduced in that paper and hence it was concluded that there was no retrocausality in the interpretation of that experiment.

1.2 What is Retrocausality?

Retrocausality or backwards causation is a concept of cause and effect where the effect precedes its cause in time, so a later event in time can affect an earlier event in time. Retrocausality is sometimes associated with the nonlocal correlations that generically arise from quantum entanglement. There is an interesting example of retrocausality. A young married lady suddenly quit smoking one day without knowing any basis for the same. After some months she became pregnant. She could then realise why she quit smoking earlier because she knew that it would be harmful for her new born baby. This is a typical case where the effect preceded the cause, that is, the retrocausality.

A large company, A, which is a defendant in a Federal lawsuit with Plaintiff "B", promises the Judge "C", a large bribe at some future date if he rules against "B" and in favor of "A." After the Judge rules against "B" he receives his bribe. Thus the "cause" of this judge's behavior, the "bribe", took place at a future date, such that the future affected the "present" (the issuing of false rulings). The future is the cause which effects the present. The cause causes itself.

1.3 What is Precognition?

Precognition is the ability to perceive or see a future either through an Extrasensory Perception (ESP) of clairvoyance or otherwise, before it happens. The term 'Precognition' is derived from the Latin 'prae' – meaning 'prior to' and 'cognition' – meaning 'to gain knowledge. Precognitive events usually appear to individuals as a flash or spontaneous vision – when in an awakened state, a person receives a short intense mental scenario. One example could be that of a mother who is driving her car and suddenly sees a vision of her child injured in a playfield. She quickly takes a U-turn and on reaching the spot finds that her child was about to fall from a tall tree. This way she was able to save her child just at the nick of time.

Since consciousness is entangled with the quantum continuum, then not only may the mind perceive events before they take place, but they may perceive information traveling from the future to the past at superluminal speeds, and then continue to perceive it as time marches on into the future thereby providing the foundation for precognition and phenomenon such as *deja vu*.

1.4 What is Déjà vu?

Have you ever come across a situation when you feel that you had already seen or met a person who is sitting before you and engaged in a conversation? The fact is that you had never met him before. To take this case further, sometimes you even feel that some of the sentences being uttered by him have already been done by him before you. What is this? This is called *Déjà vu*. *Déjà vu* is a French term describing the feeling that one has lived through the present situation before. The phrase translates literally as "already

seen". Research has associated déjà vu experiences with good memory functions. When people experience déjà vu, they would have the recognition memory triggered by certain situations which they have never encountered. Recognition memory enables people to realize the event or activity that they are experiencing has happened before.

Deja vu is the conscious experience of having experienced some events just moments before the events take place. For example, a man opens the front door, step outside, drops his keys and then a dog barks and the phone rings, and then he again experiences himself opening the door dropping his keys and then hearing a dog bark and then the ringing of his phone; like a time echo. He thus has the experience that all this has happened before or that he has done this before it happens. He may even say: "I've done this before" and then a few nanoseconds later he experiences himself saying "I've done this before."

Deja vu has been attributed to a delay in the transfer of sensory experiences from one region of the brain to another which receives that information twice, or the transmission of the same experience to the same area of the brain by two different brain areas such that the information is received twice following a brief delay [6]. Hence, someone may experience déjà vu because two or more areas of the brain are receiving or processing the same message with a slight delay between them. For example, the right and left halves of the brain are interconnected by a massive rope of nerve fibers called the corpus callosum. Each half of the brain is capable of conscious experience. Usually information is shared between the cerebral hemispheres. However, if there is a delay in transferring these signals, then one or both halves of the brain may sense it has had these experience just moments before thereby giving a sense of familiarity.

1.5 What is Quantum Entanglement?

Quantum entanglement is a physical phenomenon that occurs when pairs or groups of particles are generated such that the quantum state of each particle cannot be described independently of the state of the others, even when the particles are separated by a large distance. Measurements of physical properties such as position, momentum, spin, and polarization, performed on entangled particles are found to be correlated. For example, if a pair of particles is generated in such a way that their total spin is known to be zero, and one particle is found to have clockwise spin on a certain axis, the spin of the other particle, measured on the same axis, will be found to be counterclockwise, as is to be expected due to their entanglement.

Such phenomena were the subject of a 1935 paper by Albert Einstein, Boris Podolsky, and Nathan Rosen, and several papers by Erwin Schrödinger shortly thereafter, describing what came to be known as the EPR paradox [3]. Einstein and others considered such behavior to be impossible, as it violated the local realism view of causality (Einstein referring to it as "spooky action at a distance"). EPR asserted that if such an instant entanglement phenomenon is accepted between the two particles separated by a very large distance; this will violate the maximum limit of the speed of light. Therefore they argued that the accepted formulation of quantum mechanics must therefore be incomplete. Only after the realization of an experiment suggested by Bell [4, 5], was the nonlocal nature of quantum mechanics widely accepted.

1.6 What is Nonlocality in Quantum Entanglement?

Basically, the general "principle of locality" requires that "for an action at one point to have an influence at another point, something in the space between the points, such as a field, must mediate the action". In view of the theory of relativity, the speed at which such an action, interaction, or influence can be transmitted between distant points in space cannot exceed the speed of light. This formulation is also known as "Einstein locality" or "local relativistic causality". It is often stated as "nothing can propagate faster than light, be it energy or merely information" or simply "no spooky action-at-a-distance", as Einstein himself put it.

The phenomenon of entanglement between quantum systems raised the nonlocality problem first noted in the EPR paper: A projective measurement on a quantum system at one space location instantly collapses the state of an entangled counterpart at a distant location. Quantum mechanical nonlocality refers to this apparent entanglement-mediated violation of Einstein locality. Although entanglement correlations are affected instantaneously, they cannot be harnessed for faster-than-light communications. The reason is that the outcome of the local projective measurement is itself statistic and cannot be predicted beforehand.

1.7 What is ‘Spatial Nonlocality’ in Quantum Entanglement?

Until recently, the two (or more) quantumly entangled objects, satisfying the criterion of non-locality, could be located at any distance apart. This is called the ‘Spatial Nonlocality’ in Quantum Entanglement. It is to this type of large separation to which Einstein referred to as ‘spooky action’ because it violated the maximum limit of speed of light.

1.8 What is ‘Temporal Nonlocality’ in Quantum Entanglement?

The non-locality of quantum mechanics, as manifested by entanglement, does not apply only to particles with space-like separation, but also to particles with time-like separation. If the two objects are located at two different times (instead of different points in space) and are entangled, this is called ‘temporal nonlocality’. It means that the second object (which was generated at a subsequent time) was entangled with the first object which existed in the past, and vice versa. We shall illustrate the phenomenon of ‘temporal nonlocality’ subsequently in this paper.

The future, past, present, and consciousness are entangled within the quantum continuum. The future exists before it arrives and some people consciously perceive a future before it becomes the present; phenomenon which can be classified as evidence of entanglement and which are variably experienced as *deja vu*, premonitions, and precognition.

2. Path-breaking Experiment of Megidish et al

With various terms defined and briefly explained in the ‘Introduction’, we are now equipped to discuss a path-breaking experiment conducted by Megidish and his colleagues in Israel in 2013 [7]. Before we describe this experiment in details, it is pointed out that this experiment is a wonderful demonstration of temporal nonlocality on quantum entanglement between two photons. In order to demonstrate these principles, an entangled pair of photons was generated that had never coexisted. Using entanglement swapping between two temporally separated photon pairs, one photon was entangled from the first pair with another photon from the second pair. The first photon was detected even before the other was created. The observed two-photon state demonstrates that entanglement can be shared between time-like separated quantum systems.

Until recently, most experiments have tested entanglement over spatial gaps. The assumption is that the ‘nonlocal’ part of quantum nonlocality refers to the entanglement of properties across space. But what if entanglement also occurs across time? Is there such a thing as temporal nonlocality? For example, could a future in system "X" be entangled with a "past" or "present" in system "Y", and could information therefore pass from one to the other instantaneously? The answer is yes.

Just when you thought quantum mechanics couldn’t get any weirder, a team of physicists at the Hebrew University of Jerusalem reported in 2013 that they had successfully entangled photons that never coexisted [7]. Previous experiments involving a technique called ‘entanglement swapping’ had already showed quantum correlations across time, by delaying the measurement of one of the coexisting entangled particles; but Eli Megidish and his collaborators were the first to show entanglement between photons whose lifespan did not overlap at all.

Single photons are used as quantum particles in many experimental realizations, as they are easily manipulated and preserve their coherence for long times. A common method for generating polarization entangled photon states is using the nonlinear optical process of parametric down-conversion (PDC) in dielectric crystals. In this process, a pump photon splits into two lower-energy photons while preserving momentum and energy. With this method it is possible to create high-quality two photon states in any of the four maximally entangled states.

$$|\phi^\pm\rangle = \frac{1}{\sqrt{2}} (|h_a h_b\rangle \pm |v_a v_b\rangle)$$

$$|\psi^\pm\rangle = \frac{1}{\sqrt{2}} (|h_a v_b\rangle \pm |v_a h_b\rangle) \quad (1)$$

where $h_a(v_b)$ represents a horizontally (vertically) polarized photon in spatial mode a (b).

Photons can also be entangled by projection measurements onto maximally entangled states

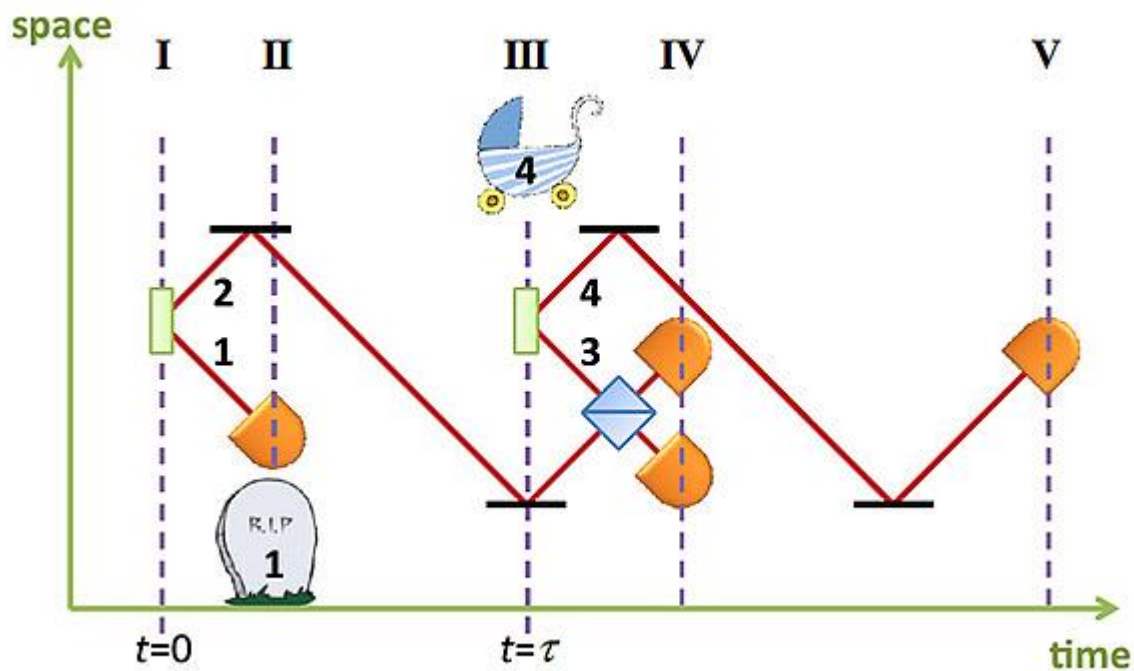


Figure 1: Time line diagram. (I) birth of photons 1 and 2. (II) detection of photon 1. (III) birth of photons 3 and 4. (IV) Bell projection of photons 2 and 3. (V) detection of photon 4.

The entanglement swapping protocol entangles two remote photons without any interaction between them. Referring to Figure 1, each of the two photons belongs initially to one of two independent entangled photon pairs (e.g., photons 1 and 4 of the entangled pairs 1-2 and 3-4). The two other photons (2 and 3) are projected by a measurement onto a Bell state. As a result, the first two photons (1 and 4) become entangled even though they may be distant from each other.

In this work it is demonstrated how the time at which quantum measurements are taken and their order, has no effect on the outcome of a quantum mechanical experiment, by entangling two photons that exist at separate times. This is achieved by first creating one photon pair (1-2) and right away measuring photon 1 (see Fig. 1). Photon 2 is delayed until a second pair (3-4) is created and photons 2 and 3 are projected onto the Bell basis. When photon 1 is measured in a certain basis, it does not 'know' that photon 4 is going to be created, and in which basis it will be measured. Nevertheless photons 1 and 4 exhibit quantum correlations despite the fact that they never coexisted.

In order to generate consecutive photon pairs at well defined times, a pulsed laser is used to pump a single PDC polarization entangled photon source. It is a probabilistic source, and thus there is a probability that two pairs will be created, each pair from one of two consecutive pulses, separated by the laser period time τ . The four-photon state is

$$|\psi^- \rangle_{a,b}^{0,0} \otimes |\psi^- \rangle_{a,b}^{\tau,\tau} = \frac{1}{2} (|h_a^0 v_b^0 \rangle - |v_a^0 h_b^0 \rangle) \otimes (|h_a^\tau v_b^\tau \rangle - |v_a^\tau h_b^\tau \rangle) \quad (2)$$

where the subscripts are the spatial mode labels and the superscripts are the time labels of the photons. In order to project the second photon of the first pair and the first photon of the second pair onto a Bell state, the former is delayed by τ in a delay line. The same delay is also applied to the second photon of the second pair and the resulting state can be reordered and written as

$$|\psi^- \rangle_{a,b}^{0,\tau} \otimes |\psi^- \rangle_{a,b}^{\tau,2\tau} = \frac{1}{2} (|\psi^+ \rangle_{a,b}^{0,2\tau} |\psi^+ \rangle_{a,b}^{\tau,\tau} - |\psi^- \rangle_{a,b}^{0,2\tau} |\psi^- \rangle_{a,b}^{\tau,\tau} - |\phi^+ \rangle_{a,b}^{0,2\tau} |\phi^+ \rangle_{a,b}^{\tau,\tau} + |\phi^- \rangle_{a,b}^{0,2\tau} |\phi^- \rangle_{a,b}^{\tau,\tau}) \quad (3)$$

When the two photons of time τ (photons 2 and 3) are projected onto any Bell state, the first and last photons (1 and 4) collapse also into the same state and entanglement is swapped. The first and last photons, that did not share between them any correlations, become entangled. According to this description, the timing of each photon is merely an additional label to discriminate between the different photons, and the time in which each photon is measured has no effect on the final outcome. The first photon from the first pair (photon 1) is measured even before the second pair is created (see Fig. 1). After the creation of the second pair, the Bell projection occurs and only after another delay period is the last photon from the second pair (photon 4) detected. Entanglement swapping creates correlations between the first and last photons non-locally not only in space, but also in time. Quantum correlations are only observed a posteriori, after the measurement of all photons is completed.

3. Another Experiment to demonstrate Retrocausality

In yet another experiment performed by Leifer and Pusey [8, 9] the usual idea of time symmetry in physics has been reformulated, which is based on reversing a physical process by replacing t with $-t$ in the equations of motion. The authors develop a stronger concept of time symmetry in which reversing a process is not only possible but that the probability of occurrence is the same whether the process is going forward or backward. They describe an experiment in which the time symmetry assumption requires that the forward and backward processes have the same probabilities, but the no-retrocausality assumption requires that they are different.

So ultimately everything boils down to the choice of whether to keep time symmetry or no-retrocausality, as you can't have both. Since time symmetry appears to be a fundamental physical symmetry, they argue that it makes more sense to allow for retrocausality. Doing so would eliminate the need for action-at-a-distance in Bell tests, and it would still be possible to explain why using retrocausality to send information is forbidden.

Having retrocausality potentially allowed the authors [8,9] to resolve the issues raised by other no-go theorems, that is, it enabled them to have Bell correlations without action-at-a-distance. Further, the existence of an arrow of time already has to be accounted for by thermodynamic arguments, i.e., it is a feature of the special boundary conditions of the universe and not itself a law of physics. Since the ability to send signals only into the future and not into the past is part of the definition of the arrow of time, it seemed likely that the inability to signal into the past in a retrocausal universe could also come about from special boundary conditions, and does not need to be a law of physics.

4. Discussions, Interpretation and Implications of these Experiments

Having discussed these experiments, and introduced retrocausality, precognition, déjà vu etc., let us now discuss their implication in the field of parapsychology.

Every particle, person, planet, star, galaxy, has a wave function. The brain and consciousness have a wave function. Reality, including the reality of time, is a manifestation of wave functions and alterations in patterns of activity within the quantum continuum which are perceived as discontinuous. This also gives rise to the perception of temporal order and what comes first, second, third, and what is in the present and in the past. The perception of temporal order, and structural units of information are not just perceived, but inserted into the quantum state which causes the reduction of the wave-packet and collapse of the wave function.

The brain and mind of a time traveler also has a wave function. As predicted by Einstein's field equations, consciousness can be accelerated into the future, and from the future, into the past. The Time traveler, upon observing his surroundings causes a collapse of the wave function.

The phenomenon of premonition must be considered from the perspective of quantum physics not Newtonian physics or Einstein's theories of relativity. The future may effect and even direct the past or the present. Entanglement has also been demonstrated among photons which do not yet exist, where the choice has not even been made to create or measure future photons. Nevertheless, decisions which will be made in the future effect the measurement of photons in the present. The same principles can be applied to precognition. Information in the future, information which does not yet exist in the present, can effect and is entangled with the consciousness which will directly perceive that information even before it arrives in the present.

The future, past, present, and consciousness are entangled within the quantum continuum. The future exists before it arrives and some people consciously perceive a future before it becomes the present; phenomenon which can be classified as evidence of entanglement and which are variably experienced as déjà vu, premonitions, and precognition and which would only be possible if the future already exists, and if time is a circle.

The past and future exist simultaneously in different and overlapping locations in space. Since space is isotropic, then, theoretically, there are no roadblocks to prevent a time traveler from choosing a location at will and then speeding into the future or the past; just as he may decide to go up-river or down-river.

Entanglement can occur independent of and before the act of measurement and choices made in the future can affect the present. "The time at which quantum measurements are taken and their order, has no effect on the outcome of a quantum mechanical experiment"[7]. Moreover, "two photons that exist at separate times can be entangled". In the scenario measuring the last photon affects the physical description of the first photon in the past, before it has even been measured. Thus, the "spooky action" is steering the system's past. Another point of view...is that the measurement of the first photon is immediately steering the future physical description of the last photon. In this case, the action is on the future of a part of the system that has not yet been created. Hence, entanglement between photons has been demonstrated even before the second photon even exists;

The same principles can be applied to conscious phenomenon, including the experience of déjà vu and premonitions; i.e. experiencing an event before it occurs. In fact, the same could be said of feelings such as "anxiety" about what may happen before it happens, or logical thought processes of predicting what will happen before it happens--all of which may be made possible not by anticipation but by the future effecting the present. Premonitions and entanglement also prove the future exists before it becomes the present.

In April of 1965, less than two weeks before he was gunned down by an assassin's bullet, President Abraham Lincoln dreamed of his own assassination. Lincoln told this dream to his wife and to several friends including Ward Hill Lamon who was Lincoln's personal friend, body guard and former law partner.

We have been here before, we will be here again, we will always be, and this is because time and consciousness are a quantum continuum and the distinctions between past present and future are illusions.

5. Conclusion

Parapsychology is the study of paranormal and psychic phenomena, including telepathy, precognition, clairvoyance, psychokinesis, déjà vu, retrocausality, regression, near-death experiences, synchronicity, reincarnation, apparitional experiences, coincidences, and other paranormal claims. Leaving a few exceptions aside, even today parapsychology is considered as pseudoscience by a vast majority of mainstream scientists. But the times are changing fast. Many reputed physicists, neuroscientists, psychologists etc. are now joining hands and removing the 'classical view glasses' from their mental eyes and switching over to the 'quantum view glasses' to narrow down the gap between actual science and 'paranormal science'. In this paper, we have discussed two experiments on 'quantum entanglement', the first one [7] involving 'temporal nonlocality' and 'entanglement swapping', and the second experiment [9] involving 'time symmetry'. It was argued that it is possible to show the phenomenon of retrocausality (effect preceding the cause), precognition and déjà vu. It is obvious that one has to go a long way to extend

this concept from micro-particles to human beings to reach some meaningful conclusion. But the effort in this direction will open the floodgates in the as-yet-vague areas of consciousness, mind and paranormal phenomena.

References

1. Dudeja, Jai Paul, "Labyrinth Walking: Origin, Patterns, Significance, Walking Procedures and Spiritual Benefits", International Journal of Yogic, Human Movement and Sports Sciences, (ISSN: 2456-4419), Vol. 3, Issue 2, Part K, 2018, pp 666-673.
2. Dudeja, Jai Paul, "Can we influence certain events that occurred in the past? Interpreting 'delayed choice quantum eraser' experiment", International Journal of Research and Analytical Reviews (IJRAR), (ISSN: 2348-1269), Vol. 6, Issue 2, Apr-June 2019, pp.217-226. <http://doi.org/10.1729/Journal.20381>
3. Einstein, A., B. Podolsky, and N. Rosen, Phys. Rev. 47, 777 (1935).
4. Bell, J. S., Physics 1, 195 (1964).
5. Aspect, A., P. Grangier, and G. Roger, Phys. Rev. Lett. 47, 460 (1981).
6. Joseph, Rhawn Gabriel, "Consciousness Of The Future: PreCognition, Premonition, Déjà vu", Journal of Cosmology.com, Vol. 18, 2014. BrainMind.com
7. Megidish, E., A. Halevy, T. Shacham, T. Dvir, L. Dovrat, and H. S. Eisenberg, "Entanglement Swapping between Photons that have Never Coexisted", Phys. Rev. Lett. 110, 210403 – Published 22 May 2013
8. Lisa Zyga, "Physicists provide support for retrocausal quantum theory, in which the future influences the past" Phys.org, July 5, 2017. <https://phys.org/news/2017-07-physicists-retrocausal-quantum-theory-future.html>
9. Matthew S. Leifer and Matthew F. Pusey, "Is a time symmetric interpretation of quantum theory possible without retrocausality?" Proc. Royal Soc. A, 21 June 2017. <https://doi.org/10.1098/rspa.2016.0607>