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Solving the instantaneous response paradox of entangled particles using the time of events theory

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Abstract:

In the present study, a new theory that relates the special theory of relativity with quantum mechanics is formulated and then used to explain the remote instantaneous response of entangled particles without the assumptions of nonlocality or hidden variables. The basic assumptions of the present theory stands on the foundation of two space times, namely, the static and dynamic space times, in which the latter contains space points that move at the speed of light. The remote instantaneous interaction of the entangled particles is due to the closeness of these particles to each other in the dynamic space time in spite of remoteness from each other in the static space time.

1. Introduction:

Numerous mysterious phenomena in quantum mechanics such as measurement effect and wave particle duality, as well as Einstein–Podolsky–Rosen (EPR) paradox and entanglement, still require concrete explanation [1]. Bell's inequality set the path toward the concept of nonlocality of entangled particles [2]. Hardy's proof showed that the inequality is not necessary, and only four dimensions in Hilbert space are needed to express the nonlocality [3]. Some later theories such as scale relativity theory depend on fractals in describing continuous non-differentiable space time (fractal space time) [4, 5]. Some theories generalized the world line formulation of two- time physics by including background fields. Conventional classical or quantum mechanics as well as one time field theory are considered ‘‘shadows’’ of two time physics systems with one less time and one less space dimension [6, 7]. One of the most important theories that have gained popular attention is the double special relativity (DSR), which is a generalization of the special relativity that introduces a second invariant scale, in addition to the speed of light *c* [8–11]. DSR assumes a physical energy (or length), which is the

Planck energy (or Planck length), joins the speed of light as an invariant, in spite of a complete relativity of inertial frames and agreement with Einstein's theory at low energies. This condition is accomplished by a non linear modification of the action of the Lorentz group on momentum space, which is generated by adding a dilatation to each boost in such a way that the Planck energy remains invariant. However, a space time that is compatible with momentum-space DSR principles could not be derived (or may be derived but with inconsistencies in classical space time) as stated by [12, 13].

All the aforementioned studies, among others, provided satisfactory descriptions of the space time in their attempt to explain the mysterious phenomena in quantum mechanics and in unifying quantum mechanics with relativity theories. Nevertheless, no available theory can provide transformations for time and space that can be used to analyze the quantum mechanics phenomena (e.g., entanglement and EPR paradox) that are simultaneously consistent with the classical space time. Hence, transformations that are applicable to both at micro and macro scales and for both micro and macro masses are not available.

The present work aims to formulate transformations that are applicable for micro and macro observers based on a new theory, which can be used to solve instantaneous response of entangled particles. This new theory uses Hubble's relation and special relativity to obtain transformations between classical and microscopic or zero-rest mass particles (ZRMPs). These transformations will then be related to quantum mechanics to elucidate the instantaneous response of entangled particles (which is one of the largest enigmas in modern physics [14]) by assuming dynamic, instead of static, space time.

2. Postulates and theoretical concepts of the theory

The present theory is based on the assumption that the expansion force of the universe leads to the movement of space. Space is supposed to be composed of infinite points that radially move with the space expansion radially outward toward the edges of the universe. These points are assumed to move at the speed of light, thereby creating the velocity limit at the speed of light. The velocity (or speed) limit is assumed to be accompanied by time limit. This time is called the time of events manufacturing (or briefly, time of events) because it is the time associated with the fastest transition of interaction of any force at speed of light, which include moving with space points. The combination of the moved spatial coordinates and the time created by this movement is called dynamic space time. Unlike the special theory of relativity, the present theory assumes that the space time is a dynamic space time, which involves movement of space, not just interaction transmission in space. According to the present theory, the photon movement at the speed of light is caused by its perfect response to the movements of space time. The present theory also assumes that the direction of movements of such dynamic space time is the same as the direction of the expansion force of the universe. Accordingly, the directions of movements are toward the outer edges of the universe or in radially outward directions. At each point in static space time, the dynamic space time movements appear like a ripple that starts from a minimum length (can be considered as Planck length) and then the ripple radius increases in a speed equal to the speed of light relative to the starting point in the static space time.

The interactions between different particles and space points during their motion caused by the expansion of the universe are classified into the following three types of interactions according to particles masses:

1. Heavier mass particles (classical objects) produce relatively higher distortion in the movements of space points, which minimize their response to expansion force. However, these particles still have speeds in the radial direction according to Hubble's law of expansion.
2. Tiny non-ZRMPs (microscopic objects) have very little (or negligible) effects on the distortion of the movements of space points. Therefore, these particles have higher speeds (caused by the expansion force) than the classical objects. However, these speeds are still less than the speed of light because the particles have non-zero rest masses.
3. ZRMPs transfer with the space points at the same speed (speed of light) in vacuum in radial outward direction.

Differences in the responses of the different type particles to the expansion force result in the differences in relative speeds of expansion among these particles, which consequently results in the differences in time evolution of such particles caused by the expansion. Given the differences in the interactions between the different types of particles with space points, assuming that the two-dimensional (ct,x) traditional representation of world lines of a zero mass particle moving at the x dimension relative to a classical observer is not applicable because zero mass particles have additional components of movements (that originates from their high response to expansion force). Minkowski space representation is modified to consider the differences in responses to the expansion force of the different types of particles. The effects of the differences in the responses to the expansion force on the relative movement of the different types of particles, especially a ZRMP and a classical observer are considered in rebuilding such representation.

Assuming that similar equations relate the speeds of tiny and ZRMPs with their distances from the earth during expansion, two equations are added to the traditional Hubble's equation. The first equation (eq. (1)) relates the expansion speed of ZRMPs with their distance from the earth, whereas the second equation (eq. (2)) relates to the expansion speed of the tiny particles with their distance from the earth. Both speeds are measured by a classical object for easy comparison. The relations are given as follows:

$$v_p = H_p r \qquad (1)$$

$$v_t = H_t r \qquad (2)$$

where v_p and v_t are the expansion velocities of the ZRMPs and tiny particles, respectively, H_p and H_t are assumed constants (they may be variables) of expansion of the ZRMPs and tiny particles, respectively (that are equivalent to Hubble's constant of expansion of the classical objects), and r is the distance from the center of the earth.

The classical Hubble's relation of the classical objects is given as:

$$v_c = Hr \qquad (3)$$

where v_c is the expansion speed of the classical objects, and H is the Hubble's constant. In eq. (1), v_p for small values of r is equal to the speed of light. As r becomes extremely large, the expansion speed as measured by Doppler shift may exceed the speed of light because of the accumulation effects caused by the accelerated expansion of the universe. Hence, the speed of light is constant. To determine the value of H_p in eq. (1), theoretically, as r approaches the wavelength λ, the velocity v_p must be equal to c, which means that H_p is not constant and is equal to the frequency f. This observation produces the usual equation that relates frequency and wavelength with the speed of light.

$$c = \lambda f \tag{4a}$$

This principle is also true for tiny particles (microscopic particles), but the velocity of a tiny particle is assumed to be v_t instead of c as r approaches λ:

$$v_t = \lambda f \tag{4b}$$

where H_t is assumed to be equal to the frequency f of the tiny particle, and λ is the De Broglie's wavelength. The expansion constants are assumed to be variables in the case of ZRMPs and tiny particles because the mechanisms of responses of these particles to the movements of the dynamic space time is by making a resonance state with the closest frequency of the dynamic space time ripple that is similar to their frequency. Classical objects have constants of expansion because the range of frequencies of the ripples of the dynamic space time is much larger than the resonance frequency of the classical objects. Therefore, these objects have similar responses to the dynamic space time movement, which is encountered by Hubble's constant.

If two different types of particles, such as a photon and a classical object, started expanding from the same point in space, after a time interval Δt, the difference in their relative distances is given by eq. (5)

$$v_p \Delta t - v_c \Delta t = r_2 - r_1 = \Delta r \tag{5}$$

where r_2 and r_1 are the distances from the center of the earth of a photon and a classical object after a time interval Δt, respectively. The time interval is assumed to be measured by the classical object. The difference in this distance Δr is in the radially outward direction, which is the direction of expansion of the universe. Δr should always be perpendicular to any movement of the classical observer other than the movement from expansion given by Hubble's law of expansion. This condition is true with negligible Hubble's expansion of a classical object because any movement is in the static space time that is confined around the object while the space points continue in crossing the classical object perpendicularly toward the radial direction during its movement.

To build a dynamic space time model, the Minkowski space time diagram should be modified. The first step is by changing the dynamic space time axes relative to the axes of ordinary Minkowski space time axes. Given that the space points are moving radially outward toward the edges of the universe, in considering two axes *ct* and *x* in static space time, these axes in dynamic space time will be moved upward toward the radial outward direction at a speed of light with a slope that is equal to one relative to its corresponding static axes. Therefore, to represent the world line of a particle that is moving with space points at the same speed, the representation should be drawn upward that is 90° relative to the static (*ct*,*x*) plane because the direction of expansion of the space points is perpendicular to the static plane. The schematic diagram of the dynamic and static space times with the world lines of zero rest mass and classical observers are shown in fig. 1.

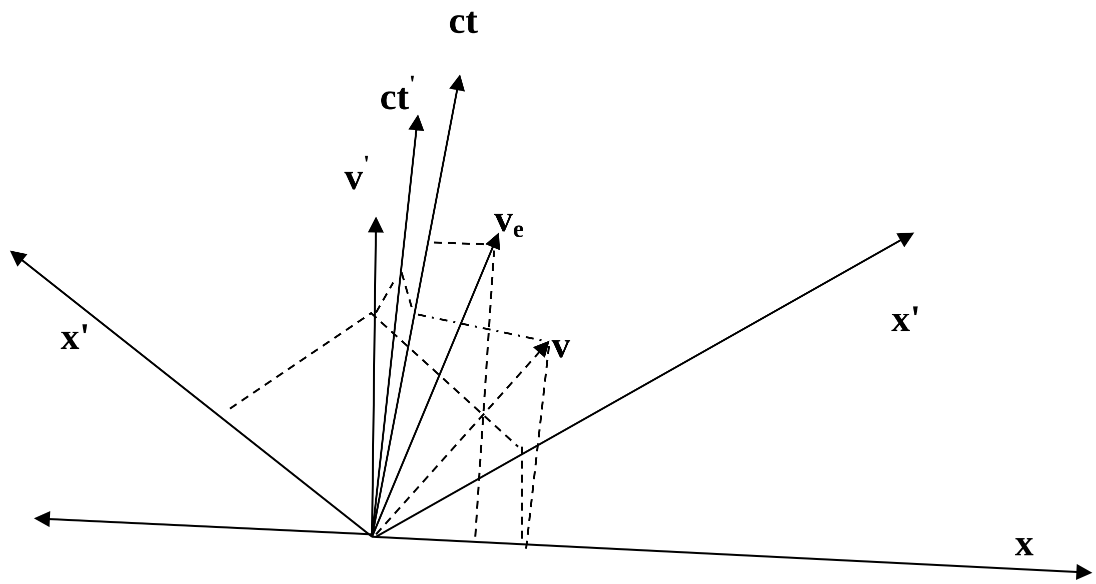

Fig. (1): schematic diagram of static space time represented by x,ct plane and dynamic space time represented by x',x",ct' axes. The world lines denoted by v' and v_e are for zero rest mass and classical observers respectively.

The static *ct*,*x* plane is assumed to become a cone of *x*', *x*",*ct*' peripheral axes (fig. 1). The *x*-dimension is divided into two axes, that is, positive *x* becomes *x*' and negative *x* becomes *x*" in the dynamic space time. This splitting of spatial axes occurs at every spatial point and at every moment, which suggests a fractal-shaped dynamic space time relative to the static space time. This observation agrees with studies conducted based on the fractal space time, especially at Planck scale lengths [4, 5]. To simplify the problem, we will only assume certain symmetry of the problem that can provide the appropriate transformations. Therefore, the origin of coordinates of a certain event at the dynamic space time should be chosen carefully to obtain the best solution from the symmetry of the problem. As noted from fig. 1, the number of dimensions is increased by one spatial dimension because of the splitting of one static spatial dimension into two dynamic spatial dimensions at the direction of expansion (which is the direction of movement of the ZRMP relative to the classical observer). Other dimensions that are perpendicular to the direction of expansion can be considered as equal to their counterparts. A ZRMP cannot be observed moving radially outward when viewed by a classical observer because in the case of ZRMPs, the relative movement is triggered by the differences in the response to the movements of space points, which is accompanied by splitting of one spatial coordinate. The splitting of this spatial axis makes the observation of the real direction of movement of the ZRMP impossible for a classical observer because the classical observer has a different number of dimensions. Thus, the classical observer cannot observe the movement of the ZRMP at this dimension, but it can observe the projection of this movement on a *ct*,*x* plane (fig. 1). Instead of the world line being represented by v', the classical observer sees the ZRMP moving on the world line represented by v. Graphically, this representation can be found as follows:

First, the values of *ct*' and *x*' or *x*'' for a certain point at the world line v' are determined. Then, these values of *ct*' and *x*' or *x*'' are projected on *ct*- and *x*-axes, respectively. The projected point represents the classically observed point, which corresponds to the original point at the ZRMP world line. All points at the world line of the ZRMP are similarly projected on *ct*,*x* plane, which determines the classically observed world line of the original ZRMP world line. Thus, the v' world line is observed as v world line on the *ct*, *x* plane. The photon can distinguish that it precedes the classical object at the radial direction, but the classical object cannot distinguish that the photon is ahead in the direction of expansion of the universe because of the differences in dimensions between the dynamic space time (ZRMP space time) and the static space time (classical observer space time).

To obtain transformations between a ZRMP and a classical observer, ZRMP is assumed to be moving with velocity v' relative to a stationary classical observer, which is v as observed by this classical observer. Another classical observer is moving with velocity v_e relative to the stationary classical observer (fig. 1). Magnitude $|v|$ must equal to $|v'| = c$, but with different directions. Although the stationary observer sees v not v', transformation velocity v' is used because it describes a more reliable case. The relative velocity between the ZRMP and the moving classical observer is determined first, and then the value is substituted in the Lorentz transformations while considering the splitting of the dimension at which the ZRMP is moving. fig. 1 also shows that, according to the present theory, the velocity of the ZRMP relative to the classical observers originates from the difference between their interactions with the space points. Thus, the relative movement between the ZRMP and the classical observer is not a spatial movement. Instead, the relative movement originates from the movement of the dynamic space time relative to the classical observer. The movement of the moving classical observer relative to the stationary one is due to spatial movements only because they have similar interactions with space points and they are at relatively close distance, wherein the movement caused by the Hubble's law can be neglected. Therefore, two kinds of relative velocities exist, that is, one caused by the differences in interaction with space points and the other caused by the spatial movements. To determine the relation between these two kinds of relative velocities, the relative movement between the ZRMP and the classical observer relative to the stationary observer is considered. If the movements occur during a time interval Δt, then the difference in distances ΔR between the ZRMP and the moving classical observer as measured by a stationary observer at the origin is:

$$\overrightarrow{\Delta R} = \overrightarrow{v'}\Delta t - \overrightarrow{v_e}\Delta t \qquad (6)$$

If we figure out carefully the origin of the velocities v_e and v', we will find that v_e is due to the dynamic in space at a certain time interval, whereas v' is due to the difference in the interaction with space points in which their movement forms the time of events. Therefore, the relationship between v' and v_e is similar to the relationship between *ct* and *x* at a certain place. Accordingly, $\overrightarrow{\Delta R}$ is a four-vector quantity, and its magnitude is given as:

$$\left(\overrightarrow{\Delta R}\right)^2 = (v'\Delta t)^2 - (v_e\Delta t)^2 \qquad (7)$$

Equation 7 shows that v_e must be imaginary to make $\overrightarrow{\Delta R}$ a four-vector quantity. Accordingly, the velocities that originated from the change in relative positions at space at a certain time interval are assumed imaginary, whereas the velocities that originated from the difference in interaction with space points are assumed real. These assumptions can be reversed if the event occurs at the frame of the classical observer. To express the relative velocity v_r between ZRMP and the moving classical observer, the following expression is assumed:

$$\vec{v}_r = \overrightarrow{v'} + i\overrightarrow{v_e} \qquad (8)$$

The value of $(v_r)^2$ can be determined using the following equation:

$$v_r{}^2 = v'^2 - v_e^2 + 2iv'v_e(\hat{j}'.\hat{j}) \qquad (9)$$

where $\hat{j}'$and $\hat{j}$ are unit vectors directed towards v' and v_e, respectively. In the imaginary part, the factor $\hat{j}' \cdot \hat{j}$ must be zero because v' is perpendicular to v_e as supposed previously (the direction of movement of space points is perpendicular to any movement of the classical observer). Thus, eq. 9 becomes:

$$v_r{}^2 = v'^2 - v_e^2 \qquad (10a)$$

If $\hat{j}'$ is not perpendicular to $\hat{j}$, as for particles with speeds less than the speed of light, then ${v_r}^2$ can be given as follows:

$$ {v_r}^2 = v_r v_r^* = v'^2 + v_e^2 \quad (10b) $$

To determine the appropriate transformations between ZRMP and a classical observer, we should begin from the Lorentz invariance. To account for the splitting of the *x*-axis and the conservation of the Lorentz invariance during the transformations as well as in reference to fig.1, the classical Lorentz invariant condition of the classical objects must be equal to an additional two terms from the Lorentz invariance conditions of the ZRMP, that is, one term for the *x*'-axis and another for the *x*''-axis. This equation can be written as follows:

$$ (ct'cos\theta)^2 - (x'cos\theta)^2 + (ct'cos\theta)^2 - (x''cos\theta)^2 = (ct)^2 - (x)^2 \quad (11) $$

where θ is the angle between each static space time dimension and its corresponding dynamic space-time dimension. θ is equal to 45° to maintain constant speed of light, which represents the speed of the dynamic space time. *x*' and *x*'' are the spatial dimensions at the dynamic space time that correspond to the positive and negative *x* coordinates, respectively, at the static space time. Eq. 11 can be rewritten as follows:

$$ 2(ct'cos\theta)^2 - ((x'cos\theta)^2 + (x''cos\theta)^2) = (ct)^2 - (x)^2 \quad (12) $$

If the origin forms an even symmetry point between *x*' and *x*'' for certain time *t*', *x*' is equal in magnitude to *x*''. In addition, the *x*-axis is split to two axes, whereas the *t*' values from the Lorentz invariance conditions of *x*' and *x*'' are added, resulting in 2*t*'. To write the invariant condition versus one variable of either *x*' or *x*'', both terms $x'cos\theta$ and $x''cos\theta$ should be equal in magnitude at certain *t*' value. Eq. 13 can be rewritten as

$$ 2(ct'cos\theta)^2 - 2(x'cos\theta)^2 = (ct)^2 - (x)^2 \quad (13) $$

for one direction of *x*' or *x*''. Substituting the value of θ (45°) and canceling similar terms yield:

$$ (ct')^2 - (x')^2 = (ct)^2 - (x)^2 \quad (14a) $$

or as a function of *x*'', it becomes

$$ (ct')^2 - (x'')^2 = (ct)^2 - (x)^2 \quad (14b) $$

which is the traditional form of the Lorentz invariance.

Using the relative velocity v_r from eqs. 8 and 10 in the Lorentz invariant condition, the generalized Lorentz transformations between ZRMP and moving classical observer are determined as follows:

$$\acute{t} = \gamma\left(t - \frac{\vec{x}}{c^2}.\left(\overrightarrow{v'} + i\overrightarrow{v_e}\right)\right) \tag{15a}$$

$x' = \gamma(x - (v' + iv_e)t)$ For positive x values

$x'' = \gamma(-x + (v' + iv_e)t)$ For negative x values

$\acute{y}$ =y

$\acute{z} = z$

Fig. 1 shows that the angle between $\vec{x}$ and $\vec{v}$ is 90°, whereas $\overrightarrow{v_e}$ is at the $\vec{x}$ direction. Substituting in eq. 15a gives

$$\acute{t} = \gamma\left(t - \frac{x}{c^2}(iv_e)\right) \tag{15b}$$

The inverse generalized Lorentz transformations are obtained by changing the sign of the relative velocity:

$$t = \gamma\left(t' + \frac{\overrightarrow{x\prime}}{c^2}.\left(\overrightarrow{v'} + i\overrightarrow{v_e}\right)\right)$$

$$t = \gamma\left(t' - \frac{\overrightarrow{x\prime\prime}}{c^2}.\left(\overrightarrow{v'} + i\overrightarrow{v_e}\right)\right) \tag{16a}$$

$x = \gamma(x' + (v' + iv_e)t)$

$x = \gamma(-x'' - (v' + iv_e)t)$

y =y'

$z = z'$

where $\gamma = \frac{1}{\sqrt{1 - \frac{v_r^2}{c^2}}}$

To find the magnitude of the transformed quantities, the usual absolute value equation is used for forward transformation:

$$\acute{t} = \gamma\left(t^2 + \left(\frac{x}{c^2}v_e\right)^2\right)^{1/2}$$

$$\acute{x} = \gamma((x - v't)^2 + (v_e t)^2)^{1/2} \tag{16b}$$

and the following transformations are used for inverse transformation:

$$t = \gamma\left((t' + \frac{x\prime}{c^2}v')^2 + \left(\frac{x\prime}{c^2}v_e\right)^2\right)^{1/2} \qquad (17)$$

$$t = \gamma\left((t' - \frac{x''}{c^2}v')^2 + \left(\frac{x''}{c^2}v_e\right)^2\right)^{1/2}$$

$$x = \gamma((x' + v't')^2 + (v_e t')^2)^{1/2}$$

$$x = \gamma((-x'' - v't')^2 + (v_e t')^2)^{1/2}$$

These transformations are applicable even for non-ZRMPs using eq. 10b instead of eq. 10a in determining γ.

Eqs. 15 and 16 show that the two coordinates of the dynamic space time are transformed into one coordinate of the static space time. Thus, two objects with the same world line in the dynamic space time may be observed with two different world lines in the static space time. This phenomenon occurs because of the splitting of the dimension at which the movement of the ZRMP occurs relative to the classical observer. This splitting leads to the observance of the reverse directions of movement of entangled objects to be at the same direction in the dynamic space time frames. To explain the mechanism of splitting of dimensions and world lines (fig. 2), we assume two ZRMPs, that is, one moving toward the positive *x* direction and the other toward the negative *x* direction. According to the present theory, both particles are moving away from the classical observers because of their high response to the movements of space points toward the edges of the universe. Thus, in dynamic space time, both ZMRPs are moving toward the same point, assuming that the initial point is the same, and then the world line of each particle will coincide with the other. Given that the movement of space points is equal to the speed of light, the axes of the dynamic space time are inclined relative to the static axes by 45°. The coordinates at the dynamic space time associated with each point in the world line of the ZRMP are projected at the corresponding coordinate of the static space time. Accordingly, one world line that is projected on the *x*'- and *x*"-axes appears as split to two world lines at the static space-time plane, that is, one world line at the direction of v_1, and the other at the direction of v_2, as shown in fig. 2.

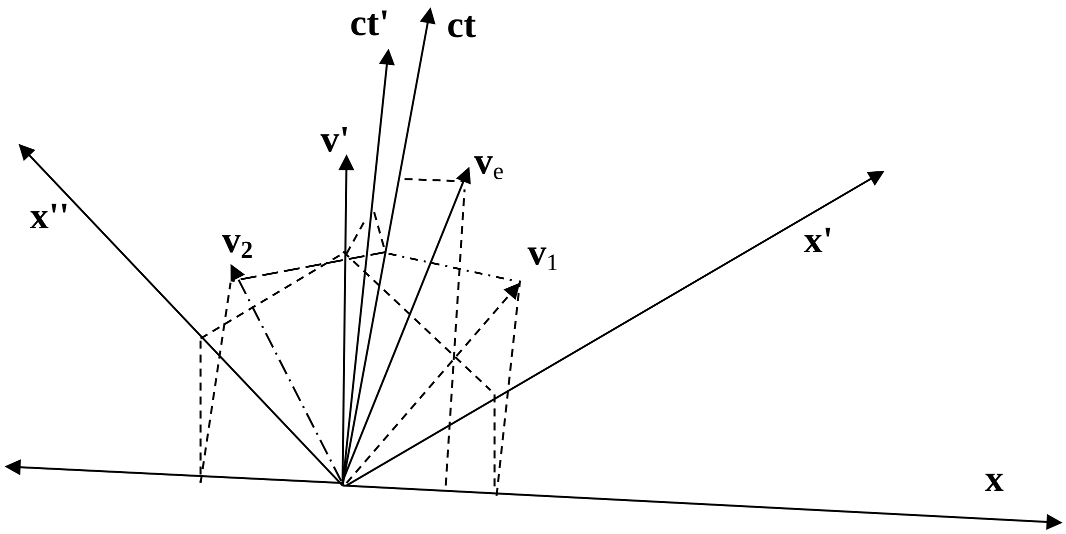

Fig. (2): schematic diagram of static space time represented by x,ct plane and dynamic space time represented by x',x'',ct' cone. The world line v' of the two ZRMPs at the dynamic space time is observed to be world lines denoted by v_1 and v_2 particles moving towards positive and negative x directions respectively as observed by the classical observer.

To relate these transformations to quantum mechanics, the measurement is considered at the frame of the classical observer. For nonrelativistic speeds without considering the velocity of the classical observer, the wave function can be written as follows:

$$\psi = Aexpi(kx - wt) \qquad (18)$$

This wave function can be rewritten as a function of dynamic space time coordinates. Assuming nonrelativistic ranges, the propagation vector in the dynamic space time must be in the direction of the velocity v'. Accordingly, if there is a wave vector $\overrightarrow{k'}$ at the dynamic space time, then it will be perpendicular to its projection $\vec{k}$ at the static space time. The importance of *k*' in nonrelativistic range is not in its value, because its value can be assumed to be equal to *k*, but its physical meaning. Wave vector *k*' have one value corresponding to two values of *k*, in which one value is negative, whereas the other is positive, as measured at the static space time that is symmetrical around the origin representing the point of creation of the entangled particles from their father particle. Using *k*' instead of *k* and *x*' instead of *x* as well as *t*' instead of *t* in eq. 18 yields

$$\psi = Aexp - i(k'x' - wt') \tag{19}$$

where r' is at the dynamic space time at the direction of k', for nonrelativistic limit

$$|r'| = |x| \tag{20}$$

Therefore, eq. 19 becomes

$$\psi = Aexp - i(k'r' - wt') \tag{21}$$

Using the same procedure, many relations of quantum mechanics can be written using the dynamic space coordinates. As an example, the linear momentum operator $\langle p' \rangle$ can be rewritten in dynamic space time as follows:

$$\langle p' \rangle = \int \psi^* \left(\frac{h}{i}\frac{\partial}{\partial r\prime}\right) \psi dr' \tag{22}$$

Before using the dynamic space time equations to solve the entanglement paradox, how the entangled particles move at the dynamic space time should be understood. To explain the mechanism of entanglement in the dynamic space time, we consider two entangled photons; one photon vibrates with vertical polarization and the other with horizontal polarization. The movement of these photons is similar to each other in the dynamic space time and they have similar wave vector $\overrightarrow{k'}$ in the dynamic space time; the difference is only in their polarization (fig. 3). This phenomenon occurs because the photons continue to move in the same path as their parent particle and carried by the same ripple of the moving space time toward the edge of the universe.

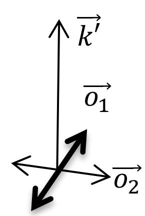

Fig. (3): The directions of the wave vector $\overrightarrow{k'}$ and polarization vectors $\overrightarrow{o_1}$ and $\overrightarrow{o_2}$ of particles 1 and 2 respectively.

In the static space time, the classical observers see two photons moving at different directions with two wave vectors having different directions. These wave vectors are the projections of the single wave vector at the dynamic space time (fig. 4).

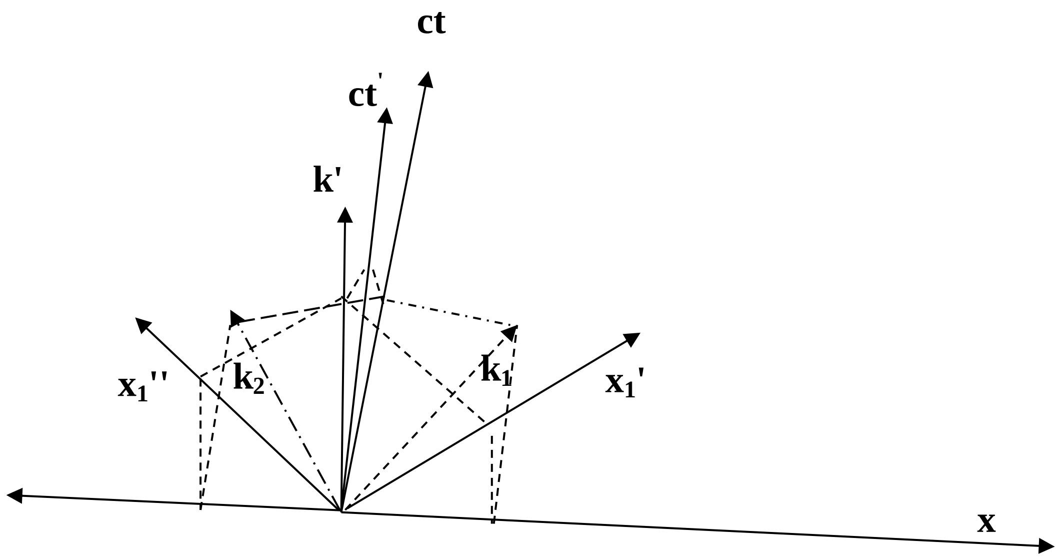

Fig. (4): the wave vectors of photons 1 and 2 in dynamic space time they have the same wave vector k', in static space time they have wave vectors k_1 and k_2 for particles 1 and 2 respectively.

If one of the photons changes its direction because of certain interaction, which thereby changes its wave vector direction in dynamic space time (and of course in static space time accordingly), then the other photon instantaneously changes its direction in a way that makes its wave vector in dynamic space time equal to its accompanying photon to conserve the entanglement between them. This phenomenon explains the general interaction of the entangled particles with the measurement process. If one of the entangled particles, for example, an electron and a positron, interacts with one detector and at the same time the other particle interact with the other detector, then if the detectors are parallel to each other, the projections of *k*' on the static space time would not be altered because both particles are under the same action as their *k*' remains the same. If one of the detectors is rotated by a certain angle while the other remains still, then one of the particles would change its wave vector in a way that is different from the other. If the other particle does not change its direction with the first particle, the wave vector in dynamic space time *k*' of the two particles would be different, thus, the entanglement of these particles would be destroyed. Accordingly, to keep the entanglement between them, the other particle would change its direction in static space time to achieve the same value of *k*' as the other particle. From the geometry of the problem, conservation of the entanglement can only be achieved if the projections of *k*' of both particles in the static space time are placed in a straight line. In other words, the other particle changes its direction to create a single straight line in its path at the static space time with the path of the other particle. The magnitude of the changes in direction of both particles depends on the angle between these detectors because angles limit the straightness of the projections of the particle paths. Change in directions lead to a change in the spin direction (or polarization direction) of the entangled particles, which provide results that are different from the EPR predictions because of the effect of the measurement process. The change in polarization is simultaneous because the particles are near to each other in the dynamic space time in spite of being away from each other in the static space time. Thus, locality is conserved in dynamic space time, but not in static space time.

In quantum mechanics, we can use the dynamic space time coordinates to conserve the locality. As an example if a system from two entangled particles 1 and 2 is considered, Assuming Bell's version experiment of two detectors that are allowed to be rotated independently. The suggested manipulation should be applicable to electron and positron from pion decay, as well as light-entangled photons. Two detectors are considered; the first detector $\vec{a}$ measures the component of electron spin (or first photon polarization), whereas the other detector $\vec{b}$ measures the spin of the positron (or second photon polarization). For simplicity and generality (to include light), spins are assumed to be in units of $\frac{\hbar}{2}$ of the electron and positron. To calculate the average value of the product of the spins, $P(\vec{a},\vec{b})$ is assumed to represent such quantity [15]. If the detectors are parallel ($\vec{a}=\vec{b}$), the original EPR/Bohm experiment [16] configuration is recovered, in which, one variable is spin up and the other is spin down, so the product is always -1. Hence, [15]

$$P(\vec{a},\vec{a}) = -1 \qquad (23)$$

However, for arbitrary orientations, quantum mechanics predicts

$$P(\vec{a},\vec{b}) = -\vec{a}.\vec{b} \qquad (24)$$

Bell's study cancels any hidden local variable theory, which is supposed to be an attempt to survive locality [15]. Accordingly, locality of quantum mechanics in static space time is ruled out. Whether locality is still ruled out or conserved in dynamic space time is determined through quantum mechanics. We consider a system of two particles with its detectors at the directions $\vec{a}$ and $\vec{b}$. The procedure assumes that locality conditions are achieved, but this time, in dynamic space time. The effect of measurement is then assumed to cause the change in direction of the propagation wave vector k' by an angle θ equal to the angle between the detectors.

The probability of the product of the spins of the two particles is assumed to be unaltered until the measurement process occurs. If the results of eq. 24 are obtained, the locality of quantum mechanics in the dynamic space time is conserved; Otherwise, it will be ruled out. According to the locality of EPR, only two states for particles 1 and 2 exist. If one particle is spin up, then the other is spin down. The first base state is assumed to be $|\psi\rangle_{12}$, which represents the spin up of particle 1 and spin down of particle 2. The second base state is $|\psi\rangle_{21}$, which represents the spin up of particle 2 and spin down of particle 1. The entangled state of these two particles can be written in the following form before the measurement process proceeds:

$$|\psi_{bef}\rangle = \alpha|\psi\rangle_{12} + \beta|\psi\rangle_{21} \qquad (25)$$

where $|\psi\rangle_{12}$ and $|\psi\rangle_{21}$ are determined from eq. 21.

$$\alpha^2 + \beta^2 = 1 \tag{26}$$

The propagation vector operator with expectation value $\langle k_1{'}\rangle$ before measurement can be written as follows:

$$\langle k_1{'}\rangle = \int \psi^* \left(\frac{2\pi}{i}\frac{\partial}{\partial r_1{'}}\right)\psi dr_1{'} \tag{27}$$

where dr_1' represents the direction of the particles in dynamic space time. The propagation vector is either at the direction of spin or at the opposite direction, in the case of electron and positron, and perpendicular with the polarization direction, in the case of photons. Assuming one particle is spin up and the other is spin down indicates that the probability of the product of spin before measurement is equal to -1, or

$$P(\vec{a}, \vec{b}) = -1$$

This result is true only if the detectors are parallel, in the case of electron and positron. However, if the detectors were not parallel, then the effect of measurement on the directions of the particles must be considered. Changing the direction of propagation of the particles can be represented by assuming that the new wave vector k_2' with operator $\widehat{k_2{'}}$ directed towards r_2 has expectation value $\langle k_2{'}\rangle$ that is given by:

$$\langle k_2{'}\rangle = \int \psi^* \left(\frac{2\pi}{i}\frac{\partial r_2{'}}{\partial r_1{'}}\frac{\partial}{\partial r_2{'}}\right)\psi dr_2{'} \tag{28}$$

$$\because \ \partial r_2{'} = \partial r_1{'} cos\theta \tag{29}$$

where θ is the angle between r_2' and r_1' or k_2' and k_1'. Thus, eq. 28 will be

$$\langle k_2{'}\rangle = \int \psi^* \left(\frac{2\pi}{i} cos\theta \frac{\partial}{\partial r_2{'}}\right)\psi dr_2{'} \tag{30}$$

or

$$\langle k_2{'}\rangle = \langle k_1{'}\rangle cos\theta \tag{31}$$

Eq. 31 shows that the expectation value of the propagation vector differs by cos θ before and after measurement. Accordingly, because of the direct relation between spin directions (or polarization directions) with the wave vector, the measured directions of spins is also be changed by the same magnitude after the measurement. Therefore, the probability of the product of spins is multiplied by cos θ, which leads to eq. 24. This observation explains why the measured values of spins of unparallel detectors differ from the EPR/Bohm experiment predictions. The same concepts can be applied to the entangled photons experiments. The results of quantum mechanics of the entangled particles are proved using local assumptions in the dynamic space time, not in the static space time.

3. Discussion and conclusions:

A new theory was proposed, which assumed the dynamic space time instead of the static space time assumed in special relativity. In this theory, ZRMP and tiny rest mass particles highly respond to the movement of space points relative to the classical observers. The difference in responses between different mass particles creates extra dimensions of the smaller rest mass particles, which include the splitting of coordinates of the smaller rest-mass particles relative to the classical rest-mass observers. Therefore, if two entangled particles are moving at the same direction in the dynamic space time, they may be observed as moving in two reversed directions in the static space time. A locality between the entangled particles is conserved in the dynamic space time but not in the static space time. The entanglement between any two particles, such as photons with different polarizations or electron and positron which have different spin directions, may be observed as changed after the measurement process. This phenomenon is caused by the change in values of the polarization or spin directions of the entangled particles after the measurement process. The change in the relative directions of the detectors results in a change in the measured spins or polarization values of the entangled particles. The change in physical property of the entangled particles proceeds in a mechanism that enables both of the particles to be moved near to each other in the dynamic space time. The explanation of this mechanism is as follows: One of the entangled particles interacts with the first detector and the other particle interacts with the second detector. During the interaction process, if the detectors are aligned, the particle spins (or polarizations) would not be affected because the projections of these particles at the static space time creates a straight path that corresponds to the same value of propagation vector for both particles at the dynamic space time. However, if the detectors are not aligned, the propagation vectors of both particles would change simultaneously (because of their closeness to each other in the dynamic space time), wherein the change proceeds in such a way that the projections of the paths of both particles at the static space time form a single straight path that corresponds to a single new value of propagation vector of both particles at the dynamic space time. From the geometry of the problem, this result cannot be achieved unless the spins or polarizations of both particles are rotated by an angle that is the same with the relative angle of directions of the detectors. The need for straight line path projection is due to the geometry of the dynamic space time relative to the static space time, which creates a single value of propagation vector of the two particles in the dynamic space time, which corresponds to a straight path in the static space time. Thus, the problem of nonlocality is resolved using the dynamic space time. The closeness of the entangled states in the dynamic space time is due to their common point of creation from their father constituent, after which they keep going near to each other because they move toward the same direction at the same speed. Therefore, nonlocality of EPR paradox is solved without using any hidden variable because both particles are close to each other in the dynamic space time.

Although these transformations describe the position and time of ZRMP and tiny particles, their location cannot be precisely determined because the exact time and location of the creation of these particles are unknown. This information is important in determining the exact values of the spatial and time coordinates because in all circumstances, we only see the projections of the paths of these particles on the static space time. Therefore, if any of these particles reverses or changes its direction, it would keep on going toward the radial direction and the projection of the static space time would not be equivalent to the original value at the dynamic space time. Hence, the present transformations are practically applicable when the origin which corresponds to the point of creation of the particles is known. However, these transformations are important in understanding the mechanism of transferring interactions between entangled particles. This analysis provides new explanations for several classically considered mysteries in quantum mechanics using semiclassical manner with a new kind of geometry of the space time. In addition, we provided the foundation for a new theory that combines special relativity with quantum mechanics in its basic frame.

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References

1. Bell, J. S. *Speakable and Unspeaksble in Quantum Mechanics*; Cambridge Univ. Press: Cambridge, UK, 1987.
2. Bell, J. S. *Phys*. **1964**, *1*, 195.
3. Hardy, L. *Phys. Rev. Lett.* **1993**, *71*, 1665.
4. Celerier, M. N.; Nottale, L. *arXiv* **2001**, *0112213v1*.
5. Nottale, L. *Cha., Solit. & Fract*. **1999,** *10*, 459.
6. Bars, I.; Kounnas, C. *Phys. Lett. B* **1997,** *402*, 25.
7. Bars, I.; Kounnas, C. *Phys. Rev. D* **1997**, *56*, 3664.

8. Amelino-Camelia, G. *Int. J. Mod. Phys*. **2002**, *D**11***, 35.

6. Amelino-Camelia, G. *Int. J. Mod. Phys.* **2002**, *D11*, 1643.

7. Amelino-Camelia, G. *Nat.* **2002**, *418*, 34.

8. Magueijo, J.; Smolin, L. *Phys. Rev. Lett.* **2002**, *88*, 190403.

9. Aloisio, R.; Galante, A.; Grillo, A.F. ; Luzio, E. ; Mendez, F. *Phys.Rev. D* **2004**, *70*, 125012.

10. Mignemi, S. *Phys. Lett. A* **2003**, *316*, 173.

14. Aczel, A.D. *Entanglement: The Greatest Mystery in Physics;* Four Walls Eight Windows, New York, USA, 2001.

15. Griffiths, D. J. *Introduction to Quantum Mechanics*: Pearson Prentice Hall, USA, 2005.

16. Bohm, D. *Phys. Rev.* **1952**, *166*, 180.