Quantum Nonlocality Explained by the Theory of Relativity

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Abstract

An enhanced interpretation of the theory of relativity based on spontaneous decay of particles and wave-particle duality has been presented explaining the observed nonlocality in quantum experiments. A gravity nullification model (GNM) based on the spontaneous particle decay has been developed that provides the missing physics in Einstein's theory of relativity to explain the fundamental relationship between mass, energy, space, and time as one continuum. GNM explains many of the observed paradoxes of existing theories of science, including action at a distance or nonlocality.

Key words: relativity theory, speed of light, nonlocality, quantum mechanics

1. INTRODUCTION

In the Galilean–Newtonian inertial frames of reference, which are either still or moving at a constant velocity, it is assumed that the lengths of objects and the rate at which time passes remain unchanged from one frame of reference to another. This leads to a different observed velocity of a moving object when observed from one frame of reference versus the other, which is moving at a different velocity. The experiments performed by A.A. Michelson and E.W. Morley(1) in the 1880s showed that the speed of light measured in different directions with respect to Earth's motion, which represented different frames of reference, remains constant. Einstein's special theory of relativity (ESTR),(1,2) put forward in 1905, resolved this discrepancy. The theory was embodied in two postulates:

Postulate 1: The laws of physics are the same in all uniformly moving frames of reference.
Postulate 2: The speed of light through empty space is invariant regardless of the motion of the source or the motion of the observer.

In order to describe the motion of a body, we must specify how the body alters its position in space with time. The position is described with respect to a system of coordinates. The Galilean–Newtonian system of coordinates represents those reference frames wherein the laws of the mechanics of Galileo–Newton can be regarded to be valid. Any coordinate system in a condition of uniform motion of translation in a straight line relative to a given Galilean–Newtonian coordinate system is also a Galilean–Newtonian coordinate system. According to the principle of relativity, general laws describing the physical description of all natural phenomena remain the same in all Galilean–Newtonian frames of reference. If all natural phenomena were accurately described by classical mechanics using the Galilean–Newtonian system of coordinates, this principle of relativity would hold valid. But the observed constancy of the speed of light in all frames of reference pointed to the inadequacy of classical mechanics to completely describe all physical phenomena, especially those phenomena that are related to electrodynamics and optics. In spite of this inadequacy, classical mechanics does predict with great accuracy the motion of heavenly bodies in our solar system as well as worldly objects encountered in our daily lives. This is because the velocities involved in such motion are very much smaller than the speed of light.

ESTR changed the notion of fixed space and time as assumed in Galilean–Newtonian or classical mechanics. Time is not absolute and varies according to the speed of the inertial frame. Two events that are simultaneous in one frame are not simultaneous as seen by an observer in the second frame of reference. The results of the special theory of relativity lead to the following equations for time dilation, space dilation, and mass as a function of the speed V of the moving frame of reference for an observer in the fixed ($V = 0$) frame of reference (Fig. 1):

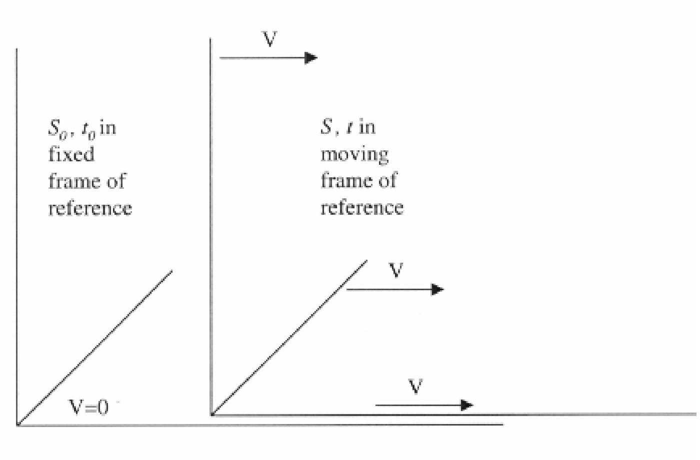

Figure 1. Fixed and moving Galilean–Newtonian frames of reference.

$$t = t_0\sqrt{1-(V/C)^2}, \quad (1)$$

$$S = S_0\sqrt{1-(V/C)^2}, \quad (2)$$

$$M = \frac{M_0}{\sqrt{1-(V/C)^2}}, \quad (3)$$

where t_0, S_0, and M_0 represent intervals of time, length or distance, and mass, respectively, in the stationary frame of reference, and t, S, and M represent the same in the moving frame of reference. The special relativity equation (2) is sometimes presented in the literature and in physics textbooks[1] in alternative terms of the coordinates χ and ξ, which represent point coordinates in the stationary and moving frames of reference, respectively, rather than the length or distance. When expressed in this alternative form, (2) changes to the form

$$\xi = x/\sqrt{1-v^2/c^2}. \quad (2a)$$

Both (2) and (2a) are consistent with Einstein's 1905 paper, "On the Electrodynamics of Moving Bodies," describing the special theory of relativity.

2. A REVIEW OF THE ESTR POSTULATES

In this paper we will evaluate the basis and results of the two postulates of the special theory of relativity proposed by Einstein by comparing them with the observed reality. Specifically, we will take a closer look at the second postulate, which imposes an apparent limit on the speed of light and action at a distance by comparing it with the recent experimental results. A new approach is put forward to fill in the gaps in what Einstein referred to as "the Hidden Factors."

2.1 Postulate 1

The first postulate simply states that the same laws in all frames of reference govern the physical phenomena in the universe. It means that there is only one universe, and a unique set of physical laws determines the outcome of a phenomenon or event with a given set of initial and boundary conditions. The initial and boundary conditions may vary from event to event but the universal laws that govern the progress or outcome remain invariant for any observer or frame of reference from which the observation is made. This postulate also assumes that there exists a fundamental order in the universe that can be described by a unique and common set of laws.

This is a very important postulate; if it were not true, then the universe would be perceived as a chaos without an order or one would have to assume the existence of multiple universes with varying sets of laws, which is counter to human experience. To a common human observer the universe is a cosmos with a well-perceived order evidenced by a unique set of laws.

2.2 Postulate 2

The second postulate states that the speed of light remains constant in any frame of reference regardless of the speed of the frame. This postulate also leads to the limitation on the maximum speed at which an entity or signal can travel in any frame of reference. This limitation is the speed of light, which also prohibits nonlocality and action at a distance in the universe. The basis for this postulate is the results of experiments such as those by A.A. Michelson and E.W. Morley, which demonstrated the constancy of the speed of light in various frames of reference with a varying degree of alignment with Earth's motion and moving at different speeds. This led to the abandonment of the ether existing as a stationary medium in space, which could affect the speed of light depending upon whether its motion opposes or reinforces the propagation speed of the light waves.

Results of some recent Bell-type EPR experiments[3] have shown that action at a distance and nonlocality are possible, and hence the second postulate of ESTR may not hold true. These results point to the existence of much higher speeds of light than a constant value of 300,000 km/s in the second postulate. In the EPR experiments the particles prepared in the singlet state may be viewed as a single object. The apparently obvious spacing between seemingly disparate parts of the object is unsettlingly paradoxical, and such matters have so far been assumed to reside outside the realm of special relativity, leaving the paradox unexplained. This forces us to reevaluate the basis of the postulate and the constancy of the speed of light to explain the observed experimental results. The arguments presented in this paper attempt to address and resolve this paradox by extending the logic of the special relativity theory.

3. SPEED OF LIGHT

Is the speed of light constant at 300,000 km/s? Or is it higher and possibly infinite, as evidenced by quantum mechanics and related experiments? In order to properly address these questions, let us look into the basic definition of velocity as defined in classical mechanics.

The speed of an object in Newtonian mechanics is defined as the ratio of the elapsed distance over the elapsed time. This definition is based on the fundamental assumption that both the elapsed distance and the elapsed time are separately measurable and distinct quantities whose ratio leads to a unique value of the velocity. However, the ESTR formulation shows that both distance and time dilate as the velocity of the moving frame of reference increases from zero. Hence distance and time are not distinct but relative quantities whose magnitudes are not independent but related directly to the magnitude of the velocity of the frame of reference itself. Space dilation, rather than distance dilation, is a commonly used term in ESTR. However, this author prefers to use the term *distance* rather than *space*, since the ESTR formulation is in terms of increments (lengths) of elapsed space, which more accurately represent a measurement of distance. The term *space* will be used in this paper to represent a more fundamental and abstract medium, which is measurable in increments of distance. When V is very much smaller than C, the distance and time dilation is negligible and hence an object is physically perceived to be changing location from one spatial position to another in a perceived or measurable elapsed time of the clock. As V approaches the value of the speed of light C, the size of the object dilates to zero, and no physical experiment can be performed to directly measure the speed of an object that has vanished or become invisible to the observer in the fixed frame of reference.

There is one other dilemma that challenges our common-sense notion of physical reality when we use the concept of velocity in conjunction with the motion of light. As discussed above, when V approaches the value of C, both the elapsed distance and the elapsed time dilate to zero and the clock stops ticking. The velocity of light, which is the ratio of elapsed distance over elapsed time, loses its meaning from a mathematical (ratio of zero distance over zero time) point of view. Also, from the point of view of physical reality it becomes incomprehensible for a photon of light to move at the speed of light in a space and time that are fully dilated (zeroed out), since such a space has no room for a particle to move and no time measurement is possible since the clock remains fully stopped without ticking. This demands an alternative physical interpretation of the space-time relationship that provides a description of motion that is consistent with the observed reality (including action at a distance and nonlocality) of photon motion at speed C in all frames of reference.

4. AN ALTERNATIVE INTERPRETATION OF THE SECOND POSTULATE OF ESTR

As discussed above, the speed of light loses its physical meaning when space and time are fully dilated (at $V = C$). To resolve this dilemma this author proposes an alternative interpretation of the special theory of relativity that defines the conservation of elapsed distance and time as a possible alternative to the concept of the speed of light used in the second postulate of ESTR. It is proposed that elapsed distance and time are conserved in relation to each other during the motion of light in the same manner as mass and energy are conserved ($E = mC^2$) during the transformation of mass to energy and vice versa. This is justified due to the following observed relationship between distance and time intervals for motion of light in any two different frames of reference, as shown in Fig. 1:

$$\frac{S_0}{t_0} = \frac{S}{t} = C. \quad (4)$$

It is to be noted that the above relationship is the same as that used in the derivation of the Lorentz transformation based on equal speed of light in different frames of reference. Hence the alternative interpretation of space-time conservation, wherein C is defined as a universal physical constant of conservation rather than the speed of light, during the motion of light does not in any way change the mathematical formulation of the Lorentz transformation or ESTR. For this reason all formulations such as (1), (2), and (3) as well other equations of ESTR remain equally valid under the new interpretation of the phenomenon of light. The only difference is in the interpretation of C, which is now defined to be a physical constant with a value of 3×10^8 m/s, exactly similar to the value of the constant speed of light defined in the original theory of relativity. The new interpretation describes C as the constant of conservation that conserves mass and energy in the equation $E = mC^2$, as well as conserves space and time in the equation $S = Ct$. Photons of light always have a speed almost equal to the value C and can never exceed this value. This extends the definition of C to represent a universal constant of conservation, a physical constant, consistent with the famous Einstein equation for the mass-energy conservation, $E = mC^2$, as well as the speed of light consistent with relativity theory.

For a body or entity moving at a velocity less than C in any frame of reference, space and time are not conserved, as described in the following discussion. Let us consider again, as in Fig. 1, a stationary and a second frame of reference that is moving with velocity V relative to the stationary frame. If a body moves with a velocity W in the moving frame of reference, then

$$\frac{S}{t} = W.$$

The Lorentz transformation and ESTR provide the following relationship for the velocity W_0 of the object observed by an observer in the stationary frame of reference:

$$\frac{S_0}{t_0} = W_0 = \frac{V + W}{1 + VW / C^2}.$$

From the above it is clear that when W is less than C,

$$\frac{S}{t} \neq \frac{S_0}{t_0}.$$

Thus the elapsed distance and time are not conserved from one frame of reference to another. As W equals C, the above relationship converts to the following space-time conservation law for all frames of reference, as derived earlier:

$$\frac{S}{t} = \frac{S_0}{t_0} = C.$$

It should be noted that if the speed V of the moving frame equals C, then regardless of the value of the object speed W in the moving frame, the above law of distance-time conservation holds true. The impact of either V or W approaching the value of C can thus be summarized as follows.

Any object or entity moving at speed C in any arbitrary frame of reference moving at a speed V with respect to the stationary frame of reference obeys the law of elapsed distance-time conservation. Similarly, any object or entity (regardless of its speed) in a frame of reference moving at speed C relative to the stationary frame of reference obeys the laws of distance-time conservation. In both of these cases the distance and time are dilated to zero with regard to any physical aspects or properties related to the moving object or entity.

The physical consequences of distance and time dilations to zero are as follows. All physical aspects of a set of entangled photons originating from a parent photon moving at speed C (measured in the stationary frame of reference), wherein the distance and time are dilated to zero in the frame of reference of the moving body, will be fully correlated or connected regardless of the separation distance between them as measured in the stationary frame of reference. Different parent photons may interfere or interact in some way just like during the superposition of the quantum wave-functions, but they are not identical or connected and will not display correlated properties. In other words, when viewed from the stationary frame of reference, wherein the distance and time are not dilated, spatial nonlocality or action at a distance will apparently exist for a pair of entangled photons since the effective distance in the frame of the moving entity is shrunk to zero. Also, simultaneity or temporal nonlocality among all physical aspects of the entangled photons will exist since the clock stops and time dilates to zero in the frame of the entity. This explanation is further clarified as follows from the wave and particle duality points of view.

The particle argument: When a particle moves at a speed close to the value of C, the size of the particle and all space associated with it and in which it moves collapses to zero. Hence, relatively speaking, the particle fills all the space around it. When the same particle and its associated space are viewed by an observer in the stationary frame of reference of Earth with an undilated and fixed space and time, the particle appears to exist everywhere in Earth's frame of reference, leading to the apparent nonlocality.

The wave argument:[(4)] It is commonly understood from the wave-particle duality that the same particle exists as a wave as it travels through empty space. The spontaneous conversion of particle mass into wave energy leads to a large increase in the wavelength as described by the de Broglie equation

$$\lambda_{dbr} = \frac{h}{mv}.$$

In the limit, as the mass fully converts to energy during the uninhibited motion of a particle such as a photon, the wavelength of the particle may become very much larger than the size or dimensions of the experiment, leading to the apparent nonlocality over the spatial extent of the experiment. A particle virtually exists over the span of its entire wavelength, hence any measurements that are made within the span of its wavelength will exhibit complete correlation in the observed properties of the particle. The argument of locality or a lack of communication between the two entangled photons limited by the speed of light fails because it is only an artifact of erroneously treating the entangled photons as two separate disconnected particles, ignoring the wave-particle duality.

Note that the elapsed distance and time dilate to zero only in the moving frame of reference with $V = C$. The distance and time in the stationary frame of reference remain independent, intact, and undilated. However, the physical properties (such as spin, polarization, charm, and color) that are inherent properties of the entity moving at $V = C$ will appear to be fully correlated or connected due to the distance and time dilation in its own (or moving) frame of reference.

The discussion above leads to the following proposed alternative interpretation of the ESTR Postulate 2:

2a. Elapsed distance and time are conserved during the motion of light in empty space.

2b. The maximum rate (C) at which elapsed distance is converted to time when light moves through empty space is invariant regardless of the motion of the light source or the motion of the observer.

In Newtonian mechanics both space and time are considered fixed and independent absolute entities. For a moving body space can be measured in terms of the elapsed distance and time can be measured in terms of the amount of the ticking of the clock. Hence the velocity in a Newtonian frame of reference is also an absolute quantity expressed as a ratio of the elapsed distance to the clock time. In ESTR space (distance) and time are not independent and absolute entities but linked together via the constancy of the speed of light in all inertial frames of reference. What is being proposed here is an alternative relationship that governs the elapsed distance and time dependence, that is, the conservation of elapsed distance and time as relative entities in a similar manner as mass and energy are conserved. This also allows the empty space in the fixed frame of reference ($V = 0$) to be an absolute medium in which a moving body travels from one point to another with a prescribed velocity. Elapsed distance, situated in empty space, is converted to elapsed time as the body moves through empty space. This gain in elapsed time slows down the clock in the frame of reference of the moving body, which leads to the observed time dilation. C is interpreted as a universal conservation constant that determines the rate at which the elapsed distance can be converted to time and vice versa, instead of as the speed of light in ESTR. This interpretation of C is similar to C in Einstein's famous mass-energy conservation law:

$$E = C^2 m,$$

where C^2 is interpreted as the rate at which mass (m) can be converted to energy (E). This interpretation of C takes away the restriction on the constancy of the speed of light or its maximum allowed limit in ESTR and allows consistency with the experimental observations and interpretations of nonlocality in quantum mechanics.

Another significance of this new interpretation is that it leads to distance-time-mass-energy as one continuum for the motion of light via their conservation through a single universal constant C, as expressed below:

$$\frac{E}{m} = \frac{S^2}{t^2} = C^2. \tag{5}$$

5. TIME DILATION AND ITS IMPACT ON THE MEASUREMENT OF THE SPEED OF PARTICLES

Using the proposed modified interpretation of the second postulate of ESTR, generic equations for distance-time dilation can be derived from the ESTR equations (1), (2), and (3). Starting from (1), a series of steps leads to an expression for time dilation in the moving frame, $dt_0 = t - t_0$, with reference to the stationary frame in terms of the speed of the object, as follows:

$$t_0 = \frac{dt_0}{\sqrt{1-(V/C)^2}-1}. \tag{6}$$

In the stationary frame of reference time t_0 is equal to the elapsed distance S_0 divided by the velocity of the object V:

$$t_0 = S_0 / V. \tag{7}$$

Substituting this in (6) leads to the following expression for time dilation in reference to the stationary ($V = 0$) inertial frame:

$$dt_0 = S_0 \left(\frac{\sqrt{1-(V/C)^2}-1}{V} \right). \tag{8}$$

This equation can also be written in a nondimensional form to define a time dilation factor (TDF) as follows:

$$\text{TDF} = \frac{C dt_0}{S_0} = \frac{\sqrt{1-(V/C)^2}-1}{V/C}. \tag{9}$$

A generalized variation of the TDF as a function of V is presented in Fig. 2. As expected, when the velocity of the object equals C, the TDF equals (–1). In other words, at $V = C$, the time dilation is 100% and the clock stops ticking. If the elapsed distance is measured in the stationary frame of reference, while the elapsed time is dilated in the photon's own frame of reference ($V = C$), the measured effective speed of a photon of light would appear to be infinite. It is to be noted that in all the physical experiments, such as those of Alan Aspect,[3] wherein the entanglement between a pair of photons is observed, the distance between the photons is measured in the stationary or the Earth frame of reference and not in the photon's frame of reference. The definition of speed loses its meaning in the photon's ($V = C$) frame of reference, since there is no ticking clock, or time dilates to zero in this frame of reference. As discussed earlier, since elapsed space and time become relative rather than absolute entities as velocity increases, the meaning and significance of the Newtonian velocity diminishes. At smaller velocities the time dilation decreases, and no time dilation occurs as V reduces to zero in the stationary frame of reference. Hence, at smaller velocities, the Newtonian definition of velocity prevails, since elapsed space and time act as independent and absolute entities. The Bell-type nonlocality can exist in experiments involving particles traveling at speeds less than C because of the wave argument discussed earlier in this paper. The equivalent wavelength of a particle depends upon its velocity. If the velocity of the particle is less than C, but large enough to cause a wavelength greater than the size or extent of the experimental measurement locations, apparent nonlocality will be observed.

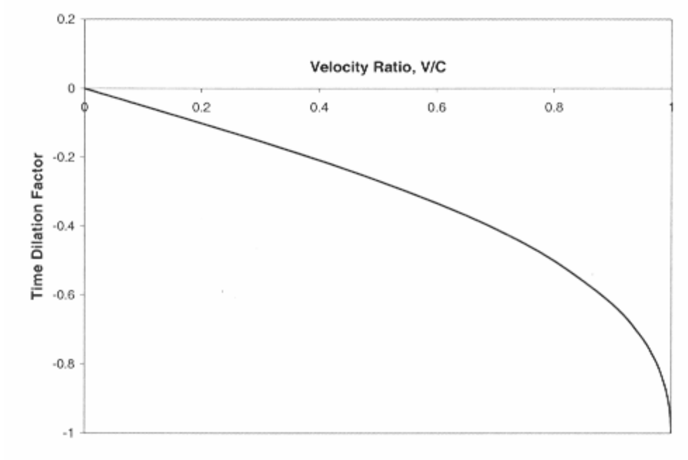

Figure 2. TDF versus velocity ratio V/C.

Time dilation dt_0 has been expressed above in (8) in terms of the elapsed distance S_0 in the stationary frame ($V = 0$). In the frame of reference of the light ($V = C$) time dilates to zero, as discussed above. Hence time in any general frame of reference moving with velocity V is larger or expanded as compared to the frame of reference of the light. The time expansion dt_c relative to the frame of reference of a photon of light moving at C can be expressed in terms of V as follows using (1) and (7):

$$dt_c = t = t_0 \sqrt{1-(V/C)^2}$$

or

$$dt_c = t = S_0 \frac{\sqrt{1-(V/C)^2}}{V}. \tag{10}$$

Thus the expansion of time in a general frame of reference with a velocity V is also proportional to the elapsed distance S_0 in the stationary frame of reference.

We will now define the concept of the measured velocity, V_{eff}, of an object that is moving with a velocity V_0 in the stationary frame of reference as the ratio of the elapsed distance S_0 to the actual or dilated time in the frame of reference moving with velocity V relative to the stationary frame of reference. As discussed earlier, in all the physical experiments, such as those of Alan Aspect,[3] wherein the entanglement between a pair of photons or other particles is observed, the distance between the particles is measured in the stationary or the Earth frame of reference and not in the particle's frame of reference:

$$V_{eff} = \frac{S_0}{t} = V_0\left(\frac{t_0}{t}\right) = \frac{V_0}{\sqrt{1-(V/C)^2}}, \tag{11}$$

$$\frac{V_{eff}}{V_0} = \frac{1}{\sqrt{1-(V/C)^2}}. \tag{12}$$

Figure 3 shows the variation of V_{eff} versus V. When V is small, V_{eff} equals V_0, as expected in the stationary frame of reference. When V approaches C, V_{eff} approaches infinity. Since, in all the physical experiments, such as those of Alan Aspect,[3] wherein the entanglement between a pair of photons is observed, the distance between the photons is measured in the stationary or the Earth frame of reference and not in the photon's frame of reference, the inferred speed of communication between the pair of entangled photons is erroneously measured to be infinite rather than C. The error in measurement during the experiment results from two entirely different sets of space-times, one associated with the experimental apparatus and another associated with the pair of photons moving at almost the value of C. This provides a possible explanation of action at a distance or nonlocality in the universe observed in various experiments with light.[3]

6. GRAVITY NULLIFICATION MODEL

What is the physical cause of the motion in the universe? In Newtonian or classical mechanics a force external to the body causes the motion of a body. The inertia of the body due to its mass opposes the external force acting on the body. The external force comes from an independent entity external to and separate from the body itself. This motion is defined as a nonspontaneous motion, since it is caused by factors (forces) external to the body.

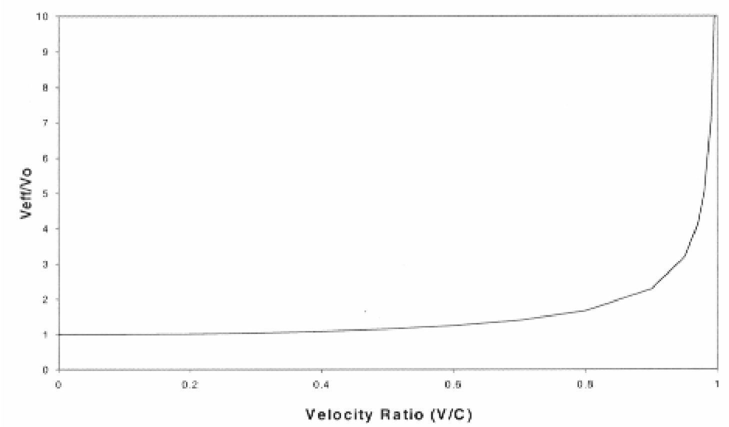

Figure 3. Measured velocity, V_{eff}, observed in a frame of reference moving with velocity V relative to the stationary frame.

As part of ESTR, Einstein derived the famous law of mass-energy conservation

$$\Delta E = C^2 \Delta m, \tag{13}$$

where E and m represent equivalent changes in energy and mass, respectively. In ESTR a conversion of mass to energy is allowed according to (13) above. We can postulate a body that has an inherent capability to convert a part or all of its mass to energy, such as is observed during the spontaneous decay[1] of a particle. In the case of elementary particles such as electrons, protons, and neutrons this may involve a substantial amount of energy, as required by $E = mC^2$. Such particles are known to be stable over long periods of time. In contrast, some unstable particles are known to decay instantly.[1] To represent such observed spontaneous decay of particles, the particle theory presumes existence of an antiparticle partner for each existing particle, which can be annihilated by the antiparticle and spontaneously convert to energy. Particles that decay instantly cannot be easily detected and hence it is not known how many such particles exist in the universe. It is postulated that the evidence of the existence of dark matter in the universe may point to the possibility that a large fraction of the universe's mass-energy may consist of such particles.

The energy released during a spontaneous conversion of mass to energy via spontaneous decay can be used to provide motion or kinetic energy to the remaining (unconverted) mass of the body or particle. The motion caused via such a postulated process of self-decaying mass that is internal to the body is defined as a spontaneous motion as opposed to the nonspontaneous motion of a classical nondecaying mass or body. Another example of spontaneous motion could be the big bang process that started the dynamic expansion of the universe and that is now believed to be a credible theory of the creation and evolution of the universe.

Since the process of spontaneous mass-energy conversion is internal to the body and absent any energy transfer across a boundary separating the body from its environment, there is no increase in entropy during this process. Hence the process of spontaneous decay of particles or wave-particle duality is an isentropic and reversible process. On the other hand, motion or kinetic energy of a classical (nondecaying) body caused by an external force involves energy transfer to the body from its environment and is an irreversible process leading to an increase in entropy.

Let us now consider a self-decaying mass M_0 at rest ($V = 0$). A small portion of the mass then spontaneously converts to energy according to (13) above. The converted energy is used by the remaining mass m to propel itself, causing a spontaneous motion with a velocity V. The relativistic kinetic energy of the body with mass m and moving at speed V is given by the following equation from ESTR:

$$KE = mC^2\left(\frac{1}{\sqrt{1-V^2/C^2}}-1\right). \tag{14}$$

Equating this kinetic energy to the energy from mass dilation given by (13), we obtain

$$(M_0 - m)C^2 = mC^2\left(\frac{1}{\sqrt{1-V^2/C^2}}-1\right). \tag{15}$$

Simplifying the above provides the following equation:

$$m = M_0\sqrt{1-(V/C)^2}. \tag{16}$$

We have shown that the gravity nullification model (GNM), (16), satisfies the laws of conservation of mass-energy both on a holistic or universal basis and within the body itself. This eliminates the singularity in the limit when $V = 0$ or $V = C$, such as the singularity observed in the big bang theory. It should be noted that when V equals C, the rest mass M_0 dilates to zero and converts fully to kinetic energy.

7. ACTION AT A DISTANCE OR NONLOCALITY EXPLAINED BY GNM

In the Newtonian mechanics that represents our classical understanding of everyday experience, an isolated object or mass can be accelerated to acquire different peak velocities depending upon the amount of force applied. An object moving at a uniform speed equal to any of the possible values of the peak velocity represents a distinct inertial frame of reference that is assumed to be independent of other frames of reference. What is ignored, however, is the fact that the applied force comes from the neighboring frame external to the frame of reference of the moving body, and the source of this force is the mass-energy of the neighboring or the connected frame. The connected frame could be either the stationary frame or any other frame moving at a different velocity than the body itself. Because of the absence or lack of consideration for this exchange or connectivity, total or universal mass-energy is not conserved in different Newtonian frames of reference, which leads to the erroneous prediction or the illusion of the isolated nonlocality of the moving body from the rest of the universe.

To clarify this aspect of the Newtonian inertial frames of reference, let us consider again the two frames of reference in Fig. 1. Let us now consider a nonmoving body in the stationary ($V = 0$) frame of reference. The same body when viewed from the moving frame of reference has a speed that is equal and opposite to the speed V of the moving frame. Hence the mass-energy of the body in the moving frame is higher than the mass-energy in the stationary frame by the amount of the kinetic energy acquired by the body. Based on the Newtonian laws of motion, this increase in kinetic energy is caused by the action of an isolated force on the body in motion. Such an understanding of the motion observed in everyday experience is so deeply rooted in us that it has become a matter of common sense for us to assume nonlocality a foregone conclusion in the universe. We forget that such an understanding, howsoever approximately true at very low velocities ($V << C$), is not justified since it violates the fundamental law of conservation of mass-energy.

Now let us consider a mass that decays spontaneously according to the GNM, (16), and attains a speed V. Because of the increased speed, the elapsed distance and time dilate as per (1) and (2). If the mass completely decays to zero, V becomes equal to C and distance and time both dilate to zero. The complete dilation of distance and time leads to the observed nonlocality and action at a distance, wherein the distance is measured in the stationary frame of reference rather than in the frame of the moving body.

It is argued and implied in ESTR that a real signal that carries information in the form of an energy wave with a finite nonzero frequency and wavelength can never travel faster than C. This is consistent with the modified Postulate 2 or the GNM as follows. The information in a signal is stored in the form of energy waves of specific frequency and wavelength, as seen by an observer in the stationary frame of reference. Since the signal maintains a finite energy or nonzero rest mass that constitutes the specific stored information during its transmission through empty space in the stationary frame of reference, its speed V remains slightly less than (however very close to the value of) C, and the distance and time do not completely dilate to zero. This preserves the locality aspects of the signal since its velocity V is slightly smaller than C. A photon of light, on the other hand, that is not burdened with a signal of a nonzero rest mass can decay its mass to zero as it travels through empty space. Hence nonlocality and coherence are observed in the behavior of a photon or its paired offspring over the entire universe.

8. GNM PREDICTS OBSERVATIONS AND RESOLVES BIG BANG MODEL PROBLEMS

GNM has been applied in conjunction with the general theory of relativity to predict universe behavior, including its creation and evolution over time. The results of GNM predictions are documented in Ref. 4. These results provide a detailed understanding and potential resolution of the following unresolved problems[5,6] experienced by the big bang model (BBM) and as yet unexplained observations of the universe behavior without resorting to the incredible scenario of inflation:

1. singularities in the initial conditions of the BBM,
2. the horizon problem,
3. the flatness problem,
4. dark matter and dark energy,
5. the puzzle of the process of creation or formation of matter,
6. the puzzle of the observed characteristics of rotational and radial velocities in galaxies.

Other significant results derived from GNM help resolve the gaps in understanding and building the bridge between the theory of relativity and quantum mechanics. A reevaluation of the Heisenberg uncertainty principle is performed using GNM. There exists a big gap in the fundamental understanding of the apparent duality that exists between the behaviors of microscopic quantum particles and macroscopic classical objects. GNM fills in this gap in knowledge and provides a physical basis for understanding quantum versus classical behavior. GNM provides deterministic mathematical expressions of the physical limits (Planck's mass and Planck's length) that govern the transition between quantum and classical behavior. GNM explains the inner workings of quantum mechanics and resolves the following well-known and as yet unresolved paradoxes:

1. deterministic and local behavior of classical objects versus probabilistic and nonlocal behavior of quantum particles,
2. collapse of the wave-function (objective reduction) or the measurement problem (*Schrödinger's cat* paradox),
3. existence of parallel universes or not.

It continues to remain a significant challenge to modern scientists to integrate gravity with other observed forces of nature in a consistent and seamless mathematical model. In particular, a viable and common mathematical description of gravity in quantum and relativity theories has eluded scientists for the last several decades, with no convergence or success in sight. GNM demonstrates that the classical (Newtonian) treatment of gravity, when used in conjunction with the spontaneous decay of mass to energy, properly accounts for both the observed quantum and classical behavior of particles at small and large scales, respectively. As such, no special or specific quantum formulation of the effects of gravity is needed. GNM thus fills in the gap in the fundamental understanding of the gravitational effects that govern the behavior of small microscopic quantum particles versus the behavior of classical macroscopic objects. Specifically, GNM provides a physical basis and understanding of the role of gravity in

- determining the particle or wave-like behavior,
- governing the relationship between Planck's mass and Planck's length.

9. SUMMARY AND CONCLUSIONS

An enhanced interpretation of the theory of relativity based on spontaneous decay of particles and wave-particle duality has been presented explaining the observed nonlocality in quantum experiments. A GNM based on spontaneous particle decay has been developed that provides the missing physics in Einstein's theory of relativity to explain the fundamental relationship between mass, energy, space, and time as one continuum, wherein C represents a universal constant of conservation as well as the speed of light in the relativity theory. GNM explains many of the observed paradoxes unexplained by the existing conventional theories of physics, including action at a distance and nonlocality. The important point of the manuscript is that it does not leave the explanation of nonlocality to the existing, unsettling, and paradoxical argument of the birth of the entangled particles from a parent reaction, but represents a part of an overall model[7] that explains the details of the underlying physical phenomena and inner workings of quantum mechanics. Further, the overall model predicts the observed behavior of the universe and thus extends the validity of the widely accepted theories to the universal scale. The overall model addresses and explains the mysterious paradoxes and inconsistencies that "conventional physics" and its existing widely accepted theories fail to resolve.

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Résumé

Une interprétation améliorée de la théorie de la relativité fondée sur la désintégration spontanée des particules et la dualité onde corpuscule a fait l'objet d'une présentation qui explique la non localisation observée dans les expériences sur les quantum. On a mis au point un modèle d'invalidation de la gravitation fondé sur la désintégration spontanée des particules, qui fournit les éléments manquants en physique en ce qui a trait à la théorie de la relativité d'Einstein qui permet d'expliquer les relations fondamentales entre la masse, l'énergie, l'espace et le temps comme un ensemble continuum. Le modèle d'invalidation de la gravitation permet d'expliquer un grand nombre des paradoxes observés des théories scientifiques actuelles y compris l'action à distance et la non localisation.

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