Origin of motion. II. Spontaneous mass-energy equivalence model unravels quantum mysteries and paradoxes

Avtar Singh[a)]
Center for Horizons Research, 3083 Copper Peak Drive, Dublin, California 94568, USA

(Received 27 July 2018; accepted 12 December 2018; published online 31 December 2018)

Abstract: Current widely accepted understanding of the origin of motion is based on the presumption of an external force or agency required to impart motion to a classical mass. Part I of this paper [A. Singh, Physics Essays, **31**, 467 (2018)] describes the missing physics of the origin of motion based on the well-established principle of mass-energy equivalence which requires a nonzero rest mass for originating spontaneous nonzero kinetic energy or motion. The proposed Universal Relativity Model (URM) based on special relativity theory describes a universal model predicting classical as well as quantum behaviors of both massive and massless particles in a single model that is shown to remove prevailing deficiencies/inconsistencies and paradoxes of the current widely accepted physics and cosmology theories. The proposed model describes a spontaneous (no external force or agency required) relativistic mass creation/dilation process observed during wave-particle behavior allowing a nonzero photon mass at rest (emission and absorption), which dilates to zero as it expands and accelerates to the speed of light through uninterrupted space. The model thus bridges gaps between relativity and Maxwell's theories. This (Part II) paper extends the URM model to describe the physics of the observed spontaneous complementary or dualistic wave-particle behavior of quantum particles as an alternative to the existing de Broglie model. The proposed models explain as well as provide mathematical formulations of the observed transition from classic to quantum behavior including the effects of gravity at quantum scales. The models also provide a physical understanding and resolution of well-known and as yet unresolved paradoxes related to the measurement problem or the observer paradox (collapse of the wave-function), spooky action-at-a-distance or nonlocality, Heisenberg's uncertainty, and parallel universes. Finally, URM provides a new perspective on physical reality entailing a complementary set of relativistic realities (subuniverses) within a single universe. © *2019 Physics Essays Publication*. [http://dx.doi.org/10.4006/0836-1398-32.1.13]

Résumé: La compréhension actuelle largement acceptée de l'origine du mouvement est basée sur la présomption d'une force externe ou d'une agence requise pour donner un mouvement à une masse classique. La première partie de cet article [A. Singh, Physics Essays, **31**, 467 (2018)] décrit la physique manquante de l'origine du mouvement basée sur le principe bien établi de l'équivalence masse-énergie qui nécessite une masse au repos non nulle pour produire une énergie ou un mouvement cinétique spontané non nul. Le modèle de relativité universelle (URM) proposé basé sur la théorie de la relativité restreinte décrit un modèle universel prédisant les comportements classiques et quantiques des particules massives et sans masse dans un modèle unique qui est montré pour éliminer les déficiences/incohérences et les paradoxes du courant largement répandu. les théories acceptées de la physique et de la cosmologie. Le modèle proposé décrit un processus de création/dilatation de masse relativiste spontané (aucune force externe ou agence requise) observé pendant le comportement des particules d'onde permettant une masse de photons non nulle au repos (émission et absorption) qui se dilate jusqu'à zéro à la vitesse de la lumière à travers l'espace ininterrompu. Le modèle comble ainsi les écarts entre la relativité et les théories de Maxwell. Cette partie II de l'article étend le modèle URM pour décrire la physique du comportement observateur spontané ou dualiste des particules quantiques spontanées ou dualistes comme alternative au modèle de Broglie existant. Les modèles proposés expliquent et fournissent des formulations mathématiques de la transition observée du comportement classique au comportement quantique, y compris les effets de la gravité aux échelles quantiques. Les modèles fournissent également une compréhension physique et la résolution de paradoxes bien connus et non encore résolus liés au problème de mesure ou au paradoxe de l'observateur (effondrement de la fonction d'onde), action effrayante à distance ou non-localité, Heisenberg l'incertitude et les univers parallèles. Enfin, l'URM offre une nouvelle perspective sur la réalité physique qui implique un ensemble complémentaire de réalités relativistes (sous-univers) au sein d'un même univers.

[a)]avsingh@alum.mit.edu

ISSN 0836-1398 (Print); 2371-2236 (Online)/2019/31(2)/13/9/$25.00

Key words: Wave Particle Duality; Mass-Energy Equivalence; Relativity; Uncertainty; Quantum Mechanics; Measurement Paradox; Spontaneous Decay; Gravity; Collapse of Wave-Function.

I. INTRODUCTION

Quantum mechanics theory, in spite of its successes, has remained enigmatic and paradoxical[b)] because of a lack of understanding of its inner workings. Scientists are still puzzled over its features such as wave-particle duality, entanglement, "spooky action at a distance," and whether or not God plays dice with the universe. The behavior of the small or quantum versus the classical large objects shows uncommon features that still remain unexplained by existing theories. Even within quantum domain, massive versus massless particles are treated differently in their mathematical descriptions lacking a cohesive universal model integrating quantum versus classic behavior. Some scientists insist that quantum uncertainty is a real indeterminism in the fundamental nature of reality. Einstein disagreed with this view stating that "God does not play dice with the universe" pointing to the incompleteness of quantum mechanics theory. Common human experience does not support the intuitions of quantum mechanics. Freeman Dyson, an eminent physicist, expressed this strangeness by saying—"I understand now that there isn't anything to be understood." Even Richard Feynman, known for his mastery of the subject, raised the question: "How does it work? What is the machinery behind the law…We have no ideas about a more basic mechanism from which these results can be deduced."

The relativistic mass-energy behavior can affect not only space-time, but also the fundamental fabric of the universe in terms of nonlocality and action at a distance. This paper investigates the inner workings of quantum mechanics via developing a new wave-particle model based on the Universal Relativity Model (URM), as an alternative to existing de Broglie model, representing the physics of the relativistic mass-energy effects and wave dynamics governing the quantum behavior. The proposed models provide mathematical formulations of the limits of quantum behavior and transition from classic to quantum behavior including the effects of gravity at quantum scales. The models also provide a physical understanding and resolution of the well-known and as yet unresolved paradoxes related to the measurement problem or the observer paradox (collapse of the wave-function), spooky action-at-a-distance or nonlocality, Heisenberg's uncertainty, and parallel universes.

II. URM BASED WAVE-PARTICLE DUALITY MODEL

Bohr's "Copenhagen interpretation" described the wave-particle duality as the basic puzzle of quantum mechanics since both of these classical conceptions of reality are required to make predictions of the observed reality. While the particle nature of light was discovered by Max Planck in 1900 and later clarified by Einstein (1905) in explaining the photoelectric effect, French physicist Louis de Broglie, in his doctoral thesis in 1924, discovered that every particle of matter also acts as a wave that guides its motion in space. Under proper conditions of size and motion of the particle and geometry of interacting bodies (such as slits), a particle will produce an interference or diffraction pattern just like a wave. Louis de Broglie proposed the following relationship between the effective wavelength and momentum of the body:

$$\lambda_{dbr} = \frac{h}{mV}, \tag{1}$$

where λ_{dbr} is de Broglie wavelength, m is the mass, and V is the velocity of the body. Louis de Broglie derived the above equation based on classical motion of a body without any consideration of the relativistic effects. The mass of the body was assumed to remain constant irrespective of the magnitude of its velocity. The need to enhance the existing well-known de Broglie model is realized because it is unable[1–4] to resolve quantum paradoxes such as nonlocality, collapse of the wave-function or the measurement problem, Heisenberg's uncertainty, and parallel universes, etc.

Using the relativistic models of URM described in Part I of this paper, a set of relativistic relationships governing the dualistic wave-particle behavior can be derived as follows. A quantum particle such as a photon is also described as a quantum wave packet with an energy e given by the following equation:

$$e = hf \tag{2}$$

wherein h is Planck's constant and f is the frequency of oscillation of the wave packet. Now, from Einstein's specific theory of relativity (ESTR), a mass m has an equivalent energy given as follows:

$$e = mC^2. \tag{3}$$

Combining the above two equations gives

$$f = \frac{mC^2}{h}. \tag{4}$$

The wavelength λ of the wave packet is related to the velocity V as follows:

$$\lambda = \frac{V}{f} = \frac{hV}{mC^2}. \tag{5}$$

In Part I, for a mass m moving at speed V and rest mass M_0, URM formulations provided the following relationship:

$$m = M_o\sqrt{1-(V/C)^2}. \tag{6}$$

Substituting the above into Eqs. (4) and (5), we obtain the following Relativistic Wave Particle (RWP) model expressions for the frequency f_{sdm} and wavelength λ_{sdm} of the spontaneous mass-energy conversion during the wave-particle behavior:

b)https://en.wikipedia.org/wiki/List_of_unsolved_problems_in_physics.

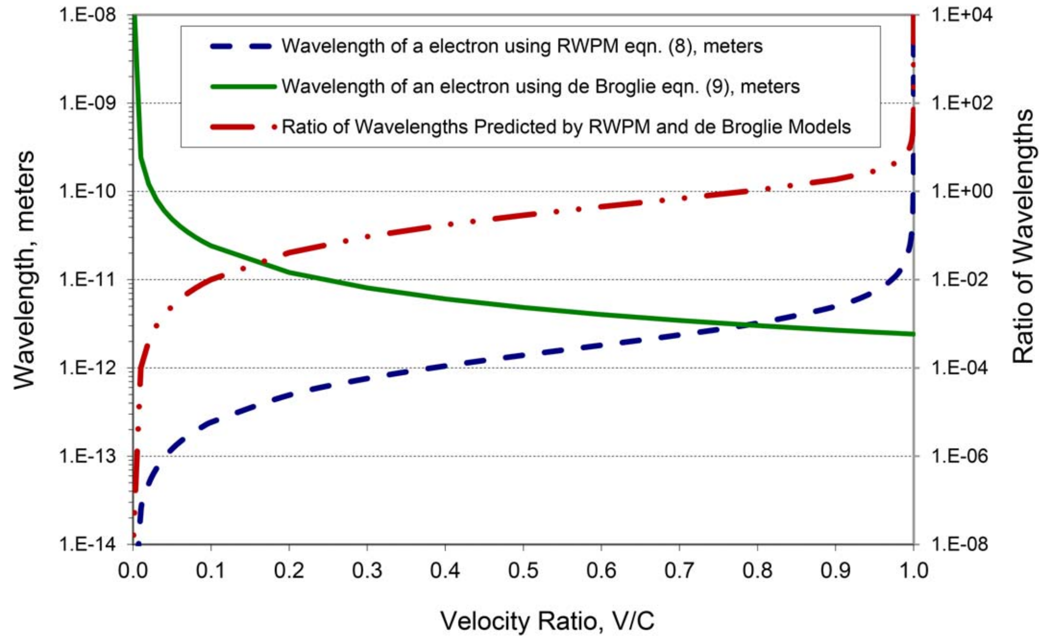

FIG. 1. (Color online) Comparison of wavelengths predicted by RWP and de Broglie models for an electron.

$$f_{sdm} = \frac{M_o C^2 \sqrt{1-(V/C)^2}}{h}, \tag{7}$$

$$\lambda_{sdm} = \frac{hV}{M_o C^2 \sqrt{1-(V/C)^2}}. \tag{8}$$

III. COMPARISON OF DE BROGLIE AND RWP MODEL

Equation (1) gives the de Broglie wavelength for a rest mass M_0 as follows:

$$\lambda_{dbr} = \frac{h}{M_0 V}. \tag{9}$$

Now, de Broglie frequency can be calculated as follows:

$$f_{dbr} = \frac{V}{\lambda_{dbr}} = \frac{M_0 V^2}{h}. \tag{10}$$

For a spontaneously converting mass, dividing Eqs. (7) and (8) by Eqs.(10) and (9), respectively, we obtain

$$\frac{f_{sdm}}{f_{dbr}} = \frac{\sqrt{1-(V/C)^2}}{(V/C)^2}, \tag{11}$$

$$\frac{\lambda_{sdm}}{\lambda_{dbr}} = \frac{(V/C)^2}{\sqrt{1-(V/C)^2}}. \tag{12}$$

Figure 1 shows wavelengths of an electron mass (9.1×10^{-31} kg) calculated by RWP equation (8) and de Broglie equation (9) as a function of velocity ratio V/C. At $V = 0$, the wavelength calculated by de Broglie model is infinite, while RWP calculated wavelength is 0. As V increases to equal C, the de Broglie wavelength decreases to reach a minimum value of 2.42×10^{-12} m while the RWP wavelength increases indefinitely because of a total mass dilation. Close agreement is seen between the wavelengths predicted by two models around V/C of 0.8. Figure 2 shows frequencies of an electron mass (9.1×10^{-31} kg) calculated by RWP equation (7) and de Broglie equation (10) as a function of velocity ratio V/C. At $V = 0$, the frequency calculated by de Broglie model is zero, while RWP calculated frequency equals 10^{20} Hz. As V increases to equal C, the de Broglie frequency increases to reach a maximum of 10^{20} Hz, while the RWP calculated frequency decreases to zero because of a total mass dilation. Again, close agreement is seen between the frequencies predicted by two models around V/C of 0.8.

It should be noted that at small velocities ($v \sim 0$), de Broglie model predicts very large wavelength even for a large mass, which is counter to the physical experience since large classical objects moving at zero or very slow speeds do not act or appear as a wave. Hence, de Broglie model does not represent physical reality at low values of v. This discrepancy is understandable since this model was originally developed for quantum particles of small masses moving at large velocities close to c. At $v = 0.8c$ the predictions of de Broglie model and RWP are fairly close as shown in Figs. 1 and 2.

IV. RWP MODEL PREDICTS PHYSICAL LIMITS OF QUANTUM VERSUS CLASSICAL BEHAVIOR

A quantum particle is an illusive entity that can appear from or disappear into nothingness or vacuum, and exhibits unexplained behavior that follows weird rules involving strange properties. The quantum behavior or properties are so far different from those of the real-life objects that there appears to exist separate worlds or universes for the ordinary real life objects versus the quantum objects. Such weirdness is apparent in the theory of parallel universes, which is one of the highly regarded theories explaining the quantum

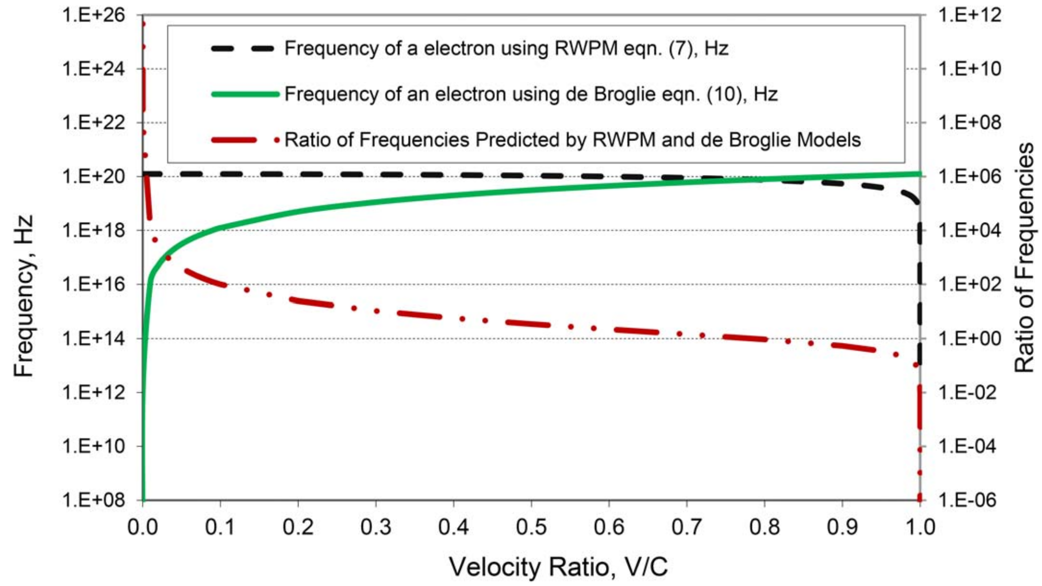

FIG. 2. (Color online) Comparison of frequencies predicted by RWP and de Broglie models for an electron.

weirdness. There still exists a big gap in the fundamental understanding of the duality of wave and particle behaviors. Roger Penrose[5] states "… I believe that the normal view of physicists is that, if we really understood quantum physics properly, we could deduce classical physics from it. …… In practice, one does not do that—one uses *either* the classical level *or* the quantum level."

In Section III, the wave-particle behavior was mathematically described ignoring gravitational effects. In the following, we will develop a URM based relativistic understanding of the quantum behavior and derive mathematical expressions of the physical limits that govern transition between quantum and classical behavior including gravity. Equation (13) below representing URM based model of a self-decaying mass was obtained in Part I, Eq. (15a), from conservation of relativistic mass-energy, kinetic energy, and gravitational energy

$$(M_0 - m)C^2 = mC^2\left\{\frac{1}{\sqrt{1-(V/C)^2}} - 1\right\} + \frac{3Gm^2}{5R}. \tag{13}$$

The fundamental characteristic of quantum behavior is the wave-particle complementarity, which allows a quantum entity to act as a wave or particle depending upon its environment. When the particle can move uninhibited, it generally acts or exists as a wave, and when it is intercepted via a measuring device or a fixed boundary wall or slits it appears to act as a particle. Such spontaneity of converting from a particle (mass) to wave (energy) is built into the observed wave-particle behavior in a variety of experiments involving quantum particles such as electrons, atoms, or molecules. From Eq. (13) above, it is evident that the spontaneous mass to energy conversion, represented by Eq. (6), exhibiting the wave-particle behavior can occur when the gravitational energy is much smaller compared to the kinetic energy,

$$\frac{3Gm^2}{5R} \le mC^2\left\{\frac{1}{\sqrt{1-(V/C)^2}} - 1\right\}. \tag{14}$$

Radius R in the above equation can be approximated by half of the wavelength given by Eq. (8)

$$R = \frac{\lambda_{sdm}}{2} = \frac{hV}{2\ MoC^2\sqrt{1-\left(\frac{V}{C}\right)^2}}. \tag{15}$$

Substituting Eqs. (6) and (15) into Eq. (14) and simplifying leads to the following:

$$M_{oq} \le \left(\sqrt{\frac{hC}{G}}\right)\left[\sqrt{\frac{5V\left(1-\sqrt{1-(V/C)^2}\right)}{6C\left(1-(V/C)^2\right)^{3/2}}}\right], \tag{16}$$

wherein M_{oq} represents the maximum or limiting rest mass that exhibits the wave-particle duality or quantum behavior. Masses greater M_{oq} would be expected to behave as classical rather than quantum due to significant gravitational effects opposing spontaneous mass-energy conversion. It should be noted that Planck's mass is defined as

$$M_{pl} = \sqrt{\frac{hC}{G}}. \tag{17}$$

Using Eq. (16), we now define Planck's Mass Factor (PMF) as follows:

$$PMF = \left[\sqrt{\frac{5V\left(1-\sqrt{1-(V/C)^2}\right)}{6C\left(1-(V/C)^2\right)^{3/2}}}\right]. \tag{18}$$

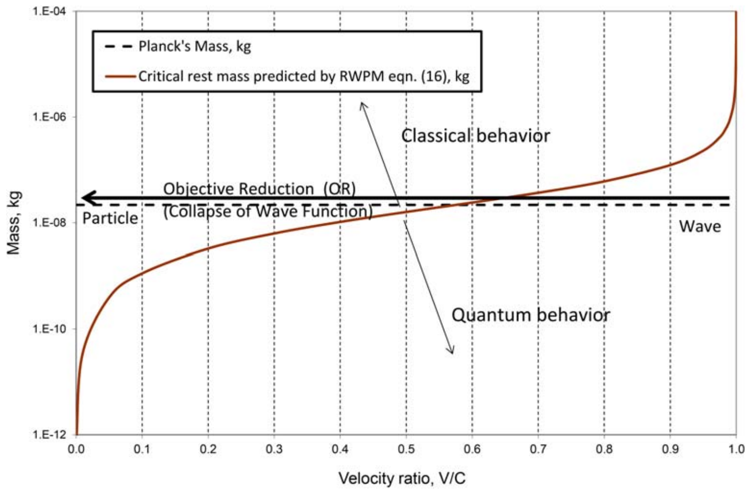

FIG. 3. (Color online) Critical quantum rest mass and objective reduction (collapse of wave function) of quantum to classical behavior predicted by RWP.

Combining Eqs. (16)–(18) gives the following criterion for a mass, expressed in terms of a nondimensional mass M_{oqn}, to act as a quantum particle:

$$M_{oqn} = \frac{M_{oq}}{M_{pl}} \le (PMF). \tag{19}$$

Figure 3 shows the critical quantum rest mass predicted by RPW equation (16) describing the limits governing the quantum versus classical behavior. For velocities close to $v/c = 0.6$, the predicted critical or maximum quantum rest mass is approximately of the order of Planck's mass, 2.1767×10^{-8} kg. For very small velocities, the critical rest mass decreases and for higher velocities close to the speed of light c, it increases by several orders of magnitude. Hence, at small velocities the quantum behavior is experienced only by very light particles and at higher velocities even a lot heavier mass can exhibit quantum properties or wave particle duality. For example, Fig. 3 shows that very large mass, such as heavier galaxies at the far edge of the universe, moving close to the speed of light may exhibit quantum behavior. Such behavior is not predicted by de Broglie model lacking the relativistic physics of spontaneous mass-energy conversion exhibited during the wave-particle behavior.

V. RWP RESOLVES KEY QUANTUM PARADOXES

RWP model can explain, as discussed below, some well-known and as yet unresolved paradoxes related to quantum measurement problem or the observer paradox, quantum entanglement or nonlocality, Heisenberg's uncertainty, and parallel universes.

A. RWP solution to the quantum measurement problem or observer's paradox (collapse of the wave function)

At the quantum level, the state of a system is described by a complex-number weighted superposition of all possible alternatives. The time-evolution of the quantum state or the Schrödinger evolution is obtained by the linear superposition of all possible states. Each of the individual states are assumed to evolve independently, but are superposed together with complex number weightings that are invariant in time. This linearity is built into the widely accepted formulation of quantum mechanics in Schrödinger's wave equation, which represents a deterministic and quantitative description of quantum reality. However, as Roger Penrose[5] points out, the rules change when a measuring device or observer looks into the quantum reality and in the process coverts it into a classical reality. This process of conversion from quantum to classical reality is defined as the *Collapse of the Wave Function* or *Reduction of the State Vector*. An example of this is the observation of an electron wave as a dot when it hits the screen. Following this process, the two alternatives are no longer superposed linearly. Instead, the squares of the weighting complex numbers become the ratio of the probabilities of the two alternatives. The reality that was fully deterministic before the collapse, all of a sudden becomes nondeterministic or probabilistic after the collapse of the wave function caused by the process of measurement or observation by a conscious observer.

This paradox or mystery of quantum mechanics theory is also known as the *Measurement Problem*. The most famous example of this is the so-called *Schrödinger's Cat* paradox in which a cat can exist in a state of being both dead and alive at the same time. A cat, which is a classical object, is never seen to exist in such a quantum state in real life experience. Roger Penrose[5] has made the following remarks regarding the quantum measurement problem:

> *"What we do not have is a thing which I call OR standing for Objective Reduction……It is a missing theory…. "I am going to regard the superposition of the one state plus the other as an unstable state—it is a bit like a decaying particle or a uranium nucleus or something like that, where it might decay into one thing or another and there is a certain time-scale associated with that decay. It is a hypothesis that it is unstable, but this instability is to be an implication of the physics we do not understand.… The thing is that, in the superposed state, you have to take into account the*

> *gravitational contribution to the energy in the superposition. But you cannot really make local sense of the energy due to (quantum) gravity and so there is a basic uncertainty in the gravitational energy… That is just the sort of thing which one gets with unstable particles."*

The mathematical formulations of RWP account for the phenomena identified above by Roger Penrose in explaining the physical basis behind the quantum measurement problem. First of all, RWP equation (13), (14), and (16) above describe the limits of classical versus quantum behavior of particles accounting for the contribution of the gravitational energy as suggested by Roger Penrose eliminating the uncertainty caused by the so-called quantum gravity absent from existing quantum mechanics theories. Second, Eq. (6) properly treats the energy conservation involving spontaneous decay of a mass. In addition to the gravitational potential energy, the kinetic energy and the mass energy are properly accounted for in RWP. This provides for a proper superposition of the mass/energy movement or conversion between various space/time states that a particle can experience before, during or following a measurement is made. In summary, RWP model integrates the missing physics described by Roger Penrose in formulating and resolving the mysterious collapse of the wave function or Objective Reduction (OR) paradox of the quantum mechanics.

Figure 3 shows a schematic of the physical process that happens during measurement of a quantum event and how a quantum wave changes to a particle for the *Objective Reduction* to occur. Let us assume that there exists a quantum entity with a rest mass equal to Planck's mass moving at close to the speed of light in free space as depicted by the right tail end of the arrow in Fig. 3. When this quantum entity (existing dominantly as a wave in the free space, as depicted by Eqs. (7) and (8), is interrupted by a classical measuring device, its velocity practically drops to zero ($v/c=0$), as depicted by the left end of the arrow in Fig. 3. As is evident, the process of measurement or any obstruction/barrier causes a sudden change or the so-called *collapse* of the quantum wave (wave function) into the region of non-quantum or classical behavior. The Objective Reduction occurs because of this sudden decrease in the quantum wave velocity close to zero leading to the collapse of the wave-function. RWP thus explains the physical process involved in the *Objective Reduction* or *Collapse of the Wave Function* that occurs during the *Measurement problem* in quantum mechanics.

B. RWP solution to quantum entanglement and action-at-a-distance or nonlocality

Another famous mystery of quantum mechanics is the *Action-at-a-distance* or *Nonlocality* caused by *Quantum Entanglement*. Einstein and his colleagues, Podolsky and Rosen, first highlighted the physical problem involved in this paradox. Subsequent experiments performed by Alan Aspect[6] and Anton Zeilinger at the Vienna Centre for Quantum Science and Technology[7] have confirmed the correctness of the predictions of quantum mechanics. In Aspect's experiments photon pairs are emitted at a source in an entangled state and travel in two different directions to two detectors located at about 12 m apart from each other. The decision to measure the direction of polarization of the two separated photons was made after the photons were in full flight from the source to the detectors. The results of the measurements showed that the two photons do not behave as two separate and independent classical objects. Instead, the observed states of the two photons were observed to be in the entangled state that matched the predicted joint probabilities of quantum mechanics. Similar experiments[8] have been performed to verify action-at-a-distance or nonlocality over distances of several hundred kilometers. Highlighting this unexplained mystery, Roger Penrose[5] states "…They are entangled in such a way that there is no way of using that entanglement to send a signal from A to B—this is very important for the consistency of quantum theory with relativity."

The mystery of the *Action-at-a-distance* or *Nonlocality* is explained by RWP Eq. (8) based on spontaneous mass-energy conversion that can induce a very large wavelength at velocities close to C as shown in Fig. 1. The spatial extent of the wavelength determines the distance over which the entanglement or nonlocality of a particle is expected to occur. The correlation or coherence over this spatial extent is instantaneous and not subject to the locality caused by the finite speed of light, which limits the speed of travel of a signal. RWP eliminates the shortcomings of the De Broglie equation that fails to predict large wavelengths at $v \sim c$ and ensuing nonlocality. Wavelengths of a quantum particle with a rest mass of M_0, can be calculated using Eq. (8). Since the wavelength is inversely proportional to the rest mass, the wavelength for the lighter rest mass is proportionally longer than the heavier one. In order to demonstrate the nonlocality of a very light mass particle due to its dramatically large wavelength, we will calculate the ratio of the wavelength of a self-decaying mass given by Eq. (8) to the radius (R) or size of the universe predicted by Hubble Model, Eq. (20) below:

$$\lambda_{sdm} = \frac{hV}{M_o C^2 \sqrt{1-(V/C)^2}}, \tag{8}$$

$$R = V/H, \tag{20}$$

wherein H is the Hubble Constant. Combining the above two equations and simplifying gives the following:

$$\frac{\lambda_{sdm}}{R} = \frac{hH}{M_o C^2}\left[\frac{1}{\sqrt{\left\{1-(V/C)^2\right\}}}\right]. \tag{21}$$

The minimum value of the ratio of the wavelength to the universe radius is given by the above equation as follows:

$$\frac{\lambda_{sdm}}{R} = \frac{hH}{M_o C^2}. \tag{22}$$

Using the above equation, we can now calculate the maximum value of the rest mass of a particle, defined here as the God-particle for which the wavelength is equal to the Hubble radius of the universe as follows:

$$M_o = \frac{hH}{C^2}. \quad (23)$$

For a Hubble Constant of $2.27 \times 10^{-18}\,\mathrm{s}^{-1}$, the rest mass of a God-particle is calculated to be 1.66×10^{-68} kg. As is apparent from Eq. (21), the ratio of wavelength to Hubble radius for an electron (mass equal to 9.11×10^{-31} kg) is several orders of magnitude (10^{-38}) smaller than the ratio of 1 for the God-particle. The God-particle has 100% probability to be at all points in the universe, satisfying an ideal nonlocality, as compared to an electron, which will be located or confined to a much smaller region of its wavelength. The wavelength of a God-particle moving at $V = C$ calculated by Eq. (8) exceeds a trillion lightyears. Hence, God-particle will appear to be in perfect coherence and entanglement all over the universe because of its wavelength encompassing the entire universe. In summary, RWP provides a mathematical and physical understanding of the observed *Quantum Entanglement* and *Action-at-a-distance* or *Nonlocality*.

C. RWP explains Heisenberg's uncertainty

The Heisenberg Uncertainty principle describes an inherent and irreducible uncertainty in prescribing both the position (Δx) and momentum (ΔmV) of quantum particles. Such uncertainty is related to the observed dual behavior of photons and other small particles such as electron, proton, etc., in the microscopic world that act both as particles as well as waves. This uncertainty is often presumed to occur due to the direct and unavoidable impact of the measuring device or process on the motion or spatial location of the measured entity itself. In classical physics and Quantum Mechanics, mass, space, and time are considered to be fixed (Newtonian frame of reference) and independent entities, which are used to define velocity and momentum of the particle. Detailed calculations by Heisenberg determined the following mathematical form of his uncertainty principle

$$(\Delta x)\{\Delta(mV)\} \geq \frac{h}{2\pi}. \quad (24)$$

Since the Planck's constant, h, is very small, the uncertainties at macroscopic level or for scales of everyday large objects are negligible. However, at microscopic level wherein we deal with small particles such as electrons, protons and atoms, the uncertainty becomes significant. For particles with higher speeds approaching the speed of light, such as electrons and photons, the relativistic effects become significant and the assumption of fixed space and time does not hold. Heisenberg's principle, known as the fundamental basis for probabilistic formulation and calculation of Quantum mechanical behavior, does not specify as to how does the uncertainty get impacted by these relativistic effects.

In the following, we will use URM to reevaluate the Heisenberg's principle and calculate physical parameters and conditions under which the principle may hold and vice versa. The wavelength of a particle, λ_{sdm}, describes the region in space over which the particle resides, hence it represents the spatial uncertainty in the position of the particle

$$\Delta x \;\approx\; \lambda_{sdm} \quad (25)$$

Using Eq. (6), the uncertainty in momentum mV can be calculated as follows:

$$\Delta(mV) = M_o\left(\frac{1-2\left(\frac{V}{C}\right)^2}{\sqrt{1-\left(\frac{V}{C}\right)^2}}\right)(\Delta V) \quad (26)$$

Substituting equations (25) and (26) into (24) and simplifying, the following is obtained,

$$(\Delta x)\{\Delta(mV)\} \geq \frac{h}{2\pi}\left[2\pi\left(\frac{V}{C}\right)\left\{1-\frac{\left(\frac{V}{C}\right)^2}{1-\left(\frac{V}{C}\right)^2}\right\}\Delta\left(\frac{V}{C}\right)\right]. \quad (27)$$

Let us define a Heisenberg's Uncertainty Factor (HUF) as follows:

$$HUF_{sdm} = \left[2\pi\left(\frac{V}{C}\right)\left\{1-\frac{\left(\frac{V}{C}\right)^2}{1-\left(\frac{V}{C}\right)^2}\right\}\Delta\left(\frac{V}{C}\right)\right]. \quad (28)$$

Equation (24) then can be rewritten as follows:

$$(\Delta x)\{\Delta(mV)\} \geq \frac{h}{2\pi}(HUF_{sdm}). \quad (29)$$

Comparing the above against the Heisenberg's principle, Eq. (24), the principle is satisfied when HUF ≥ 1 and violated when HUF < 1. It is apparent from Eq. (28) that HUF depends directly upon the value of velocity V and its uncertainty ΔV. If the uncertainty ΔV is zero, HUF will be zero and hence, the Heisenberg's principle will be violated. For nonzero ΔV, predicted values of the HUF for a self-decaying mass are shown in Fig. 4. It is to be noted that for velocities less than approximately 70% of the speed of light C, the HUF is less than 1 and the Heisenberg's principle is violated even for an uncertainty in velocity V being as high as 90%. For smaller uncertainties in V, the principle is satisfied only for much larger velocities. For 1% uncertainty in V, the minimum value of V is greater than 95% of the speed of light C for the principle to hold true.

In summary, the URM provides the physics behind the Heisenberg's Uncertainty principle, its limitations and boundaries within which it holds true:

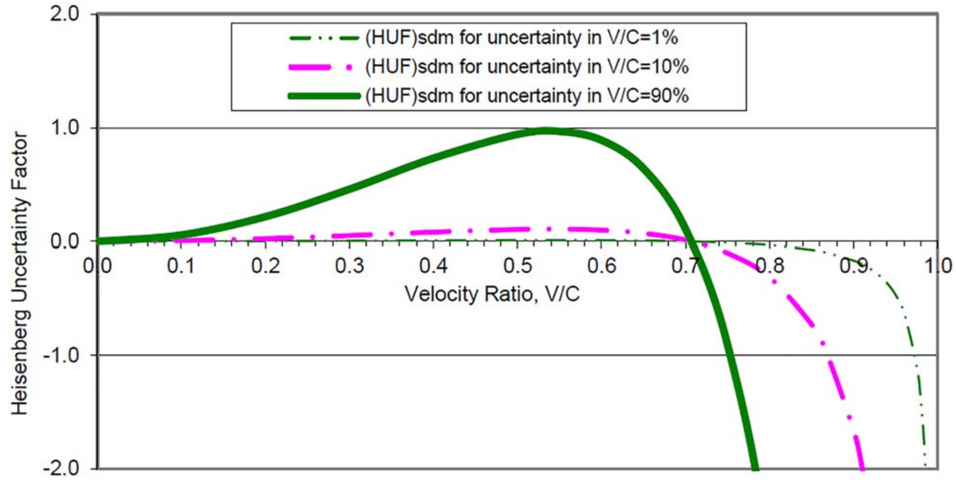

FIG. 4. (Color online) Heisenberg's uncertainty factor for a self-decaying mass.

- URM accounts for the fundamental missing relativistic physics in the formulation of the Heisenberg's principle.
- URM reveals that there is no inherent uncertainty in nature insofar as the true relativistic nature of reality is realized and treated as such.

D. URM/RWP explains theory of parallel universes

The theory of parallel universes[5] has been advanced by its proponents to explain the mysterious collapse of the wave function consisting of infinite number of states to one classical solution experienced by the observer. Each of the infinite number of universes corresponds to a probable classical outcome that can occur when an observer looks at the quantum system. The parallel universes coexist but are not quite parallel in the strict sense, since they do communicate with each other at the quantum level through a common space and time. An observer cannot experience them all and can detect them only indirectly via their impact on the observed or collapsed events in space-time.

The proponents argue that the theory of parallel universes is by far the simplest in explaining the observed quantum experiments since it involves the fewest additional assumptions. When an observation is made, it is presumed that the whole ensemble of parallel universes partitions in two groups with different outcomes. The observer happens to experience only one of the outcomes in his own universe. The other dilemma solved by this theory is the so-called observer paradox in quantum cosmology. In a classical quantum observation, the observer is outside the quantum system and looking at it causing the collapse of the wave function. However, when the observer is within or part of the quantum system itself, such as in the case of observations of the universe by an observer within it, the standard interpretation of the quantum theory fails. Hence, the quantum cosmological observations cannot be explained by the standard interpretation of quantum theory. The theory of parallel universes eliminates this dilemma. A third point forwarded as an advantage of this theory is that it does not require the strict definition as to who the observer is. The definition of an observer relative to the quantum system is an open question in the standard interpretation, and probably involves a definition of the consciousness, which is not an easy problem to resolve. The theory of parallel universes eliminates the observer and mind from interpretation of the observed reality. However, the key weakness of the theory is that it cannot be tested and involves many open questions with regard to the properties and nature of mass-energy-space-time interactions among many universes.

RWP model provides a physical understanding of the many possible outcomes signifying parallel subuniverses, of an observation depending upon the characteristics of the observer. According to RWP, the mass-energy-space-time dilation is directly dependent upon the relative velocity ratio (v/c) between the observer and the observed. Two different observers traveling at different speeds experience different mass-energy-space-time and hence different physical realities. Figure 5 shows RWP predicted mass-space-time dilation as a function of the velocity of the observer as well as the progressions of manifold outcomes of the parallel universes. At low velocities, the mass-space-time (M_0, S_0,

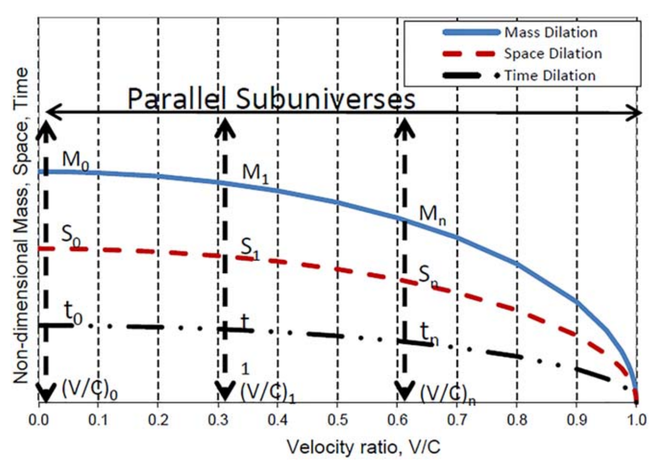

FIG. 5. (Color online) Depiction of RWP subuniverses within a single universe model.

and t_0) act as fixed or classical as assumed in the Newtonian mechanics. However, different events and outcomes (M_n, S_n, *and* t_n) can exist for different observers moving at different speeds $(v/c)_n$ relative to each other at lower velocities. However, at large velocities when V approaches c, the mass-space-time dilate to almost zero and hence the outcomes or events/phenomenon observed by different observers experience quantum entanglement becoming completely coherent with each other. In a way, higher velocity represents a higher level of space/time dilation leading to a nonlocality or nonrelativity in what is observed. In summary, RWP provides a qualitative physical understanding of the theory of parallel subuniverses within a unified single relativistic universe correlated via different mass-space-time characteristics of different observers' frames of references moving at various speeds.

VI. SUMMARY AND CONCLUSIONS

URM describes the missing physics that reveals the hidden variables behind the incomplete formulations of quantum mechanics. These hidden variables are identified as spontaneously converting mass, space, and time as per relativity theory. There is no inherent uncertainty built into natural phenomena; the observed uncertainty in quantum measurements results from the measurement error caused by the destructive nature of measurement that alters the relativistic mass-space-time of the measured event. URM describes the fundamental relativistic mechanism governing the quantum events and as to how gravity and measurement interference could affect the wave-particle nature of the observed collapse of the wave function to classic behavior. The limits of quantum versus classical behavior are predicted in terms of the rest mass and velocity of the self-converting quantum particle. Nonlocality observed in quantum phenomena is caused by the space-time dilation and/or the large wavelengths as expansion velocity v approaches to c. The physical reality or state of a rest mass (or even universe) could be described as a set of infinite number of complementary relativistic mass-space-time states as a function of varying velocity of the frame of reference of the observer. There is only one universe entailing multiple complementary or parallel subuniverses or worlds representing the infinite number of complementary mass-space-time states. There is no need for fine tuning (or anthropic principle) of our universe among multiuniverses theory with varying universal constants. URM consolidates and replaces many different interpretations of quantum mechanics into one coherent picture of reality within a holistic relativistic framework and model vindicated by the empirical observations of the universe as described in Part I.

[1]A. Singh, *The Hidden Factor: An Approach for Resolving Paradoxes of Science, Cosmology and Universal Reality* (AuthorHouse, Bloomington, IN, 2003).
[2]A. Singh, Phys. Essays **20**, 346 (2007).
[3]A. Singh, Phys. Essays **19**, 19 (2007).
[4]A. Singh, "Which of our basic physical assumptions are wrong?," FQXi Questioning the foundations essay contest, Foundations Questions Institute, (http://fqxi.org/ community/forum/topic/1317/ (2012).
[5]R. Penrose, A. Shimony, N. Cartwright, and S. Hawking, *The Large, the Small and the Human Mind* (Cambridge University Press, Cambridge, UK, 1999).
[6]A. Aspect, P. Grangier, and G. Roger, Phys. Rev. Lett. **49**, 91 (1982).
[7]Z. Merali, Nature **525**, 14 (2015).
[8]J. Yin, Y. Cao, Y.-H. Li, S.-K. Liao, L. Zhang, J.-G. Ren, W.-Q. Cai, W.-Y. Liu, B. Li, H. Dai, G.-B. Li, Q.-M. Lu, Y.-H. Gong, Y. Xu, S.-L. Li, F.-Z. Li, Y.-Y. Yin, Z.-Q. Jiang, M. Li, J.-J. Jia, G. Ren, D. He, Y.-L. Zhou, X.-X. Zhang, N. Wang, X. Chang, Z.-C. Zhu, N.-L. Liu, Y.-A. Chen, C.-Y. Lu, R. Shu, C.-Z. Peng, J.-Y. Wang, and J.-W. Pan, "Satellite-based entanglement distribution over 1200 kilometers," e-print arXiv:1707.01339 [quant-ph] (2017).