

## **Non-zero Photon Mass Resolves Current Physics & Cosmology Paradoxes**

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### **ABSTRACT**

An alternate photon model is proposed to remove prevailing inconsistencies of the widely-accepted (Maxwell's theory) assumptions of a zero photon rest mass and its fixed speed of light  $C$ . The prevailing mainstream assumptions are that the rest mass of a photon is zero since a photon cannot be possibly be accelerated from rest up to the speed of light and that photons are traveling at the speed of light at the instant they are formed. The proposed model describes a postulated spontaneous mass creation/dilation process allowing a non-zero photon mass at rest (emission and absorption), which dilates to zero as it expands and accelerates thru uninterrupted space. The model thus bridges gaps between relativity and Maxwell's theories. Integrating gravity into the model provides a fundamental universe model that is shown to predict the observed universe behavior and resolves paradoxes of the standard model cosmology. It also explains the inner workings of quantum mechanics as well as eliminates black hole singularity and inconsistencies of current theories. The model also makes testable predictions for falsification via future observations and provides a new fundamental understanding of universal constants such as  $C$ , commonly known as speed of light, and Cosmological Constant (Dark Energy). The results may have significant implications for the current standard model cosmology and fundamental understanding of the universe.

### **INTRODUCTION**

Photons are fundamental particles. All electromagnetic radiation is quantized as photons [1]. The smallest amount of electromagnetic radiation that can exist is one photon, whatever its wavelength, frequency, energy, or momentum. The very abundance of photons in the universe raises the question as to how the photons came to existence. Photons are produced by atoms when a bound electron moves from one orbital to another orbital with less (more negative) energy. Photons can also be emitted by an unstable nucleus when it undergoes some types of nuclear decay. Furthermore, photons are produced whenever charged particles are accelerated.

The prevailing assumptions of the Maxwell's theory are that the rest mass of a photon is zero since a photon cannot be possibly be accelerated from rest up to the speed of light and that photons are traveling at the speed of light at the instant they are formed. Speed of light  $C$  is presumed as a cosmic speed limit based on the assumption of zero photon mass that could be stable forever. If photons have a little non-zero mass, they would travel at speed less than  $C$ , would be unstable, and eventually decay into lighter particles. Then  $C$  would essentially become a fixed universal constant rather than the constant speed of light as widely accepted. A non-zero photon mass would also require modifications to the Standard Model of particle physics (which posits a zero photon mass), the Maxwell equations describing EM waves/fields, and Coulomb's inverse-square law for electrical attractions of charged particles [1,2].

### **ISSUES AND INCONSISTENCIES RELATED TO MAXWELL'S PHOTON MODEL**

#### **Observed Experimental Limits on Photon Mass and Lifetime**

There are no measurements to prove that the photon mass is exactly zero. Experiments don't determine exact quantities because of small errors inherent in making measurements. Scientists have, however, put

an upper limit [3,4,5] on the photon rest mass. In 1994, the Charge Composition Explorer spacecraft measured the Earth's magnetic field and physicists used this data to define an upper limit of 0.0000000000000006 electron volts for the mass of photons, with a high certainty in the results. This number (3.55E-52 kg, the lightest particle) is close to zero; it is equivalent to 0.000000000000000000000000000039 times the mass of an electron. The work [6] carried out by Jun Luo and his colleagues at Huazhong University of Science and Technology in Wuhan, China establishes a new limit on photon mass as less than  $10^{-54}$  kilograms or  $7 \times 10^{-19}$  electron volts. This was established by an experiment in which light is aimed at a sensitive torsion balance; if light had mass, the rotating balance would suffer an additional tiny torque. This represents a 20-fold improvement over previous limits on photon mass.

A recent study [7] analyzed observations of the cosmic microwave background radiation (CMBR) from the NASA's COBE satellite (1989) to calculate the limit on the photonic lifetime. The results of the study found no indication of missing low-energy light and a perfect black body behavior of the CMBR. This led to the conclusion that the minimum lifetime of a photon is  $10^{18}$  years much greater than the 13.7 billion years of universe age predicted by the Big Bang model.

### Inconsistencies Related to the Zero Photon Mass and Fixed Speed

Maxwell's theory hypothesis is that the photon rest mass is zero and it moves at exactly the speed of light. However, these hypotheses are in direct conflict with the principle of wave-particle duality and theory of relativity as discussed below:

1. The complimentary wave-particle behavior of a photon is well established by scientific experiments and theories. If a photon has no rest mass, it cannot act as a particle. The concept of a photon as a particle was proposed by Einstein to explain the observed photoelectric effect wherein the energy of absorbed light quanta can cause an emission of electrons from a surface. Einstein showed that the wave nature of light could not lead to the observed photoelectric effect.
2. Photons are deflected by a gravitational field by the same amount as a non-zero mass traveling at the speed of light with the same momentum as the photon.
3. When a photon is created from an atom at rest, its initial velocity of emission from the atom must be zero to satisfy the stationary boundary condition. Hence, the assumption of a photon having its velocity equal to the speed of light at the instant of its birth or emission is not valid.
4. While the Maxwell's theory assumes a zero rest mass, it still ascribes a non-zero momentum to the photon. Since the momentum of an entity is physically defined as the product of its mass and velocity, a non-zero momentum is internally inconsistent in conjunction with a zero rest mass. The relativistic energy  $E$  of a particle is described by Special Relativity theory as follows:

$$E^2 = (M_0C^2)^2 + (pC)^2 \quad (1)$$

Wherein,  $M_0$  is the rest mass and  $p$  is the momentum of the particle, and  $C$  is the speed of light. Maxwell's theory assumes that a photon rest mass is zero and it has a non-zero positive momentum  $p$ . This leads to  $E = pC$ , or  $p=E/C=hf/C$ , wherein  $h$  is Planck's constant and  $f$  is frequency.

5. A non-zero photon rest mass is inconsistent with special relativity (SR) because it would require an infinite amount of kinetic energy (KE) and infinite increase in mass when a rest mass  $M_0$  is accelerated to the speed of light as predicted by the following equations of special relativity:

$$KE = M_0C^2 \left( \frac{1}{\sqrt{1-(V/C)^2}} - 1 \right) \quad (2),$$

and

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

If the rest mass of the photon were non-zero, the theory of quantum electrodynamics would also be "in trouble" primarily through loss of gauge invariance, which would make it non-renormalizable; also,

charge-conservation would no longer be absolutely guaranteed. In order to avoid the above difficulties related to relativity and Maxwell's theories, physicists have accepted [1,2] the hypotheses of photon having a zero rest mass and fixed speed of light as a compromise consensus position irrespective of its serious inconsistencies.

### **Recent Studies Results Support Non-zero Photon Rest Mass**

It is almost certainly impossible to do any experiment, which would establish that the photon rest mass is exactly zero. However, a recent study [8] investigates the theory that photons from a light source are transformed into axions, hypothetical elementary particles, on interacting with an extragalactic magnetic field. Axions could then be transformed back into photons by interacting with other magnetic fields. Test results [8] provide the evidence of the existence of heavy photons with non-zero rest mass and a velocity much less than the speed of light outside of the boundary of matter, howsoever only for a small distance and time. When light hits a semiconductor material and is absorbed, its photons can become "excitons," sometimes referred to as "heavy photons" because they carry energy, like photons, but have mass, like electrons. Excitons typically exist for only a short time--trillionths of a second--and travel only a few microns before turning back into photons, which are then emitted from the material. Scientists from the University of Pittsburgh and Bell Labs, the R&D arm of Lucent Technologies, report [9] that they have designed and demonstrated a two-dimensional semiconductor structure in which excitons exist longer and travel farther than previously recorded. They report a system in which excitons move freely over distances of hundreds of microns. The researchers "stretched out" the excitons by pulling them apart with an electrical field. This extended the excitons' lifetimes by a million (up to 30 microseconds) and expanded the distances the excitons traveled (up to a millimeter). They were able to "see" the excitons by observing the emitted photons. Recent analytical results [10] show that all free physical fields should have a nonzero rest mass according to the field theory of gravitation. This general physical conclusion is in good correspondence with the basic Minkowski axiom [11]: "A substance being at any worldpoint can be always considered as staying at rest under reasonable definition of space and time. The axiom tells us in other words that at any worldpoint any velocity  $v$  is always less than  $c$ . According to this,  $c$  is the upper limit for supersubstantial velocities and this is a more profound meaning of quantity  $c$ ".

### **A FUNDAMENTAL SOLUTION TO THE PHOTON REST MASS AND SPEED DILEMMA**

The proposed model provides a mathematical representation of the postulated mass creation/dilation process allowing spontaneous conversion of the photon mass to kinetic energy and vice versa that is consistent with the recent experimental observations. It allows a non-zero photon mass at its emission and absorption, which dilates to zero as it travels thru empty space at the speed of light predicting the observed photon variable mass and speed behavior as well as a stable lifetime of the order of the universe age.

Following its emission from the stationary surface, a photon is assumed to accelerate away to the speed of light when its motion is not constrained by the medium of propagation. Since, there are no external forces acting on the photon, its acceleration to the speed of light has to be internally induced. If the mass of a photon were non-zero due to its finite non-zero energy, then according to the theory of relativity, equation (2), it would take an infinite amount of energy to accelerate it to the speed of light  $C$  as its KE increases infinitely. Hence, mass of the photon must decrease as its speed increases such that the total energy is conserved. In summary, since there is no external source of force/energy to move the photon, the kinetic energy for its motion must be internally induced via conversion of the rest mass to kinetic energy. And this leads the following hypothesis or postulate regarding the spontaneous self-decaying (conversion of mass to energy) nature of the photon:

**Postulate I: The motion of the photon is induced by the spontaneous conversion of its rest mass to the kinetic energy of the remaining mass. As mass decreases, the kinetic energy increases in accordance with the theory of special relativity and conservation of total mass-energy.**

References [13, thru 17] propose an alternative photon model, described below, based on the postulate above. Let us now consider a mass  $M_o$  at rest ( $V=0$ ) representing a total relativistic energy,  $E_o = M_o C^2$ , wherein  $C$  is the speed of light. Transformation of a small portion of the mass,  $\Delta m$ , to energy, also defined as the transformation energy (TE), can be described by the special theory of relativity as follows:

$$TE = \Delta m \cdot C^2 = (M_o - m)C^2 \quad (4)$$

As per postulate above, TE is utilized in inducing spontaneous expansive motion  $V$  within the remaining photon mass  $m$ . The total energy of the photon,  $E_o = M_o C^2$ , is conserved and maintained throughout the emission, free travel, and absorption at impact with a surface. The relativistic kinetic energy (RKE) of the remaining mass,  $m$ , is given by the following equation of the special theory of relativity:

$$RKE = m C^2 \left( \frac{1}{\sqrt{1-(V/C)^2}} - 1 \right) \quad (5)$$

In the absence of gravitational force or energy, equating this kinetic energy to TE, we obtain the following:

$$(M_o - m)C^2 = m C^2 \left( \frac{1}{\sqrt{1-(V/C)^2}} - 1 \right) \quad (6)$$

Simplifying the above provides the following:

$$m = M_o \sqrt{1-(V/C)^2} \quad (7)$$

The relativistic mass energy of the photon is given by:  $RME = mC^2$  (8)

And, the relativistic momentum is described as  $p_r = mV$  (9)

The relativistic frequency  $f_r$  is given by  $f_r = mC^2/h$  (10)

Combining eqns. (7) and (10) leads to the following,

$$f_r = (M_o C^2 / h) \sqrt{1-(V/C)^2} \quad (11)$$

The relativistic wavelength is then given by,

$$\lambda_r = V / f_r = Vh / (M_o C^2 \sqrt{1-(V/C)^2}) \quad (12)$$

Figure 1 shows the actual mass of the microwave photon with a rest mass of  $10^{-40}$  kilograms, calculated by equation (3) for a non-decaying photon and equation (7) for a self-decaying photon as a function of its velocity. At the boundary of emission when the photon velocity is zero, its actual mass is equal to the rest mass. As velocity increases, the mass calculated by equation (3) increases; while the mass calculated by equation (7) decreases to zero as  $V$  approaches  $C$ .

Figure 1: Mass of a microwave photon with a rest mass of  $10^{-40}$  kg versus velocity.

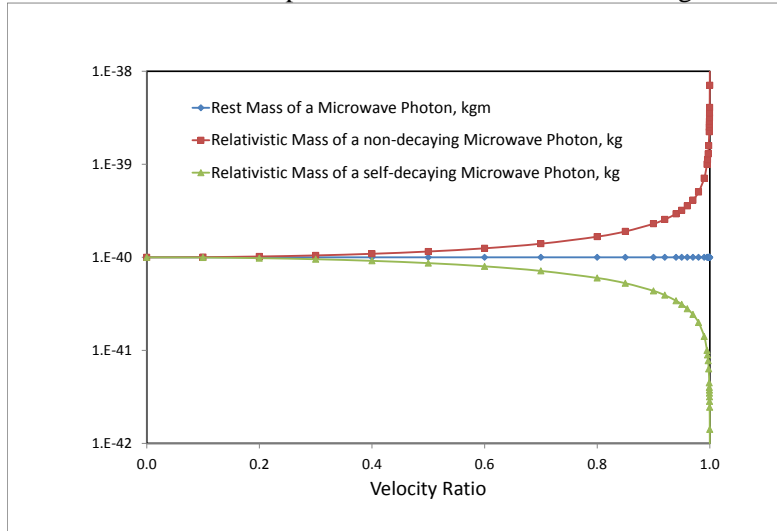


Figure 2: Momentum ( $p=hf/C$ ) vs relativistic momentum ( $mV$ ) of a microwave photon with a rest mass of  $10^{-40}$  kg versus velocity.

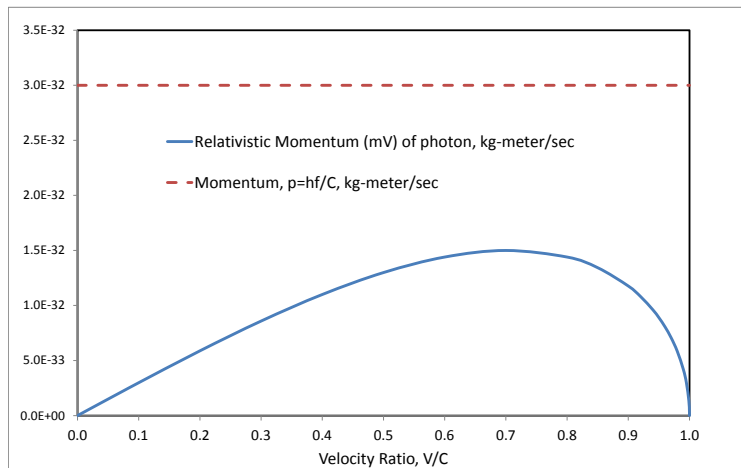


Figure 2 shows the photon momentum calculated by standard model eqn. (1) with zero rest mass and relativistic momentum calculated by the proposed model equation (11). While the standard model momentum ( $p=hf_0/C$ ) remains constant, the relativistic momentum decreases to zero at the time of emission due to the zero velocity and at  $V=C$  due to zero mass. The maximum relativistic momentum ( $mV$ ) is approximately half of the standard model momentum and occurs around 70% of the speed of light. The proposed model eliminates the earlier described inconsistencies of Maxwell’s photon model.

### UNIVERSAL VINDICATION OF THE FUNDAMENTAL SPONTANEOUS MASS-ENERGY CONVERSION MODEL

An integrated model including the effects of gravity is proposed in references [13 thru 18], which extends the above model to predict the observed universe behavior. It provides quasi-static or time-invariant mass-energy field equations that predict the observed galaxy and universe expansions. Integrating gravity in equation (8), the following Universal Relativity Model (URM) equation (15) is obtained for relativistic universe mass  $m$  as a function of size or radius  $R$  describing the universe as a spontaneously

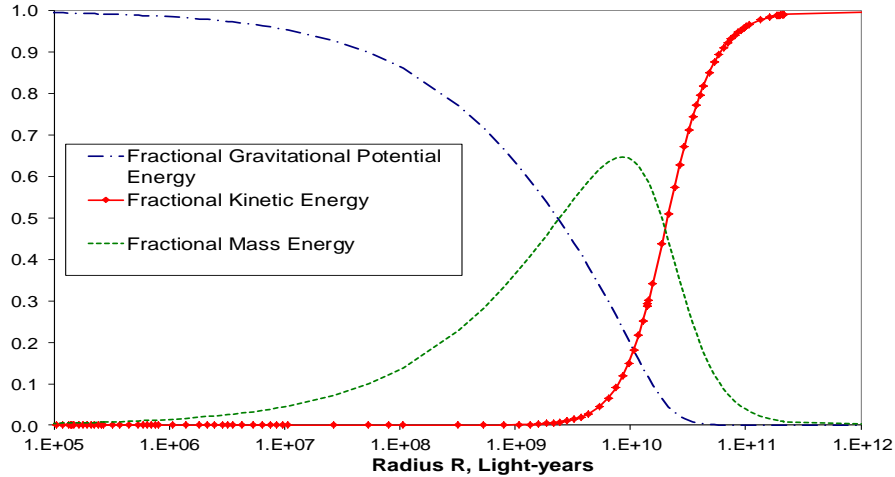
decaying/forming mass with rest mass  $M_o$ .  $\Lambda$  represents Einstein's Cosmological constant,  $G$  is gravitation constant, and  $C$  is the speed of light.

$$m = \frac{5RC^2}{6G} \left[ \sqrt{\left\{ \left( 1 + \frac{\Lambda R^2}{6} \right)^2 + \frac{12GM_o}{5RC^2} \right\}} - \left( 1 + \frac{\Lambda R^2}{6} \right) \right] \quad (15)$$

URM equation (16) below describes the time-invariant or quasi-static Relativistic Universe Expansion (RUE) model as an alternative to the Linear Hubble (LHM) model,  $V=HR$  in the standard Big Bang Model (BBM). It is shown [17] that for the range of observed galactic distances (up to approximately 5 to 9 billion light-years) wherein the LHM is seen to hold, the RUE eqn. (16) matches the predictions of the LHM. For values of  $R$  larger than approximately 14 billion light-years, the expansion velocity calculated by the Linear Hubble model (LHM) exceeds the velocity of light  $C$  and hence, violates the theory of relativity. The velocity predicted by RUE, on the other hand, approaches the speed of light  $C$  asymptotically as  $R$  increases indefinitely. Since the RUE predicted  $V$  never exceeds  $C$ , it never violates relativity theory.

$$\frac{V}{C} = \sqrt{1 - \left\{ 1 / \left( 1 + \frac{\Lambda R^2}{6} \right) \right\}^2} \quad (16)$$

Figure 3: URM predicted fractional mass energy, gravitational potential energy, and kinetic energy.



URM Solves [18] the Dark Energy Puzzle as shown in Figure 3, which depicts the predicted fractional mass energy ( $mC^2$ ), gravitational potential energy (GPE), and relativistic kinetic energy (RKE) for a range of universe sizes. The sum of the three energies remains constant at  $M_oC^2$ . During the early universe up to about 2 billion light-years, GPE dominates. At about 9 billion light-years, the GPE and RKE even out. Following this period, the increasing RKE, commonly referred to as dark energy or vacuum energy, dominates fueling the non-linear relativistic universe expansion, which eludes us as the apparent accelerated expansion as opposed to the linear Hubble expansion. URM thus resolves the puzzle of the elusive dark energy or vacuum energy paralyzing modern physics and cosmology. There is no singularity (Big Bang) as  $R$  approaches zero since mass also tends to zero. URM also predicts uniformity of the observed microwave background radiation and stability of classical masses and quantum particles [13].

Figure 4: Comparison of LHM and RUE predictions of Supernova and near field data.

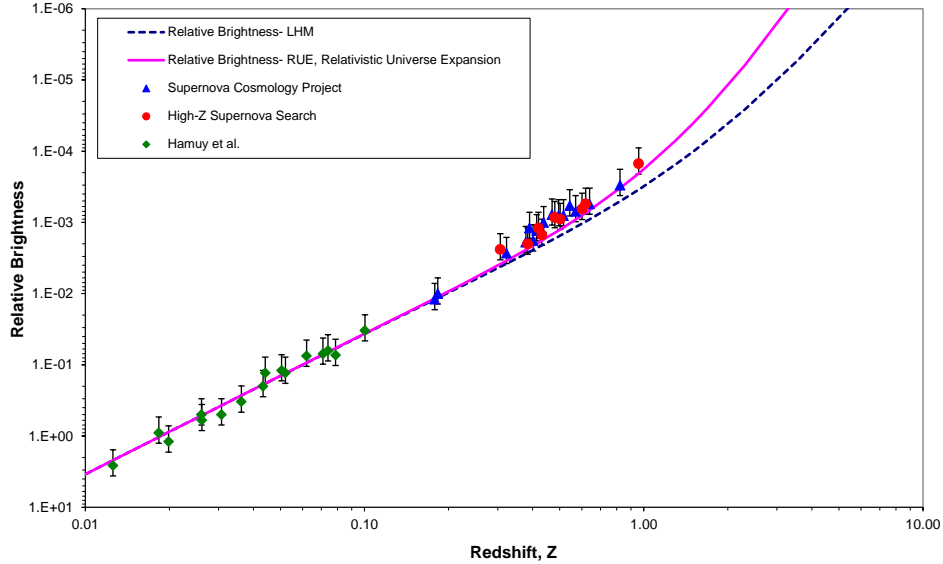


Figure 4 shows comparison of the supernova [19,20] and other near-field [21] data against the predicted relative brightness for LHM versus RUE. A good agreement is seen between the predictions of the RUE and the measured values. The LHM under-predicts the trend of the observed data beyond  $Z=0.4$ , as it does not accurately account for the relativistic effects that are dominant at large  $R$  or redshift values. The relativistic universe expansion leads to the observed accelerated expansion. Hence, the supernova data vindicates the RUE model predictions.

The model is also vindicated by recent observations of mature galaxies in the far-field or very early universe. As of 2012, there were about 50 possible objects or mature galaxies  $z = 8$  or farther, and another 100  $z = 7$  candidates, ranging up to 13.39 billion light year away, based on photometric redshift estimates released by the Hubble eXtreme Deep Field (XDF) project from observations made between mid-2002 and December 2012 [22]. The model also predicts the results of a recent study [20] that shows the total number of galaxies in the universe up to  $z=8$  is about two trillion, almost a factor of ten higher than would be seen in an all sky survey at Hubble Ultra-Deep Field depth. The model predictions extend much beyond the 14 billion years, the current age of the universe predicted by the standard model limited by the linear Hubble model. Based on an average galaxy size of 1010 solar mass, the UR predicted total number of galaxies up to  $z = 8$  falls between the maximum of  $3.2 \times 10^{12}$  x and minimum of  $1.1 \times 10^{12}$  which is in close agreement with the published results, maximum of  $2.7 \times 10^{12}$  and minimum of  $1.4 \times 10^{12}$ , in reference [23]. The predicted results also support other conclusions of the study that the number of galaxies decreases with time after the initial birthing at  $z < 1$  and the possibility of large number of undetected galaxies existing at higher redshifts  $z > 12$  as shown in Figure 5. **These URM predictions are testable via future observations of mature galaxies in the still unexplored far-field universe beyond 14 billion light-years as the cosmological observational capabilities improve in the near future.**

## IMPLICATIONS OF URM FOR THE FUNDAMENTAL UNIVERSAL UNDERSTANDING

1.  $C$ , commonly known as the speed of light, represents a universal fundamental constant of conservation of mass-energy ( $C = \sqrt{\Delta E / \Delta m}$ ). Speed of a photon of light could vary from zero to a maximum limit equal to  $C$ . However, at  $V=C$ , space and time dilate to zero and hence, speed  $V$

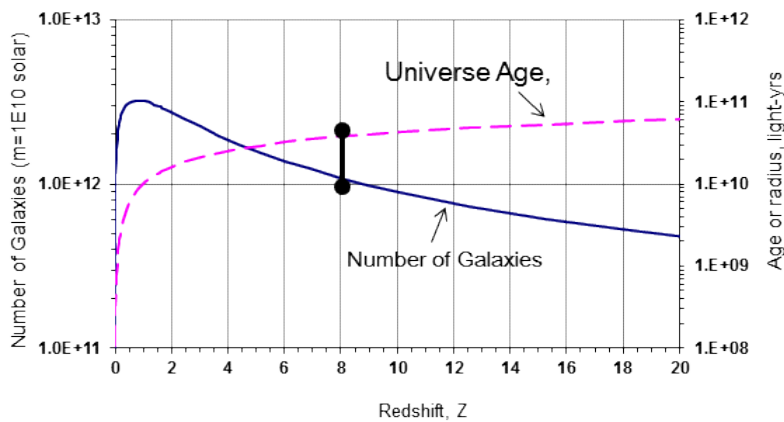
becomes indeterminate and physically meaningless. Hence,  $V$  is always  $<C$  for a physical entity. This general physical conclusion is in good correspondence with the basic Minkowski axiom [11].

2. Photon or universe rest mass is non-zero,  $M_0 = E/C^2$ , wherein  $E$  represents energy. Photon or universe total energy,  $E=M_0C^2$ , remains constant while mass spontaneously dilates or converts to equivalent relativistic kinetic energy with increasing  $V$  during accelerated expansion.

URM allows non-zero photon rest mass at emission and absorption as required by relativity while allowing Maxwell's theory mandated  $V$  approaching  $C$  and mass dilating to zero during the uninterrupted travel thru empty space. Hence, URM bridges the gap between relativity and Maxwell's theories.

3. The most fundamental state of the photon or universe is the Zero Point State (ZPS) at  $V=C$ , wherein mass, space, and time are dilated to pure kinetic energy state – the all-inclusive, absolute (non-relative), eternal state. There are infinite number of less fundamental relative states at  $V<C$  representing varying mass, space, time realities that QM refers to as parallel universes (many worlds).
4. Each of the parallel relative less fundamental states ( $V<C$ ) has its own space and clock-time with varying clock speed with no synchronicity among the infinite number of clocks and their time evolutions. Since there is no unique universal time, there is no unique beginning (big bang), evolution, or ending.
5. Relativity, and not (quantum) uncertainty, governed by spontaneous mass-energy conversion or equivalence is fundamental to the universe wherein all things and phenomena are relativistically entwined in spite of their apparently different form, location and time. Uncertainty is not inherent in nature but in the measurement induced error when a quantum ( $V\sim C$ ) phenomenon happening in relativistically dilated space-time is measured in fixed space-time ( $V\ll C$ ).

Fig. 5: Evolution of number of galaxies (mass =  $1E10$  Solar) and universe Age vs. Redshift  $Z$



## SUMMARY & CONCLUSION

The widely-accepted (Maxwell's theory) assumptions of a zero photon rest mass and fixed speed of light are inconsistent with relativity theory. Relativistic formulations of the fundamental physics of spontaneous mass-energy conversion or decay provide a new photon dynamics model that eliminates these inconsistencies. The proposed model incorporates a postulated spontaneous mass creation/dilation process allowing a non-zero photon mass at rest (emission and absorption),



which dilates to zero as it expands and accelerates thru uninterrupted space. This model removes the currently assumed restriction of a zero photon rest mass that is shown to be inconsistent with recent measurements. Integrating gravity into this model provides a universe model (URM) that is shown to predict the observed universe behavior and resolves the current paradoxes (black hole singularity, dark energy, dark matter, inflation). The observed accelerated universe expansion or Dark Energy (Cosmological Constant) is described mathematically, rather than Einstein's fudge constant, as relativistic kinetic energy resulting from spontaneous mass-energy conversion or decay. It also explains the inner workings of quantum mechanics (quantum gravity, parallel universes, observer's paradox, and nonlocality) eliminating known inconsistencies between GR and QFT. URM also provides testable predictions for falsification via future observations as well as new fundamental universal understanding of the physics and cosmology theories. The commonly known speed of light,  $C$ , is described as a fundamental universal constant of conservation or equivalence of mass-energy rather than the fixed speed of light.

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## APPENDIX (For Background Information Only)

The “Absurd Universe” as described by Michael Turner [12] represents the consensus characterization of the controversial Big Bang and Standard Model cosmology. The mission of science to achieve a fundamental unified theory is founded on the basic premise that there exists a single universe and one set of universal laws that govern the observed universe. In spite of several alternate cosmology theories, there remains a serious lack of a cohesive theory that resolves the so-called cosmic conundrum entailing many unexplained paradoxes and inconsistencies including dark energy, dark matter, quantum gravity, parallel universes, superluminous inflation, and black hole singularity etc.

The work published [13 thru 18] by the author shows that the root cause of these inconsistencies is the potential missing physics of the spontaneous mass-energy conversion mechanism observed in spontaneous decay of particles and wave-particle behavior. The black hole singularity experienced by General Relativity (GR) is shown to be an artifact of such missing physics of spontaneous conversion of mass to energy and vice versa representing the equivalence of mass and energy. When large amount of mass is pulled in by gravity attraction force into a small volume it results into a very high density. As the volume becomes smaller and smaller, the density tends to increase to infinity leading to the singularity. Including the missing physics of the spontaneous transformation of matter to radiative energy into a simplified universal general relativity model – URM, that eliminates this singularity. The integrated model also explains the observed rotational velocities of stars in galaxies without the need for the mysterious and illusory dark matter. The Cosmological Constant is known as “Einstein’s Biggest Blunder” because he introduced this into his relativity theory as an extraneous anti-gravity constant to counter gravity to allow a static (time-invariant or non-expanding) universe. URM also explains dark energy via a new fundamental mechanistic understanding of the Cosmological Constant and time-invariant relativistic universe expansion as an alternative to the standard Big Bang model. URM successfully predicts the observed linear Hubble expansion as well as the apparent accelerating expansion derived from Supernova observations. URM) also predicts the observed behavior of the universe and galaxies evolution and other observations.

Spontaneous mass-energy conversion representing the equivalence of mass and energy is shown to be the most fundamental universal mechanism explaining the observed far-field or 96% of the universe. The proposed model provides a relativistic physical basis for the inner workings of quantum mechanics eliminating the need for its many incredible and unverifiable predictions including the superluminous inflation, multiple universes, objective reduction, and quantum gravity. It also predicts the limits of the observed quantum and classical behaviors.

### **The Proposed Model Explains the Missing Physics of Wave Particle Duality, Collapse of the Wave Function, Non-locality, and Photoelectric Effect as described below [12 and 13]:**

The photon model described above provides a consistent description via a new relativistic spontaneous mass dilation/creation model of the observed phenomenon of **wave-particle duality** of a photon. The wavelike behavior is observed during its uninterrupted travel or flight from the source to a detection screen. The photon velocity is equal to (or very close to) the speed of light and most of its energy is in the form of pure kinetic energy or a wave as the photon mass dilates. Such kinetic energy is mostly undetectable and behaves closely like the unknown **dark energy** of the universe because of its zero frequency (eqn. (13)) and infinite wavelength (eqn. (14)). The momentum and energy of the photon become detectable (non-zero) as mass attains non-zero values as  $v$  decreases. At the point of emission or absorption when the motion of the photon is stopped or interrupted completely, it acts like a particle of a non-zero rest mass, wherein the wave kinetic energy spontaneously converts (collapses) to mass as per equation (9). This process provides a physical description [12] of the **collapse of the wave function or the Observer’s Paradox** in quantum mechanics. The proposed mass creation/dilation model describes the

inner workings of quantum mechanics and the physical quantum states of a photon or universe as a continuum series of varying mass/energy/momentum states (substituting many world's or parallel universe interpretations of QM) depending upon its velocity  $V$ . The **non-locality** of a photon is explained via its infinite wavelength predicted by the model as it travels thru unrestricted empty space at velocities close to  $C$ . A more detailed mathematical description of the wave particle duality phenomenon using the proposed model is provided in reference [13]. The model also explains the observed **photoelectric effect** wherein the energy of absorbed light quanta can cause an emission of electrons from a surface. Einstein showed that the wave nature of light could not lead to the observed photoelectric effect. When a photon hits the surface of a matter stopping its velocity from the speed of light to zero, its momentum/energy due to its non-zero rest mass gets imparted to excite and emit the electrons from the material surface causing the photoelectric effect.

URM provides some consistent answers [13,18] to many key fundamental questions such as the following:

- What governs the stability of classical masses and quantum particles?
- What governs the quantum versus classic behavior and the inner workings of quantum mechanics?
- Is Heisenberg Uncertainty a fundamental property of the universe or a measurement-error- induced feature?
- What leads to Non-locality or Spooky Action-at-distance?
- How to explain wave-particle duality – a new understanding based on spontaneous decay of mass?
- What is photon mass and speed – a new photon model?
- What governs the creation and dilation of matter? Is there anti-matter? Can something (Big Bang) be created out of “Nothing”?
- How to explain Quantum Gravity and Time Paradox?
- What is Quantum Vacuum; what it entails?
- What is the fundamental nature of reality? Is there a continuum of mass-energy-space-time? How it comes about?
- Could the speed of light be exceeded? What is  $C$ ? Do the universal constants vary with time?
- Did the universe have a beginning – the Big Bang? Does it have an ending?
- Are there parallel universes?
- Why the cosmological constant is so small as compared to that calculated by quantum mechanics?
- Is there dark matter? Do black holes exist?
- What causes objective reduction from quantum to classical reality? What role does the observer's consciousness play in observing and interpreting the physical reality?
- Could a mathematical framework for consciousness be integrated into physics and cosmology theories?
- Could science reveal the ultimate reality and purpose of the universe and life in it? How to bridge the gap between physics and philosophy?

In summary, modern physics and cosmology have not reached a dead end, but merely suffering from missing fundamental physics of spontaneous decay or mass-energy conversion induced motion from the well-known mainstream theories. Inclusion of the missing physics of spontaneity of mass-energy equivalence is shown to potentially cure their shortcomings/inconsistencies and enhance their predictability of the observed universe. Such inclusion restores simplicity, certainty, and elegance to the chaotic universe predicted by current mainstream theories and enhances fundamental understanding of the universe.