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The Theory of Super Photon and the Cosmological Insight into the Physical Origin of the Hubble Constant and the Universal Gravity

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ABSTRACT

A lightly damped oscillator model is applied to the propagation of photons through space from a mechanical perspective on the cosmological scale. From it, the cosmological insights into the physical origin of the Hubble constant and the Universal Gravity are elucidated. The exponential correlation between Cosmic Redshift and the Hubble constant is derived. The energy dissipated by a photon over one cycle is elicited as the product of the Planck constant and the Hubble constant; the tiny portion of energy dissipated per photon in each cycle is defined as a Super photon. There is an unnoticeable and vast ocean of Super photons in the Universe. A Super photon theory is developed quantitatively. The correlation between the Universal Gravitational constant and the Hubble constant is derived. The mysteries behind the dynamic equilibrium and circulation of energy and mass of the Universe is uncovered. Furthermore, a Generalised Law of the Universal Gravity is elicited. With rigorous theoretical derivation, a quantitative theory is developed, which can elucidate precisely the Virial relation, the Tully-Fisher relation and the Modified Newtonian Dynamics relations. The cosmological insights into the physical origin of the Modified Newtonian Dynamics and the Tully-Fisher relations are revealed.

Key words: Hubble constant, Super photon, Universal Gravity, dynamic equilibrium, energy and mass dynamic circulation, Tully-Fisher relation, Modified Newtonian Dynamics

1. INTRODUCTION

Both the theories of Expanding Universe and the theories of Tired Light agree that there is apparent energy reduction for photons travelling through space, which is demonstrated by the increase of wavelength of photons, the Cosmic Redshift. The difference lies in how to explain the observed increase of wavelength. Although Gravitational Redshift contributes only a small percentage to the total Cosmic Redshift, it has been theoretically and experimentally verified precisely. Gravitational Redshift manifests the two-way energy exchange of γ photons with the gravitational field of the Earth through interactions, γ photons with apparent weight or equivalent mass travelling in the gravitational field behave similarly as ordinary particles with mass [1-3]. It is also theoretically verified that moving particles in vacuum experience a force resembling friction [4, 5] through interacting with the electro-magnetic field in it. Furthermore, this frictional force can cause a change in momentum due to a change in internal energy and mass while the velocity remains constant [5]. Photons can be viewed as particles in motion at constant velocity (c) with internal or equivalent masses in both vacuum and transparent media [3, 6, 7]. Therefore, it could be expected that photons experience a force resembling friction in vacuum and other transparent spaces through interactions with the contents inside where the photons travelling through. Although the friction force is extremely small and it is negligible in most cases, it is not negligible on the cosmological scale. From a mechanical perspective, a lightly damped oscillator model [8-9] is employed to elucidate the properties and propagations of photons in vacuum and in other transparent spaces. Based on the analysis of the lightly damped oscillator model for photons, the empirical exponential correlation between the Cosmic Redshift and the Hubble constant is derived theoretically (Section 2). The energy dissipated by a photon over one cycle is elicited as the product of the Planck constant and the Hubble constant; the tiny portion of energy dissipated per photon in each cycle is defined as a Super photon (Section 3). There is an unnoticeable and vast ocean of Super photons in the

Universe (Section 3). The correlation between the Universal Gravitational constant and the Hubble constant is deduced (Section 4). The mysteries behind the dynamic equilibrium and circulation of energy and mass of the Universe is disclosed (Section 4). A Generalised Law of Universal Gravity is derived. Afterwards, the Virial relation within the Solar system, the Tully-Fisher relation and the Modified Newtonian Dynamics relation and acceleration in Galaxies are brought out quantitatively (Section 5). A Super photon theory is developed quantitatively (Sections 2-5).

2. LIGHTLY DAMPED OSCILLATOR MODEL, THE COSMIC REDSHIFT AND THE HUBBLE CONSTANT

If the friction force is not negligible on the cosmological scale, it is important to add a dissipative element to the harmonic oscillator model which will enable a small portion of the energy to be dissipated, thereby reducing the amplitude of the oscillations, then the mass–spring–damper system can come to a thermodynamic equilibrium with its surroundings. With the adding of the dissipative element, a two-way street for the energy exchange opened [8-9]. This is a path for energy to leave the oscillator. This path also allows energy to be fed back to the oscillator from its surroundings; a dynamic equilibrium may be achieved with an equal and nonzero absolute (Kelvin) temperature for the oscillators and their surrounding space. In the case of photons and other observable matter in the space, this nonzero dynamic equilibrium temperature is the physical origin of the temperature of Cosmic Background Microwave Radiation (CBMR), which had been predicted through several methods before the Big Bang theory [10]. This article will not involve the assumptions of dark matter and dark energy that are the foundations of the Big Bang theory. So if we say matter or energy, we are talking about matter and energy which are either detectable technically or theoretically verifiable from measurable evidences.

The most common and useful dissipative element is the viscous damper, represented in Fig. 1 as a dashpot. A dashpot is typically consisting of a cylinder filled with a viscous fluid in which the motion of a movable vane is resisted by viscous drag. The friction force, $F_{vis} = -R_m v$, where R_m is the viscous resistance coefficient, $v = \dot{x}$ is the velocity of the mass. The equation of motion for a viscously damped harmonic oscillator [8, 9] is,

$$\ddot{\boldsymbol{x}} + \frac{\boldsymbol{R_m}}{\boldsymbol{m}}\dot{\boldsymbol{x}} + \boldsymbol{\omega_0}^2\,\boldsymbol{x} = \boldsymbol{0} \tag{1}$$

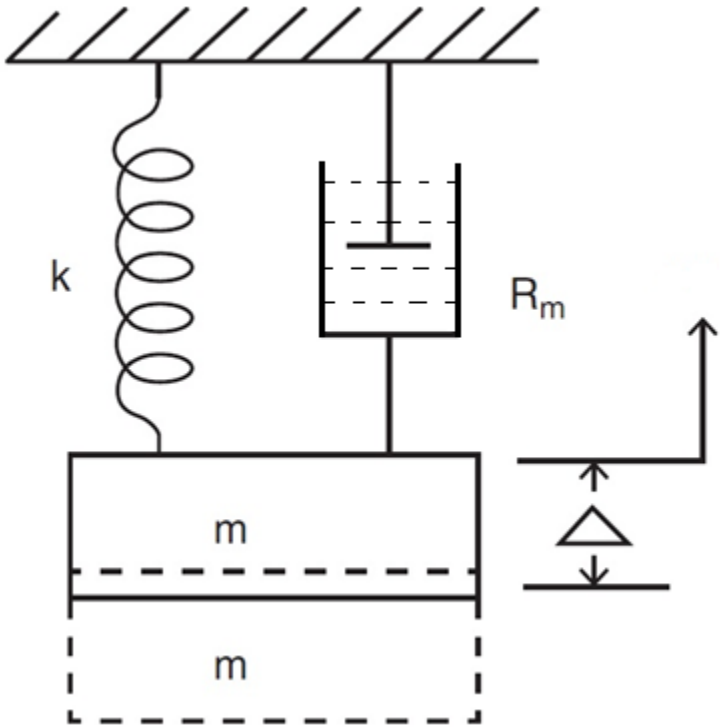

Figure 1 A dashpot representing the viscous resistance, R_m, added to the simple harmonic oscillating mass (m) - spring (k) system.

Where, $\ddot{x}$ is the acceleration, $\omega_0 = \sqrt{\frac{k}{m}}$ is the natural angular frequency of the un-dampened harmonic oscillator, m is the internal or inertia mass of the oscillator. When $(\frac{R_m}{2m})^2 \ll {\omega_0}^2$, it is called a lightly dampened oscillator. The propagation of a photon in space may be viewed as

a lightly dampened oscillator in motion at constant velocity from a mechanical point of view on the cosmological scale. The solution of equation 1 for a lightly dampened oscillator is,

$$\boldsymbol{x(t) = A_0\, e^{-\frac{t}{\tau}}\, \cos(\omega t + \varphi) = A \cos(\omega t + \varphi)} \tag{2}$$

The choice of $\tau = \frac{2m}{R_m}$ makes sense, since τ has the unit of time as required for dimensional homogeneity. Specifically, for photons, it may be explained that a photon with larger equivalent mass has larger effective interacting cross-section area, thus has higher viscous resistance coefficient, hence, the ratio of the equivalent mass versus the viscous resistance coefficient is a constant. Where A_0 and φ are subsequently the amplitude and the phase at a specified time $t = 0$, thus they are constants. Where ω and A are the angular frequency and the amplitude of the lightly dampened oscillator at a later time $t > 0$. When damping is small enough, the resonant frequency ω is approximately equal to the natural frequency ω_0. The energy dissipated by the viscous force over a whole cycle (a period time of $T \ll \tau$) from the $n\ th$ cycle of the photon [6-8] is,

$$\boldsymbol{\Delta E_T = -\left(k + \frac{m}{\tau^2}\right)\frac{A^2}{2}\left(1 - e^{-\frac{2T}{\tau}}\right) \approx -\left(\frac{k}{m} + \frac{1}{\tau^2}\right)\frac{m\,A^2\,T}{\tau}}$$

$$\boldsymbol{\approx -2\pi m A^2 \omega f_\tau \left[1 + \left(\frac{f_\tau}{\omega}\right)^2\right] = -h f_\tau \left[1 + \left(\frac{f_\tau}{\omega}\right)^2\right]} \tag{3}$$

$$\boldsymbol{f_\tau = \frac{1}{\tau} = \frac{R_m}{2m} \ll \omega_0} \tag{4}$$

Here ω and A are subsequently the angular frequency and the amplitude of oscillating of the photon at the $n\ th$ cycle, $\frac{k}{m} = \omega^2$, $\omega = \frac{2\pi}{T}$. And $h = 2\pi m A^2 \omega$ [6], which is the Planck constant for photons, hence,

$$\boldsymbol{\frac{dE}{dt} \approx \frac{\Delta E_T}{T} \approx -h f f_\tau \left[1 + \left(\frac{f_\tau}{\omega}\right)^2\right] = -E f_\tau \left[1 + \left(\frac{f_\tau}{\omega}\right)^2\right]} \tag{5}$$

Both sides of equation 5 divided by E and multiplied by dt, we have,

$$\boldsymbol{\frac{dE}{E} \approx -f_\tau \left[1 + \left(\frac{f_\tau}{\omega}\right)^2\right] dt} \tag{6}$$

Integrating both sides of equation 6, it is derived approximately,

$$\boldsymbol{E \approx E_0\, e^{-f_\tau\left[1+\left(\frac{f_\tau}{\omega}\right)^2\right]t}} \tag{7}$$

While, $f_\tau \ll \omega$ for a lightly damped oscillator, equation 7 can be further approximated to,

$$\boldsymbol{E \approx E_0\, e^{-f_\tau t}} \tag{8}$$

The cosmic redshift is defined as [11-15],

$$\boldsymbol{z = \frac{\lambda_{ob}-\lambda_{em}}{\lambda_{em}} = \frac{\lambda_{ob}}{\lambda_{em}} - 1 = \frac{E_{em}}{E_{ob}} - 1 \approx H\,\frac{D}{c}} \tag{9}$$

Where D is the Euclidean distance from the emission point to the observation point of the light, c is the speed of the light in vacuum, H is the Hubble constant. λ_{ob} and λ_{em} are subsequently the wavelengths of the stream of photons at observation point and at emission point. Where E_{ob} and E_{em} are subsequently the energy of the stream of photons at observation point and at emission point.

E_{ob} in equation 9 is equivalent to E in equations 7 & 8, E_{em} in equation 9 is equivalent to E_0 in equations 7 & 8. Hence, by the combination of equations 7, 8 and 9, we get,

$$\boldsymbol{z = e^{f_\tau\left[1+\left(\frac{f_\tau}{\omega}\right)^2\right]t} - 1 \approx e^{f_\tau t} - 1} \tag{10}$$

Where t is time, a variable parameter, for $f_\tau t \ll 1$, at a time $t \ll \tau = \frac{1}{f_\tau}$ (τ is approximately 10^{10} years as calculated at the end of this section for photons), equation 10 can be further approximated to,

$$\boldsymbol{z \approx f_\tau\, t \approx f_\tau\, \frac{D}{c}} \tag{11}$$

Comparing equation 9 with equation 11, we have,

$$\boldsymbol{H \approx f_\tau} \tag{12}$$

Taking count of equations 9 and 10, more precisely, H has a weak dependence on the frequency and wavelength of the photons,

$$\boldsymbol{H = f_\tau\left[1 + \left(\frac{f_\tau}{\omega}\right)^2\right] = f_\tau\left[1 + \left(\frac{f_\tau \lambda}{2\pi C}\right)^2\right] \approx f_\tau} \tag{13}$$

The frequency and wavelength dependence terms are extremely weak, because $f_\tau \approx H \ll \omega$ for lightly damped oscillators. The extremely weak dependence has been observed experimentally, it cannot be explained by Expanding Universe (EU) theories, however it can be explained by Tired Light (TL) theories, if you are interested in it, please see reference [14]. Combining equations from 9 to 13, an accurate and widely applicable relationship of z and H is acquired as following,

$$\boldsymbol{z = \frac{E_{em}}{E_{ob}} - 1 = e^{\frac{H}{c}D} - 1 = \exp\left(\frac{H}{c}D\right) - 1} \tag{14}$$

Both the TL theories and the EU theories have proposed similar exponential correlation between the cosmic redshift z (or expanding velocity $v = cz$) and the Hubble constant H [11-22], either from the best fit of observational data or from theoretically derivations based on ad hoc assumptions. The exponential relationship, assigned clear physical meaning to every parameter, is derived here upon analysing the model of a lightly damped oscillator for photons travelling through space from a mechanical perspective. The theoretically derived exponential relationship between the cosmic redshift z and the Hubble constant H is a strong supportive evidence of the suitability of the viscously damped harmonic oscillator model for photons travelling through space on the cosmological scale [18]. Physics is built upon models; the aim is the finding and application of the best possible model, which is the most simple and precise. By the way, the exponential relationship has been taken by the believers of the EU and Big Bang theories as a supportive evidence of accelerating expansion of the Universe far away from us, the speed of the expansion is derived as even much larger than the speed of light for the space far away from us.

Inverting equation 14, the distance D estimated based on the measured z , can be calculated as,

$$\boldsymbol{D = \frac{c}{H} ln(1 + z)} \tag{15}$$

In a non-expanding Euclidean universe, the angular size δ of an object is $\delta = 2arctant\left(\frac{d}{2D}\right)$ [11-15], where d is a diameter (e.g. major or minor axis of a galaxy) and D is the distance to the object. In a small-angle approximation,

$$\boldsymbol{\delta \approx \frac{d}{D}} \tag{16}$$

In the TL theories, equation 16 holds in close approximation for galaxies and galaxy clusters. However, the EU theories originated from Einstein's General Relativity (GR) and Big Bang (BB) theories predict the angular size δ as,

$$\boldsymbol{\delta \approx (1+z)\frac{d}{D}} \tag{17}$$

The $1+z$ increase in angular size predicted by the EU and BB theories has not been observed yet; observed data are more compatible with the TL theories in a non-expanding Euclidean universe [11-15]. The universe seems neither expanding continuously nor expanding in accelerating. Hence, the birth of the Universe is unlikely from a Big Bang. There is not a single convincing evidence that could be validated to confirm the existing of dark matter and/or dark energy, which is claimed theoretically to occupy approximately 95% of the total energy and mass of the Universe according to the EU and BB theories developed from Einstein's General Relativity.

From 2016 to 2018, the measured values of the Hubble constant [22-26] varied from 67.6 to 73.52 $kms^{-1}Mpc^{-1}$. This article will focus on the Hubble constant originated mainly from the viscous resistance of the majority of the vast space which is named as vacuum, thus taking a value towards the low-end as 68 $kms^{-1}Mpc^{-1}$. Converting it into SI units, it is approximately $2.2 \times 10^{-18}\ s^{-1}$, for $H \approx f_\tau$, hence $\tau = \frac{1}{f_\tau} \approx 1.44 \times 10^{10}$ years. The reason behind this choice is that $H \approx f_\tau = \frac{R_m}{2m}$, by taking R_m as the viscous resistance coefficient of vacuum, it should be the lowest in comparison with transparent media containing matters as electrons, atoms and molecules. Apart from stars, planets, photons and vacuum, there are all

sorts of matters in space, for example, intergalactic matters and interstellar matters containing electrons, protons, atoms and molecules which are mostly transparent to photons [27]. Photon-matter interactions affect the measured z values thus cause data scatters, which generally make the calculated H values larger based on the measured Cosmic Redshift z values because of larger energy loss of the photons. The measured Cosmic Redshift and the calculated Hubble constant depend on the contents in the space where the light travelled through. This article focuses on the Hubble constant originated mainly from the viscous resistance of vacuum, hence, a value towards the low-end as 68 $kms^{-1}Mpc^{-1}$ is chosen for the following sections as a best possible estimation at this moment. A more precise value may be chosen in the future when the Hubble constant for photons travelling through vacuum could be precisely determined experimentally or theoretically, which is expected to be close to the current value of choice.

3. SUPER PHOTON AND PHOTON / PHOTON INTERACTION

From last section, it is elicited that the Hubble constant is an extremely low frequency with its physical origin from the time constant, the ratio between the viscous resistance R_m of space and the mass m of photons travelling through space. We will focus on the space called vacuum, the majority part of the vast space, which is full of gravitational and electro-magnetic fields, CBMR photons and neutrinos. The product of H and h are linked with the tiny portion of internal energy and mass loss of a photon into space per cycle through interactions, which can be elicited from equations 3 and 13. Incorporating H from equation 13 into equations 3 and 8, we get,

$$\Delta \boldsymbol{E_T} \approx -\boldsymbol{hH} \approx \boldsymbol{-1.458 \times 10^{-51}} \quad \boldsymbol{[J]} \tag{18}$$

$$\boldsymbol{E \approx E_0 e^{-Ht}} \tag{19}$$

ΔE_T in equations 3 and 18, represents the energy dissipated over one cycle by one photon, which is an extremely small portion of energy. With such extremely low energy and frequency,

we may name it Super photon to distinguish it from normal photons. For a Super photon, applying $\lambda_s = \frac{c}{f_s}$, taking $f_s \approx H$ from equations 13 and 18, we can then derive the wavelength of the Super photon as $\lambda_s \approx 1.363 \times 10^{26}$ [m]. A normal photon may be perceived as a packet of a number (N) of Super photons in a resonance state locally, the energy of a Super photon ($E_s = \Delta E_T$) may be assigned as the basic energy unit, hence the energy of a normal photon (E) equals,

$$\boldsymbol{E = N\,E_s} \tag{20}$$

Consider the relationships between normal photons [6, 7, 28, 29] and Super photons,

$$\boldsymbol{f = NH,\ \lambda = \frac{\lambda_s}{N},\ \ m = \frac{h}{c\,\lambda} = N\frac{h}{c\,\lambda_s} = Nm_s} \tag{21}$$

Where f, λ and m are subsequently the frequency, wavelength and mass of a normal photon, where H, λ_s and m_s are subsequently the frequency, wavelength and mass of a Super photon. There are an enormous number of normal photons in the Universe. Every normal photon oscillates an enormous number of cycles and releases a Super photon per cycle, hence the total number of Super photons in the Universe must be gigantically vast. There is an unnoticeable and vast ocean of Super photons in the Universe. The ocean of Super photons with internal mass and energy might be linked with the so-called dark matter or weakly interacting massive particles, but they are naturally ordinary matter and energy with intrinsic properties similar with normal photons and a single Super photon has extremely low internal energy and mass. Experiments based on the Bell inequalities, have verified quantum entanglement of photons over long distances in space [30]. The mystery of long-distance quantum entanglement may be explained based on that normal photons are packets of Super photons in resonance states locally. Two entangled photons emitted from a single source are connected by a number of Super photons, therefore even after they are separated long distance from each other, they are still connected together as a pair through their shared Super photons with extremely long wavelength $\lambda_s \approx 1.363 \times 10^{26}$ [m]. Henrik Broberg [28, 29] proposed the theory of

elementary quanta with outstanding thoughts based on ad hoc hypothesises. It is always a challenging to build a new theory upon ad hoc hypothesises which are not fully comprehensive, like a pioneer exploring an unknown field, who can only quest in the darkness. By combining some of his brilliant concepts for example the interacting strength and effective cross-section area of a photon, with my Super photon theory, which is based on solid and clear physical model, a Super photon theory is developed quantitatively. And from the Super photon theory, several new concepts are proposed. Thereafter, the physical origin of the Universal Gravity and the dynamic circulation of mass and energy of our harmonic and entangled Universe are elucidated, inspired by Henrik's theory of elementary quanta; Furthermore, a Generalised Law of the Universal Gravity is derived and the Virial relation, the Tully-Fisher relation and the Modified Newtonian Dynamics equation and acceleration are brought out quantitatively.

Let us first focus on the photon and Super photon interaction. If we introduce the interacting strength between a normal photon having energy $E = N\,E_s$ and a Super photon having energy E_S as an effective cross-section area $\sigma_p = N\sigma_S$, where σ_s is the interacting strength thus effective cross-section area between two Super photons. We further define the average numerical density of the Super photons in a unit of space as ρ_n. During the time interval Δt, the normal photon we are investigating will sweep through an effective volume of space as $\sigma_p\, c\, \Delta t = N\sigma_s\, c\, \Delta t$ where c is the speed of light. Therefore, the normal photon will meet a number ($\rho_n N\sigma_S\, c\, \Delta t$) of Super photons during the time interval Δt. The $\rho_n N\sigma_S\, c\, \Delta t$ Super photons interact with the normal photon during the time interval Δt, hence the normal photon exchanges energy with the ocean of Super photons as,

$$\Delta \boldsymbol{N} = -\boldsymbol{\rho_n N \sigma_S\, c\, \Delta t} \tag{22}$$

The negative sign means releasing energy to the ocean of Super photons. Both sides of equation 22 divided by N, then we have,

$$\frac{\boldsymbol{dN}}{\boldsymbol{N}} \approx \frac{\boldsymbol{\Delta N}}{\boldsymbol{N}} = -\boldsymbol{\rho_n \sigma_S\, c\, \Delta t} \approx -\boldsymbol{\rho_n \sigma_S\, c\, dt} \tag{23}$$

Integrating both sides of equation 23, it is derived,

$$\boldsymbol{N_t = N_0\, e^{-\rho_n \sigma_S\, c\, t}} \tag{24}$$

Where N_t is the number of Super photons remaining in the normal photon packet at time t, N_0 is the number of Super photons in the normal photon packet at time $t = 0$. Multiply both sides by E_S and using equation 20, we get,

$$\boldsymbol{E = E_0\, e^{-\rho_n \sigma_S\, c\, t}} \tag{25}$$

Comparing equation 25 with equation 19, we have,

$$\boldsymbol{H = \rho_n \sigma_S\, c} \tag{26}$$

Hence, the interacting strength / effective cross-section area, between a normal photon and a Super photon is,

$$\boldsymbol{\sigma_p = N\sigma_s = \frac{N\,H}{\rho_n\, c}} \tag{27}$$

It is now possible to define the average mass density of Super photons as ρ_0, taking account of the total number of Super photons. The equivalent internal mass of a Super photon is m_s, thus,

$$\boldsymbol{\rho_0 = m_s \rho_n = \frac{h}{c\lambda_s}\rho_n \quad \rho_n = \frac{\rho_0\, c\, \lambda_s}{h}} \tag{28}$$

Inserting ρ_n from the formula above into equation 27 and using equation 21, we get,

$$\boldsymbol{\sigma_p = \frac{h\,H}{\rho_0\, c^2 \lambda_s / N} = \frac{h\,H}{\rho_0\, c^2 \lambda} = \frac{m\,H}{\rho_0\, c}} \tag{29}$$

While $\lambda \rightarrow \lambda_s$ and $m \rightarrow m_s$, $\sigma_p \rightarrow \sigma_s$, hence equation 29 is applicable to both normal and Super photons. It is interesting to calculate the ratio between the effective cross-section area and the internal mass (A_0) of a photon from equation 29 (applicable to both normal and Super photons),

$$\boldsymbol{A_0 = \frac{\sigma_p}{m} = \frac{H}{\rho_0\, c}} \quad \textbf{[m}^2\textbf{/kg]} \tag{30}$$

Therefore,

$$\boldsymbol{\sigma_p = A_0 m} \tag{31}$$

$$\boldsymbol{A_0 \rho_0\, c = H} \tag{32}$$

The volume of space, which is swept through by the effective cross-section area of a photon during one cycle is,

$$\boldsymbol{V_0 = A_0\, m\, \lambda = \frac{h\, H}{\rho_0\, c^2}} \tag{33}$$

Where a Super photon has such an extremely long wavelength and such an extremely low energy and mass, Super photons are spread out in the observable Universe and they have a vast number. Hence, the average mass density of Super photons ρ_0 must be a constant on the cosmological scale. It is highlighted here that ρ_0 is an important Universal constant on the cosmological scale. Hence from equations 28, 30 and 33, we can see that ρ_n, A_0 and V_0 are three Universal constants on the cosmological scale. While normal photons releasing energy and mass during travelling through the space, the ocean of Super photons gains the energy and mass released by the travelling photons, eventually an energy and mass balance between them will be achieved, which is manifested by the stable CBMR temperature.

4. PHOTON / MATTER PARTICLE INTEREACTION AND UNIVERSAL GRAVITY

A particle of condensed matter may be perceived as condensed packets of confined and discrete standing electromagnetic waves (photons) in several modes of resonances [31-34]. Let us imagine a relatively stationary condensed particle immersed in the ocean of Super photons [31-33] as shown schematically in Fig. 1.

The relatively stationary particle with a mass of m_p would receive an inflow of Super photons and neutrinos at light speed from its surrounding space. As the average numerical density of Super photons is ρ_n, and because the particle is approximately at rest versus the background space, where all Super photons and neutrinos are roaming at light speed (c). This article will only focus on Super photons (including normal photons which are packets of Super photons in

resonance states locally), because neutrinos are fermions and they are supposed to make negligible contribution to the Universal Gravity.

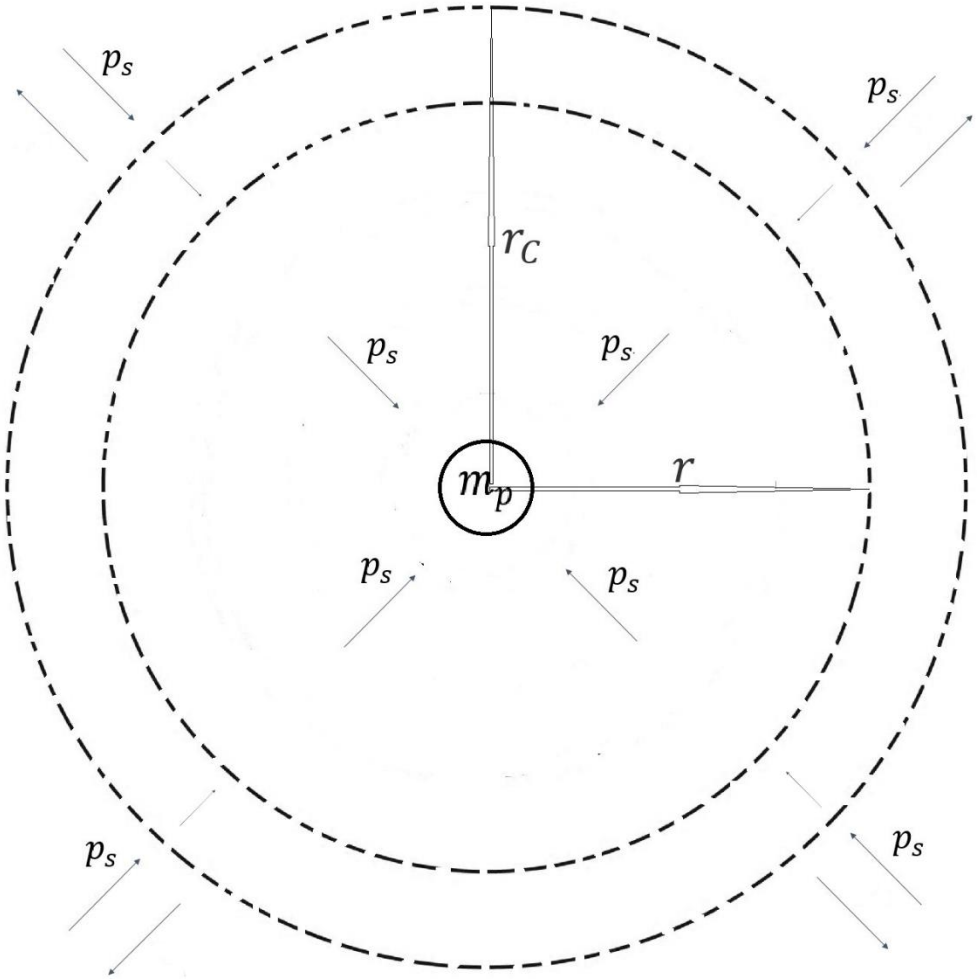

Figure 1 Schematic diagram showing the inward flow of super photons with momentum p_s towards a condensed particle with mass m_p.

Assume a percentage β_1 $(-1 \leq \beta_1 \leq 1)$ of the ρ_n Super photons interacting with the relatively stationary particle with the momentum of every Super photon as,

$$\boldsymbol{p_s = \frac{h}{\lambda_s} = \frac{E_s}{c} = m_s\, c} \tag{34}$$

Where, h is the Planck constant, p_s ,λ_s , E_s and m_s are subsequently the momentum, the wavelength, the energy and the mass of a Super photon. The number of Super photons interacting with the condensed particle during the time Δt is,

$$\Delta \boldsymbol{N} = \boldsymbol{\beta_1 \rho_n \sigma_p \, c \, \Delta t} \tag{35}$$

Where, σ_p is the effective cross-section area. If $\beta_1 = 1$, it means the condensed particle is a black hole, it absorbs all the Super photons from its surrounding space. The 100% absorbing without emitting cannot last forever from a dynamic equilibrium point of view; eventually the black hole will emit to achieve a dynamic equilibrium with its surroundings. If $\beta_1 = -1$, it means the particle emits all of its mass and energy away without absorbing, the condensed particle will eventually spread out all its mass and energy to its surrounding space.

Let us first consider the restricted occasion of a net number of Super photons flowing into the particle, while $0 \leq \beta_1 \leq 1$, the corresponding mass and energy flowing into the particle is,

$$\Delta \boldsymbol{m_p} = \Delta \boldsymbol{N} \, \boldsymbol{m_s} = \boldsymbol{\beta_1 m_s \rho_n \sigma_p \, c \, \Delta t} \tag{36}$$

$$\Delta \boldsymbol{E_p} = \Delta \boldsymbol{N E_s} = \boldsymbol{\beta_1 m_s \rho_n \sigma_p \, c^3 \, \Delta t} \tag{37}$$

Inserting $\sigma_p = A_0 \, m_p$ and $\rho_0 = m_s \rho_n$ into equations 36 and 37 above, we have,

$$\Delta \boldsymbol{m_p} = \frac{\Delta \boldsymbol{E_p}}{\boldsymbol{c^2}} = \boldsymbol{\beta_1 A_0 \rho_0 m_p \, c \, \Delta t} \tag{38}$$

Because $H = A_0 \, \rho_0 \, c$ from equation 32, hence,

$$\Delta \boldsymbol{m_p} = \frac{\Delta \boldsymbol{E_p}}{\boldsymbol{c^2}} = \boldsymbol{\beta_1 H m_p \Delta t} \tag{39}$$

Where, H is the Hubble constant, A_0 is the ratio of the effective cross-section area versus the equivalent mass of the photon, ρ_0 is the average mass density of Super photons, m_p and E_p are subsequently the mass and energy of the condensed particle. The mass and energy of the condensed particle as the function of time by the integration of equation 39 are,

$$\boldsymbol{m_p\,(t) = m_p(0)\, e^{\beta_1 H t}} \tag{40}$$

$$\boldsymbol{E_p(t) = E_p(0)\, e^{\beta_1 H t}} \tag{41}$$

Remembering H is approximately $2.2 \times 10^{-18}\, s^{-1}$, $0 \leq \beta_1 \leq 1$, therefore during a short period of time, the mass and energy change are extremely tiny. However, the tiny mass and energy absorbed accompany an inward force, the force leads to contracting, vibrating and spinning of the compositions of the condensed particle around their equilibrium positions because the absorbed Super photons and photons have linear and circular polarizations. It may be explained further as following. It is verified that the effect of the two kinds of polarization of photons (linear and circular) at a certain range of frequencies on silica nano-particles is quite different [35]. Linear polarization causes the particles to vibrate along the line of polarization while circular polarization causes the particles to spin. This may help to explain the spinning and vibrating of the galaxies, the stars and the planets. Absorbing Super photons and normal photons with circular polarization causes the spinning of the galaxies, the stars and the planets. This process converts the free roaming incoherent thermal energy of Super photons and normal photons into the coherent kinetic energy of the condensed particles. The contracting, vibrating and spinning of the condensed particle induce friction forces, which cause the increase of the internal temperature and pressure. The increase of temperature and pressure inside the particle trigger off expanding and radiation, therefore, photons are released into its surrounding space; part of the coherent kinetic energy is converted back to the incoherent thermal energy. To keep a relatively stable state of movement (including the spinning and the orbital velocities) and temperature, the condensed particle needs continuously absorb Super photons and normal photons from its surrounding space, which means $0 < \beta_1 < 1$. The condensed particle also needs emit photons because of compressing, frictions and radiations; hence, a dynamic equilibrium state will be achieved. This dynamic equilibrium process has significant physical meaning because it is the process, which converts the free roaming low frequency incoherent thermal energy into coherent kinetic energy and high frequency thermal energy, which is similar with a phenomenon called phase change which causes the reduction of entropy while

energy is conservative. It is the mechanism of reversing the destiny of the universe from the Heat Death predicted by the second law of thermodynamics if viewing the Universe as a closed system. Strictly speaking, there is no absolutely closed system, because vacuum contains and flows mass and energy [31-33], it remains an open question if it is reasonable to view the Universe as a closed system. The secret of mass and energy dynamic circulating of the Universe with mass and energy conservation is uncovered here. Hence, the creation of the Universe and its destiny are for Eternity under dynamic equilibrium, they are neither for Heat Death, nor for Big Rip, nor for Big crunch.

For a normal photon, its wavelength continually increases hence releasing a Super photon every cycle until reaching a thermodynamic equilibrium with the Cosmic Background Microwave Radiation (CBMR), so the physical volume of a normal photon is expanding during its lifetime before its energy reaches equilibrium with the CBMR. It is the normal photons in vacuum, which are continuously expanding until reaching a thermodynamic equilibrium with the CBMR, it is not the space itself in expanding. Afterwards, these photons in equilibrium with the CBMR behave as ideal harmonic oscillators, which absorb and release Super photons in a two-way street for energy and mass exchange in equal rate; they become part of the CBMR. If the photons in equilibrium with the CBMR travel only through vacuum at the CBMR temperature, they can travel forever without net energy change, hence they spread evenly across the whole Universe. However, they can impinge Galaxies, stars and planets and are absorbed and are recycled.

The condensed particles absorb Super photons and normal photons thus mass and energy from its surrounding spaces and converting the incoherent thermal energy into coherent kinetic energy. And the condensed particles release mass and energy into its surrounding space as normal photons because of frictions and radiations, the emitted photons eventually return the mass and energy to the space by releasing Super photons every cycle while travelling at light

speed to achieve mass and energy balance in the ocean of Super photons. The nuclear reactions and element generations inside the centre of galaxies and inside Stars are probably merely by-processes and by-products because of the impinging of photons and neutrinos at the speed of light from all directions and the high temperature and high pressure induced by impinging and frictions, which worth further research. In a parable, all the Galaxies, stars and planets are music instruments with different keys and strings, Super photons are the fingers of a glorious musician, and all sorts of visible and invisible lights are melodies spew out from the music instruments. It is interesting that the melodies can eventually turn back to Super photons – the wonderful fingers of the glorious musician. Particles with different size and mass absorb and release different range of frequency and wavelength of Super photons and normal photons to achieve dynamic equilibriums with their surrounding spaces. Hence, they are perfect or near perfect blackbodies. Dynamic equilibriums are achieved which is demonstrated by the relatively stationary spectrums of radiations from majority of the galaxies, the stars and the planets with their characteristic temperatures and brightness in the Universe, including the CBMR. The CBMR becomes the buffer of the Universe in a dynamic equilibrium state.

Now let us re-derive Newton's gravity law from the Super photon theory to gain insight into its physical origin and to explore new applications. We have some basic assumptions here that the total mass and energy are conserved within the Universe, the interactions between localized masses and energies follow the same set of physical laws. The interactions between localized masses and energies help to achieve dynamic equilibrium states. If under some condition for some reason the oscillation goes too far outside the dynamic equilibrium, a new state of dynamic equilibrium will eventually be established.

As shown schematically in Fig. 1, we define r_C to represent the radius of the equivalent effective interacting cross-section area ($4\pi r_C^2 = A_0 m_p$, from $\sigma_p = A_0 m$ in equation 31) of the condensed particle with mass m_p,

$$\boldsymbol{r_C} = \sqrt{\frac{\boldsymbol{A_0\, m_p}}{\boldsymbol{4\pi}}} \tag{42}$$

Outside the ball of the effective radius r_C, there will be a random distribution of Super photons. From equation 35 above, the number of Super photons flowing through the effective interacting cross-section area ($4\pi r_C^2$) during the period of time Δt towards the particle is,

$$\boldsymbol{\Delta N = \beta_1 \rho_n \sigma_p\, c\, \Delta t = \beta_1 A_0 \rho_n m_p\, c\, \Delta t} \tag{43}$$

At a distance $r \leq r_C$ from the centre, the flow must carry the same number of Super photons, but flow through a smaller area, if we define the local numerical density of Super photons as $\rho_n(r)$,

$$\boldsymbol{4\pi r^2 \rho_n(r)\, c = \beta_1 A_0 \rho_n m_p\, c} \tag{44}$$

The local numerical density with a local gradient of Super photons around the condensed particle as a function of r is therefore,

$$\boldsymbol{\rho_n(r) = \frac{\beta_1 A_0 m_p \rho_n}{4\pi r^2}} \tag{45}$$

Similar with equation 43 but applied at the radius r, the inward flowing rate of Super photons is,

$$\boldsymbol{\frac{dN}{dt} = \rho_n(r)\, \sigma_p\, c = A_0 \rho_n(r) m_p\, c} \tag{46}$$

This represents a directed rate of momentum or a force transferred to the particle corresponding to,

$$\boldsymbol{F = -\frac{dp}{dt} = -p_s \frac{dN}{dt} = -\frac{\beta_1 A_0^2\, c^2\, \rho_0}{4\pi} \frac{m_p^2}{r^2}} \tag{47}$$

The force in equation 47 represents the Universal Gravity force between the centre mass m_p and the equivalent effective mass $-m_p$, which represents the average counter interaction from the rest of the Universe outside the ball with the effective radius r_C, and through the ocean of Super photons to achieve a mass, energy and force balance. The negative sign simply means when the centre mass m_p of the particle absorbing super photons and contracting, the

equivalent effective mass of the rest of the Universe $-m_p$ releasing super photons and expanding; While the centre mass m_p of the particle releasing super photons and expanding, the equivalent effective mass $-m_p$ absorbing super photons and contracting. If locally two particles with different mass interact with each other, like the Sun and the Earth, while a net gravitational attracting force is induced between them because they shield each other in the roaming ocean of Super photons, hence, they tend to become closer to each other. If the Sun and the Earth are viewed together as a whole, a net contracting of mass and energy happens, thus a frictional force and a centrifuge force for orbital movement emerge to counter the attracting force to achieve a dynamic equilibrium to maintain approximately even distribution of mass and energy on a cosmological scale. Detailed analysis and calculations will be done in next section. Now let us compare equation 47 with Newton's gravity law, they are the same if we assign,

$$\boldsymbol{G = \frac{\beta_1 A_0^2 c^2 \rho_0}{4\pi}} \tag{48}$$

By using equation 32, we have,

$$\boldsymbol{G = \frac{\beta_1 A_0 H c}{4\pi} = \frac{\beta_1 H^2}{4\pi \rho_0}} \tag{49}$$

The Universal Gravitational Constant may be interpreted as the interacting and coupling constant of a condensed particle with the rest of the Universe through the ocean of Super photons. Physical science is mainly about the correlation of physical quantities. The correlation between the Universal Gravitational constant and the Hubble constant is disclosed quantitatively here. For fully understanding its implications, further research is worthwhile. By inserting $H \approx 2.2 \times 10^{-18}\, s^{-1}$, $G \approx 6.6739 \times 10^{-11}$ $m^3/kg{\cdot}s^2$ and $\beta_1 \approx 0.5$ (on cosmological scale at r_C under equilibrium state, there are roughly equal number Super photons flowing in and out the background space of the condensed particle on average) into equation 49, we get the average mass density of Super photons on cosmology scale,

$$\boldsymbol{\rho_0 \approx\ 2.886 \times 10^{-27}\ \ kg/m^3} \tag{50}$$

The constant A_0 is,

$$\boldsymbol{A_0 \approx 2.54 \qquad\qquad m^2/kg} \tag{51}$$

Then we can derive,

$$\boldsymbol{G \approx 1.379 \times 10^{25} H^2} \tag{52}$$

The accuracy of the numbers in equations 50-52 depends on the accuracy of the measured G and H. Having ρ_0 and A_0 at hand, we can do some interesting calculations.

As an example, let us start from using equation 42 to calculate the effective radius of the Solar System and the Milky Way Galaxy based on their known total masses. In the Solar system, 99.86% of the system's known mass concentrates in the Sun [36], the total mass in the solar system is approximately 1.9885×10^{30}, inserting the value and A_0 into equation 42, we get $r_C \approx 6.34\ \times 10^{14}$ m. The border where the Solar System terminates is not precisely defined, because its outer boundaries are shaped by two separate forces: the solar wind and the Sun's gravity. The limit of the solar wind's influence is roughly four times Pluto's distance from the Sun, the heliopause, the outer boundary of the heliosphere, is considered the beginning of the interstellar media, which is approximately 2×10^{13} m. The Sun's Hill sphere, the effective range of its gravitational dominance, is thought to extend up to a thousand times further, which approximately reaches 10^{16} m [37]. Our calculation sits approximately in the middle of these estimated radius based on observation and estimation. Regarding the Milky Way Galaxy, recent studies [38, 39] indicate a range in mass, as large as 4.5×10^{12} $M_\odot$ and as small as 8×10^{11} $M_\odot$, where $M_\odot$ is the standard mass of the Sun. If we take both values, which are approximately from 1.591 to 8.95×10^{42} kg and inserting them into equation 42, we have r_C from 5.67×10^{20} to 1.35×10^{21} m. The Milky Way is the second-largest galaxy in the Local Group, with its stellar disk approximately 30 kpc in diameter. If we believe that the ring-like filament of stars wrapping around the Milky Way belongs to the Milky Way itself, which are

rippling above and below the relatively flat galactic plane, its stellar disk could reach a diameter of 46–55 kpc [40]. The radius based on a diameter from 30 kpc to 55 kpc are between approximately 4.629×10^{20} and 8.487×10^{20} m, which are in good agreement with our calculated values from equation 42 between 5.67×10^{20} and 1.35×10^{21} m. Vice vasa, the total mass based on the observed effective radius may be estimated. For example, if we use the observed approximately 4.629×10^{20} m and 8.487×10^{20} m as the effective radius, the estimated mass of the Milky Way from equation 42 would be between 5.3×10^{11} $M_\odot$ and 1.8×10^{12} $M_\odot$. The dimensions and masses of other galaxies and stars may be estimated in the same way.

5. THE GRAVITATIONAL FORCE BETWEEN TWO BODIES, A GENERALISED LAW OF GRAVITY, THE TULY-FISHER RELATION AND THE MODIFIDED NEWTONIAN DYNAMICS

The total momentum rate carried by the Super photons from background space to the body of a condensed particle corresponds to a limited force from equation 43 in combination with equations 28, 30 and 34 as following,

$$\boldsymbol{F_L(m_p) = -p_s \frac{dN}{dt} = -\frac{h}{\lambda_s}\beta_1 A_0 \rho_n m_p\, c = -c\, H\, \beta_1\, m_p} \tag{53}$$

Where, p_s is the momentum of a Super photon. Specifically, for the Sun (with $\beta_1 \approx 0.5$ at dynamic equilibrium state):

$$\boldsymbol{F_L(M_{Sun}) = -c\, H\, \beta_1\, M_{Sun} \approx -6.56 \times 10^{20}\ N} \tag{54}$$

To be compared with the gravitational force on the earth from the Sun according to Newton's Law:

$$\boldsymbol{F = -\frac{G\, M_{Sun}\, M_E}{r^2} \approx -3.54 \times 10^{22}\ N} \tag{55}$$

This would imply that the Earth receives a larger total momentum per second than the limited momentum flow rate towards the Sun from the Sun's back-ground space. How can this and the Newtonian gravitational force be explained?

The solution is hidden in the difference between the flows of Super photons absorbed by the particles in each of the participating bodies and the number of interactions that takes place between each Super photon and the specific particle before it is absorbed. Each particle absorbs Super photons from space corresponding to the rate of:

$$\frac{dN}{dt} = \beta_1 A_0 \, m_p \, c \, \rho_n = \frac{\beta_1 H \, m_p}{m_s} \tag{56}$$

Where, m_s is the mass of a Super photon, m_p is the mass of the particle. m_p would be the mass of the Earth particle if we aim to calculate the gravitational force on the Earth from the Sun. Let us imagine a Super photon in the Sun-Earth system while it interacts with the Earth particle. The Earth absorbs $\beta_1 H \Delta t \frac{m_p}{m_s}$ Super photons from its surrounding space during the time interval of Δt; the earth interacts with a total of $A_0 \, \rho_n(r) \, m_p \, c \, \Delta t$ Super photons directed towards the Sun during the same time. From equation 45 above, for the Sun-Earth system $\rho_n(r) = \frac{\beta_1 A_0 \, M_{Sun} \, \rho_n}{4\pi r^2}$. There shall be a small percentage ($0 < \beta_2 < 1$) of the Super photons absorbed by the Earth is not from the Super photons flowing towards the Sun. Hence the probability for absorption by the Earth is:

$$P_{abs} = \frac{\beta_1 H \Delta t \, m_p / m_s}{\beta_1 \beta_2 H \Delta t \, m_p / m_s + A_0 \, \rho_n(r) m_p \, c \, \Delta t} \tag{57}$$

The item containing β_2 in the denominator of equation 57 is for avoiding double counting, equation 57 can be simplified to:

$$P_{abs} = \frac{1}{\beta_2 + \frac{A_0 \rho_{n(r)} c \, m_s}{H \beta_1}} = \frac{1}{\beta_2 + \frac{A_0 M_{Sun}}{4\pi r^2}} \tag{58}$$

Hence the probability for interaction without absorption is $P_I = 1 - P_{abs}$, by inserting the values for M_{Sun} (the mass of the Sun) and r (the distance between the Sun and the Earth), it

can be calculated as $\frac{A_0 M_{Sun}}{4\pi r^2} \approx 1.8 \times 10^7$. As we know $0 < \beta_2 < 1$, which can be neglected in comparison with 1.8×10^7. For wider applications, using M represents the centre mass inside the system, like the M_{Sun} for the solar system, equation 58 can be generalised as,

$$\boldsymbol{P_{abs} = \frac{1}{\beta_2 + \frac{A_0 M}{4\pi r^2}} \approx \frac{4\pi r^2}{A_0 M}} \tag{59}$$

For the Sun-Earth system, $P_{abs} \approx 1/(1.8 \times 10^7) \approx 5.57 \times 10^{-8}$ and $P_I \approx 1$. Therefore, as an average, a Super photon in the flow towards the Sun would react with the Earth approximately 1.8×10^7 times before it eventually being absorbed, and it would each time supply the momentum of $p_s = m_s c$ to the Earth directed towards the Sun. It may be noted here that the wave-length of the Super photon is comparable with the observable Universe, therefore, the here discussed interactions may take place simultaneously over long distances. Our universe is entangled together with Super photons with super long wavelength. In accordance with equations 49, 53, 56 and 58 above, the total force acting in between the Earth and the Sun can be derived as following,

$$\boldsymbol{F = -\frac{1}{P_{abs}} c H \beta_1 M_E = -c H \beta_1 \beta_2 M_E - \frac{G M_{Sun} M_E}{r^2} \approx -\frac{G M_{Sun} M_E}{r^2}} \tag{60}$$

Therefore, for two-body interacting via gravity, the equation of Newton's gravity law is an idea approximation while $c H \beta_1 \beta_2 M_E \ll \frac{G M_{Sun} M_E}{r^2}$, which is true in the solar system. For wider applications, using M represents the centre mass inside the r of the system, and use m represents the mass of the obiter, equation 60 can be generalised as,

$$\boldsymbol{F = -c H \beta_1 \beta_2 m - \frac{G M m}{r^2}} \tag{61}$$

Equation 61 may be named the Generalised Law of Gravity equation of a two-body system. The generalised acceleration a of a two-body system can be derived from equation 61 by dividing the mass of the obiter, hence,

$$\boldsymbol{a = -c H \beta_1 \beta_2 - \frac{G M}{r^2} = a_0 + a_N = \mu a_N} \tag{62}$$

Where, the Newtonian acceleration is,

$$\boldsymbol{a_N = -\frac{GM}{r^2}} \tag{63}$$

The Universal acceleration is,

$$\boldsymbol{a_0 = -c\,H\,\beta_1\beta_2} \tag{64}$$

And,

$$\boldsymbol{\mu = 1 + \frac{a_0}{a_N} = 1 + \frac{c\,H\,\beta_1\beta_2 r^2}{G\,M}} \tag{65}$$

The minus sign in a_N, a_0 and equations 62-64 simply means that the direction is towards the centre, which is often neglected in some literatures. Because $0 \leq \beta_1 \leq 1$ and $0 < \beta_2 < 1$, the absolute value of the Universal acceleration $|a_0| < c\,H \approx 6.6 \times 10^{-10}\ m/s^2$. Using $\beta_1 \approx 0.5$ (approximately half of the Super photons flowing towards the centre of the system from the background space at a dynamic equilibrium state) and $\beta_2 \approx 0.167$ (approximately $\frac{1}{6}$ of the Super photons absorbed by the orbiter is not from the Super photons flowing towards the centre of the system, which is a reasonable assumption. However, the exact reason behind the specific number of $\frac{1}{6}$ worth further research), the calculated $|a_0|$ is approximately $0.55 \times 10^{-10}\ m/s^2$. For stars rotate around its rotational axis located in the galaxy centre in a velocity v, the centrifugal acceleration ($-\frac{v^2}{r}$) shall equal to the acceleration from equation 62, hence,

$$\boldsymbol{v^2 = c\,H\,\beta_1\beta_2 r + \frac{G\,M}{r} = -a_0 r + \frac{G\,M}{r}} \tag{66}$$

Therefore,

$$\boldsymbol{v^4 = a_0^2\,r^2 - 2G\,M\,a_0 + (\frac{GM}{r})^2} \tag{67}$$

If $\frac{G\,M}{r} \gg -a_0 r$ which is applicable in the solar system, it can be derived from equations 66 and 67 that $v^2 \approx \frac{G\,M}{r}$ (the Virial relation which is proved in the Solar system), then we are in the Newtonian regime.

For Galaxies with much larger and distributed masses, when r becomes distant enough, $(\frac{GM}{r})^2$ becomes negligible, a regime is entered with approximately constant density of Super photons, hence,

$$\frac{\rho_n(r)}{\rho_n} = \frac{G\,M}{c\,H\,r^2} \approx \boldsymbol{\beta_1} \quad \boldsymbol{thus} \quad \boldsymbol{r^2} \approx \frac{G\,M}{c\,H\,\beta_1} \tag{68}$$

Combining equations 67 and 68, we have,

$$\boldsymbol{v^4} \approx \boldsymbol{a_0^2\,r^2 - 2G\,M\,a_0} = \boldsymbol{G\,M\,|a_0|(2+\beta_2) = GMa_M} \tag{69}$$

Equation 69 reveals the Tully-Fisher relation [41] and the modified Newtonian dynamics (MoND) relation proposed in 1983 [42, 43] with the MoND acceleration $a_M \approx 1.2 \times 10^{-10}\ m/s^2$ according to Milgrom if taking the Hubble constant approximately as 68 $kms^{-1}Mpc^{-1}$, which is in good agreement with our theoretic calculation from the Super photon theory from equations 64 and 69 above . Astronomical observations show that for disk galaxies, the fourth power of the orbital speed (v_f^4) of stars moving around the core of the galaxy at the flat end of the rotation curve is proportional to the total luminosity L_u of the galaxy. Since L_u is proportional to the observable mass *M* of the galaxy, it is obtained that $v_f^4 \propto M$. This is well known as the Tully-Fisher relation, which is a widely applicable relation and it is originated from empirical fitting of astronomical observations and calculations. This type of rotation curve differs drastically from that of planets rotating around the Sun, whose orbital speed according to Newtonian mechanics and General Relativity in the weak field and small velocity approximations is $v^2 \cong \frac{G\,M}{r}$, the Virial relation. The physical basis of the Tully-Fisher law is the relation between a galaxy's total observable mass M and the velocity at the flat end of the rotation curve v_f. In 1983, Milgrom interpreted the Tully-Fisher relation as an indication of a deviation from Newtonian gravity, claiming a MoND [42, 43]. Milgrom hypothesized that this relation should hold exactly, thus interpreting it as an inductive law of nature instead of an empirical relation [41-44]. According to Milgrom, the deeper significance of this relation

between this special galactic acceleration and the Hubble constant should be revealed by future cosmological insights. Now the Super photon theory has revealed the cosmological insights into the physical origin of both the MoND and the Tully-Fisher empirical relations, which have been sought after for over thirty years [42-46]. If taking the distribution of the observable mass and including the estimated mass of photons, the rotation curve of Galaxies will be able to be fully explained without the assumption of dark matter. If the universe is neither expanding continuously nor expanding in accelerating, the assumption of dark energy becomes unnecessary.

6. CONCLUSIONS AND FURTHER WORK

A lightly damped oscillator model for the propagation of photons in space is analysed from a mechanical perspective on the cosmological scale. Based on the model and using experimental verified relationships, basic definitions and first principles, an equation is deduced displaying the exponential relationship between the Cosmic Redshift z and the Hubble constant H, assigning clear physical meaning to every parameter, especially to the Hubble constant. The energy dissipated by a photon over one cycle is deduced as the product of the Planck constant and the Hubble constant. The tiny portion of energy dissipated per photon in each cycle is defined as a Super photon. There is an unnoticeable and vast ocean of Super photons in the Universe. Through analysing the interactions between Super photons, normal photons and condensed particles, a Super photon theory is developed quantitatively. The equation of mass – effective interacting radius is obtained from the Super photon theory and it is employed to calculate the effective radius of the Solar System and the Milky Way Galaxy based on known masses or vice visa. The calculated results are in good agreement with the estimated values based on astronomical observations and calculations.

The physical origins of the Universal Gravity, the rotation of Galaxies and the dynamic equilibrium of our harmonic and entangled Universe are elucidated. The large condensed particles with high enough masses are able to absorb roaming Super photons and normal photons thus mass and energy from vast space and convert the incoherent thermal energy to coherent mechanical energy and higher frequency thermal energy. And the condensed particles emit mass and energy to its surrounding space as photons because of frictions and radiations, the emitted photons eventually return the mass and energy to the space by releasing Super photons every cycle while travelling at the speed of light to achieve a sustainable number of Super photons in the ocean of Super photons. The mystery behind the dynamic circulation of mass and energy of our harmonic and entangled Universe is unveiled. Particles with different size and mass absorb and emit different range of frequency of Super photons and normal photons, demonstrating relatively stable characteristic temperatures, which manifests dynamic equilibrium achieved.

A generalised Law of the Universal Gravity of two-body is derived while applying the Super photon theory to a system of two-body interacting via gravity. Thereafter, the Virial relation, the Tully-Fisher relation and the MoND relation and acceleration are elucidated quantitatively. The cosmological insights into the physical origins of both the MoND and the Tully-Fisher empirical relations, which have been sought after for over thirty years, are revealed quantitatively by the Super photon theory.

The Super photon theory proposed here is still in the stage of infancy, however the author believes that the theory has the huge potential to be further developed to explain physical phenomena that have plagued the physical world, for example the dark matter and dark energy issues, solving the Hubble Tension by accurately distinguishing the contribution to the Hubble constant from the friction force in vacuum and from the friction force in other transparent spaces containing electrons, protons, atoms and molecules; the accurate calculation of the

CMBR temperature and the theoretic explain of its anisotropic distribution in details. New research directions and frontiers may be developed, for example the understanding of the interacting and recirculating of neutrinos quantitatively and understanding the mechanisms of the creation of light elements inside the centres of stars and galaxies and calculating the abundance of the light elements in the Universe. Further development of the Super photon theory with the inclusion of the interacting and recirculating of neutrinos quantitatively may help to develop a unified law of physics, which will be applicable to both the microcosm and the macrocosm. There is a wide and bright window, which is open for vast opportunities for new research directions and frontiers in physics and science, and in turn, opportunities for the advance of technology and engineering may follow.

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REFERENCES

1. R.V. Pound and G.A. Rebka, Apparent Weight of Photons, Phys. Rev. Lett. 4, 337-341 (1960).
2. R.V. Pound and J.L. Snider, Effect of Gravity on Nuclear Resounance, Phys. Rev. Lett. 13, 539-540 (1964).

3. H.E. Puthoff, Polarizable-Vacuum (PV) Approach to General Relativity, pre-print, https://www.researchgate.net/publication/226207263 (2002).
4. A. Manjavacas and, F. J. Garc´ıa de Abajo, Thermal and vacuum friction acting on rotating particles, *Phys. Rev. A* 82, 063827 (2010).
5. M. Sonnleitner, N. Trautmann and S.M. Barnett, Will a Decaying Atom Feel a Friction Force, *Phys. Rev. Lett.* 118, 053601 (2017).
6. W.D.Zhang, Our Harmonic and Entangled Universe Part I : The Planck Constant and the Conservation of Angular Momentum, pre-print, https://www.researchgate.net/publication/334108005 (2019).
7. W.D.Zhang, Our Harmonic and Entangled World Part 1 : Planck's Constant, the Property and Propagation of Photons, pre-print, https://www.researchgate.net/publication/327321921 (2018).
8. S.L.Garret, *Understanding Acoustics* (Springer International Publishing) (2017).
9. MIT, http://web.mit.edu/8.01t/www/materials/modules/chapter23.pdf (2013).
10. A.K.T.Assis and M.C.D.Neves, History of the 2.7 K Temperature Prior to Penzias and Wilson, *Aperiron*, 2, 79-84 (1995).
11. P.A.LaViolette, Is the Universe Really Expanding? *The Astrophysical Journal*. 301, 544-553 (1986).
12. H. Traunmüller, From magnitudes and redshifts of supernovae, their light-curves, and angular sizes of galaxies to a tenable cosmology, *Astrophys Space Sci* 350:755–767 (2014).
13. H. Traunmüller, Towards a More Well-Founded Cosmology, pre-print, https://www.preprints.org/manuscript/201703.0115/v1 (2017).
14. M.-H.Shao, The energy loss of photons and cosmological redshift, *Physics Essays* 26, 183-190, 2 (2013).

15. L.Marmet, On the Interpretation of Spectral Red-Shift in Astrophysics: A Survey of Red-Shift Mechanisms – II, pre-print, *https://arxiv.org/pdf/1801.07582* (2018).
16. A.G.Riess, W.H.Press & R.P.Kirshner, A Precise Distance Indicator: Type Ia Supernova Multi-color Light Curve Shapes constant, pre-print, *https://arxiv.org/abs/astro-ph/9604143* (1996).
17. L.A.Marosi, Hubble Diagram Test of 280 Supernovae Redshift Data, *Journal of Modern Physics*, 5, 29-33 (2014).
18. L.A.Marosi, Extended Hubble Diagram on the Basis of Gamma Ray Bursts Including the High Redshift Range of z = 0.0331 - 8.1, International Journal of Astronomy and Astrophysics , 9, 1-11 (2019).
19. A.K.T.Assis, On Hubble's Law of Redshift, Olber's Paradox and the Cosmic Background Radiation, *Aperiron*, 12, 13-29 (1992).
20. S.Perlmutter, *et al.* , Discovery of a supernova explosion at half the age of the Universe, *Nature*, 391, 51-54 (1998).
21. W.S.Stensch, The Redshifting of Electromagnetic Radiation: A Heuristic Model. *Physics Essays*,14, 154-159 (2001).
22. S.Birrer, T.Treu, C. E.Rusu, V.Bonvin, *et al.* , H0LiCOW - IX. Cosmographic analysis of the doubly imaged quasar SDSS 1206+4332 and a new measurement of the Hubble constant, *arXiv:1809.01274* (2018).
23. A. G. Riess, S.Casertano, W.Yuan, L.Macri, B.Bucciarelli, M. G. Lattanzi, J. W.MacKenty, J. B.,Bowers, W.Zheng, A. V.Filippenko, C.Huang, R. I.Anderson, Milky Way Cepheid Standards for Measuring Cosmic Distances and Application to Gaia DR2: Implications for the Hubble Constant, *The Astrophysical Journal.* 861 (2): 126 (2018).

24. The LIGO Scientific Collaboration and The Virgo Collaboration; The 1M2H Collaboration; The Dark Energy Camera GW-EM Collaboration and the DES Collaboration; The DLT40 Collaboration; The Las Cumbres Observatory Collaboration; The VINROUGE Collaboration; The MASTER Collaboration: A gravitational-wave standard siren measurement of the Hubble constant Nature. Advance online publication (7678): 85–88. Nature.551, 85A (2017).
25. J.N.Grieb, A.G.Sánchez, S.Salazar-Albornoz, The clustering of galaxies in the completed SDSS-III Baryon Oscillation Spectroscopic Survey: Cosmological implications of the Fourier space wedges of the final sample, *Monthly Notices of the Royal Astronomical Society*. 467 (2) stw3384 (2016).
26. A.G.Riess, L.M.Macri, S.L.Hoffmann, D.Scolnic, S.Casertano, A.V.Filippenko, B. E.Tucker, M.J.Reid, D.O.Jones , A 2.4% Determination of the Local Value of the Hubble Constant, *The Astrophysical Journal***.** 826 (1): 56 (2016).
27. H.Mo, F. Bosch and S.White, *Galaxy Formation and Evolution* (Cambridge University Press, Cambridge) p. 689 (2010).
28. H.Broberg, The Elementary Quantum – Some consequences in Physics and Astrophysics of a Minimal, Energy Quantum. *ESA STM-*, 223 (1981).
29. H.Broberg, Quantized Vacuum Energy and the Hierarchy of Matter. In H.C. Arp et al., editor, Progress in New Cosmologies: Beyond the Big Bang (Plenum Press, New York) page 333 (1993).
30. J.G.Ren, P.Xu, H.L.Yong, *et al.*, Ground-to-satellite quantum teleportation, pre-print, *https://arxiv.org/abs/1707.00934* (2017).
31. W.D. Zhang, Our Harmonic and Entangled Universe Part II: The Cosmological Insight into the Physical Origin of Cosmic redshift and Hubble Constant, pre-print, https://www.researchgate.net/publication/334391622 (2019).

32. W.D. Zhang, Our Harmonic and Entangled World Part 2: Discovering the Super Photon and Several Mysteries of Our Universe, pre-print, https://www.researchgate.net/publication/328049503 (2018).
33. W.D. Zhang, Our Harmonic and Entangled Universe Part III: The Cosmological Insight into the Physical Origin of the Universal Gravity and the Rotation of Galaxies, pre-print, https://www.researchgate.net/publication/332253104 (2019).
34. R.L. Oldershaw, The Hidden Meaning of Planck's Constant. *Universal Journal of Physics and Application* 1(2): 88-92 (2013).
35. J. Ahn, Z.J.Xu, J.Bang, Y.H.Deng, T.M. Hoang, Q.K. Han, R.M.Ma, T.C.Li., Optically Levitated Nanodumbbell Torsion Balance and GHz Nanomechanical Rotor, *Phys. Rev. Lett.* 121, 033603 (2018).
36. M.Woolfson, The origin and evolution of the solar system, *Astronomy & Geophysics*. 41 (1): 1.12 (2000).
37. M.Littmann, Planets Beyond: Discovering the Outer Solar System (Courier Dover Publications) pp. 162–163 (2004).
38. S.Phelps, *et al.*, The Mass of the Milky Way and M31 Using the Method of Least Action, *The Astrophysical Journal*. 775 (2): 12 (2013).
39. P.R.Kafle, *et al.*, On the Shoulders of Giants: Properties of the Stellar Halo and the Milky Way Mass Distribution, *The Astrophysical Journal*. 794 (1): 17 (2014).
40. H.J.Newberg, *et al*., Rings and Radial Waves in the Disk of the Milky Way, *The Astrophysical Journal*. 801 (2): 105 (2015).
41. J. Binney, S.Tremaine, Galactic Dynamics, 2nd ed. (Princeton University Press: Princeton, NY, USA, 2008).
42. M. Milgrom, A modification of the Newtonian dynamics as a possible alternative to the hidden mass hypothesis, Astrophys. J., 270, 365–370 (1983).

43. M. Milgrom, A modification of the Newtonian dynamics as a possible alternative to the hidden mass hypothesis, Astrophys. J., 270, 371–389(1983).
44. E.P.J. de Hass, pre-print, https://www.researchgate.net/publication/325385065 (2018).
45. J.D. Bekenstein, The modified Newtonian dynamics - MOND and its implications for new physics Contemporary Physics. 47: 387-403 (2006).
46. S.S. McGaugh, Novel Test of Modified Newtonian Dynamics with Gas Rich Galaxies, Phys. Rev. Lett., 106, 121303 (2011).