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AN ALTERNATIVE TO UNDERSTAND THE ORIGIN OF UNIVERSAL GRAVITATION AND THE COSMIC BACKGROUND MICROWAVE RADIATION FROM A SUPER PHOTON THEORY

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ABSTRACT

Through analysing the interactions between the immersed matter particles and the thermal bath of a vast Super photon ocean, the Super photon theory is developed quantitatively. The correlation between the Gravitational constant and the Hubble constant is deduced. The generalised law of Universal Gravitation, the Tully-Fisher law, and the Modified Newtonian Dynamics relation are derived theoretically. The dynamic equilibrium and circulation of mass and energy of the Universe are discussed. Flavour oscillation observed in neutrinos is taken as an evidence of immersed matter particles that undergo two-way energy exchange with the thermal bath of the vast Super photon ocean having local fluctuations. Gravitational waves are viewed as periodic density and pressure oscillations of the Super photon particles propagating through the vast Super photon ocean. The temperature and the spectrum of the Cosmic Microwave Background Radiation are explained theoretically and determined accurately using the Super photon theory together with the fluctuation-dissipation theorem. The capability of a photon particle travelling at the constant speed of light in the free space with a friction force is verified theoretically. Further supporting evidences to the Super photon theory are provided. An experiment is proposed for the further proof of the Super photon theory.

Keywords: Universal Gravitation, super photon, dynamic equilibrium and circulation, Tully-Fisher law, modified Newtonian dynamics, cosmic background microwave radiation, fluctuation-dissipation theorem.

INTRODUCTION

It is interesting to know that Hubble remained cautiously against the Big-Bang hypothesis until the end of his life. In order to account for cosmic redshifts in a nonexpanding Universe, Hubble called for a new principle of nature, like the kind of Tired-Light mechanism (Hubble, 1937; Assis, 1992). On the other hand, he was aware of the theoretical difficulties of such a radical assumption that was in conflict with Einstein's General Relativity. The differential geometry used in Einstein's General Relativity is technically useful and predictive, however, it has limitations. Einstein's General Relativity spring out of Maxwell's equations, hence, the ideal approximations of massless photon and frictionless free space are inherited, it also does not include the self-rotational effect (Zhang, 2021a, 2021b). The dynamic absorption and dissipation of energy are not handled by the geometric theory of gravitation (the General Relativity.)

Photon particles propagate at constant velocities (c and v) in the free space and other spaces of transparent media (Pound and Rebka, 1960; Broberg, 1993; Kardar and Golestanian, 1999; Manjavacas and García, 2010). They interact with each other, although the interactions are extremely weak. Photon particles experience an extremely weak force (F_{vis}) resembling friction in the spaces they travelling through (Zhang, 2021a, 2021b), i.e.

$$F_{vis} = -R_m v \tag{1}$$

where R_m is the viscous resistance coefficient of the space, v is the constant velocity of the photon particle travelling through the space. From a mechanical perspective, a lightly damped oscillator model was applied to elucidate the properties and propagations of the photon particles in the free space. Based on the analysis of the lightly damped oscillator model for the photon particles, an alternative for the understanding of the physical origin of the Cosmic Redshift and the Hubble constant were elucidated. An equation was deduced displaying the exponential relationship between the Cosmic Redshift z and the Hubble constant H with clearly defined physical meaning of every parameter involved (Zhang, 2021a). The Hubble constant was derived as an extremely low frequency with its origin from the time constant, the ratio between the viscous resistance R_m of the free space and the inertial mass m of the photon particle travelling through, i.e.

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$$H \approx f_\tau = \frac{1}{\tau} = \frac{R_m}{2m} \quad (2)$$

The energy dissipated by a photon particle during one cycle was deduced as the product of the Planck constant and the Hubble constant, which was defined as a Super photon (Zhang, 2021a, 2021b). A Super photon is a fundamental unit of energy and mass in dynamic circulation. There is an unnoticeable and vast Super photon ocean in the Universe. The normal photons and the Super photons in gigantic number in the Universe interact with each other and create a thermal bath, a vast photon ocean, or more fundamentally a vast Super photon ocean. Through the analysing of the interactions between the Super photons and the normal photons, the foundation of the Super photon theory was developed quantitatively (Zhang, 2021a, 2021b). A normal photon particle is a dynamic packet of a number (N) of the Super photon particles in a local agglomeration. The interacting strength between a normal photon (having energy $= N E_S$) and a Super photon (having energy E_S) as an effective cross-section area $\sigma_p = N\sigma_S$ was introduced, where σ_s is the interacting strength thus effective cross-section area between two Super photons. The average numerical density of the Super photons (including the Super photons in the dynamic packets of the normal photons) in a unit of the free space was defined as ρ_n. During the time interval Δt, a normal photon sweeps 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 in the free space. Therefore, the normal photon particle meets a number ($\rho_n N\sigma_S\, c\, \Delta t$) of the Super photons during the time interval Δt. The number of $\rho_n N\sigma_S\, c\, \Delta t$ Super photons interacts with the normal photon particle during the time interval Δt. Hence, the normal photon particle exchanging energy with the Super photon ocean during the time interval Δt (Zhang, 2021a) is

$$\Delta N = -\rho_n N\sigma_S\, c\, \Delta t \quad (3)$$

The Super photons are spread out in the observable Universe and they have a giant number. Hence, the average mass density of the Super photons (ρ_0) must be a constant on a cosmological scale. Two other Universal constants (R_0 and V_0) were proposed together with ρ_0 (Broberg, 1993; Zhang, 2021a), where R_0 is the ratio between the effective cross-section area and the inertial mass of a photon particle, V_0 is the volume of the free space, which is swept through by the effective cross-section area of a photon particle during one cycle. These constants are applicable to both the normal photons and the Super photons. Some defined or derived relations (Zhang, 2021a) useful for this article, are listed as follows:

$$\rho_0 = m_s\rho_n = \frac{h}{c\lambda_s}\rho_n \quad (4)$$

$$R_0 = \frac{\sigma_p}{m} = \frac{H}{\rho_0\, c} \quad (5)$$

$$V_0 = R_0\, m\, \lambda = \frac{h\, H}{\rho_0\, c^2} \quad (6)$$

where h is the Planck constant, H is the Hubble constant, c is the speed of the photons in the free space, λ_s and m_s are subsequently the wavelength and the inertial mass of the Super photon.

In this article, the correlation between the Universal Gravitational constant and the Hubble constant is deduced. A generalised law of Universal Gravitation is derived. The Virial relation within the Solar system, the Tully-Fisher law, and the Modified Newtonian Dynamics relation and acceleration in Galaxies are derived theoretically. The capability of a photon particle travelling at the constant speed of light in the free space with a friction force is theoretically verified. The temperature and the spectrum of the Cosmic Microwave Background Radiation (CMBR) are explained theoretically and determined accurately using the Super photon theory and the fluctuation-dissipation theorem. Further supporting evidences to the Super photon theory are provided. An experiment is proposed for the further proof of the Super photon theory.

The interactions between Super photon particles and concrete matter particles, the origin of the Universal Gravitation

Imagining a relatively stationary concrete matter particle (Zhang, 2021b) immersed in the ocean of Super photon particles as shown schematically in Figure 1, the matter particle with the inertial mass m_p and the equivalent effective interacting cross-section area $\sigma_p = 4\pi r_c^2$ would receive an inflow of the Super photon particles and neutrinos at light speed from its surrounding space. This article focuses on the Super photon particles (including the normal photon particles that are dynamic packets of the Super photon particles locally) because neutrinos are fermions that are supposed to make negligible contribution to the long-distance force of the Universal Gravitation.

A Super photon is a photon with the smallest unit of energy and mass, a photon is a dynamic packet of Super photons locally. All photons including the normal photons and the Super photons have wave and particle dualities. The average numerical density of the Super photon particles in a unit of the free space was defined as ρ_n

(Zhang, 2021a), assuming a percentage $\beta_1(-100\% \leq \beta_1 \leq 100\%)$ of the ρ_n Super photon particles from the free space flowing into the matter particle with the momentum of every Super photon particle as follows:

$$p_s = \frac{h}{\lambda_s} = \frac{E_s}{c} = m_s c \tag{7}$$

where p_s, λ_s, E_s, and m_s are subsequently the momentum, the wavelength, the energy, and the inertial mass of the Super photon particle.

It is interesting to point out that the Super photon particle has a momentum, so there must be pressure in the Super photon ocean. Gravitational waves may be viewed as periodic Super photon density and pressure oscillations propagating through the vast ocean of the Super photons with relatively long wavelengths. The number of Super photon particles flowing into the matter particle during the time Δt is

$$\Delta N = \beta_1 \rho_n \sigma_p c \Delta t \tag{8}$$

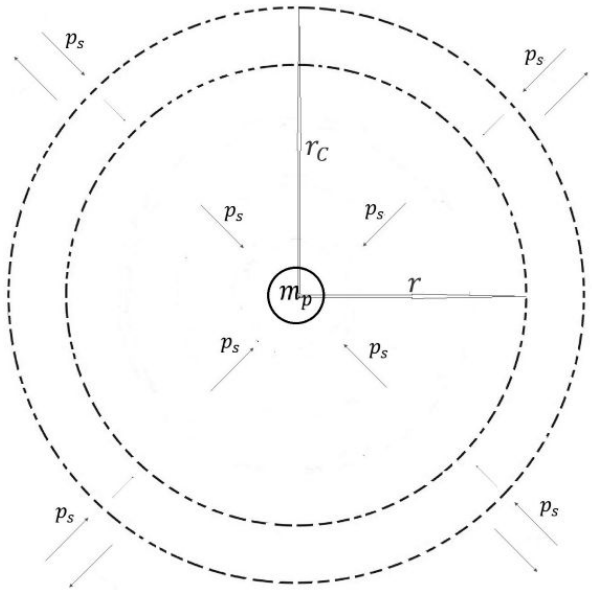

Fig. 1. The schematic diagram showing the inward flow of the Super photon particles with momentum p_s per Super photon towards a relatively stationary matter particle with the mass m_p.

If $\beta_1 = 1$, it means that the matter particle 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 it will emit to achieve a dynamic equilibrium with its surrounding space. At this extreme, the matter particle behaves similar to some Black Hole but without the problem of singularity. Another extreme, if $\beta_1 = -1$, it means that the matter particle emits its mass and energy out, the mass and energy of the matter particle will eventually be spread out into the vast space of the Super photon ocean if keeping $\beta_1 = -1$ enough time. The restricted occasion of a net number of the Super photon particles flowing into the matter particle will be investigated first, which means $0 < \beta_1 \leq 1$. The corresponding mass and energy flowing into the matter particle are

$$\Delta m_p = \Delta N\, m_s = \beta_1 m_s \rho_n \sigma_p\, c\, \Delta t \tag{9}$$

$$\Delta E_p = \Delta N E_s = \beta_1 m_s \rho_n \sigma_p c^3\, \Delta t \tag{10}$$

where m_p and E_p are subsequently the mass and energy of the matter particle.

Inserting $\sigma_p = R_0 m_p$ and $\rho_0 = m_s \rho_n$ from equations (4) and (5) into equations (9) and (10) leads to

$$\Delta m_p = \frac{\Delta E_p}{c^2} = \beta_1 R_0 \rho_0 m_p\, c\, \Delta t \tag{11}$$

Because $H = A_0\, \rho_0\, c$ from equation (4), hence,

$$\Delta m_p = \frac{\Delta E_p}{c^2} = \beta_1 H m_p \Delta t \tag{12}$$

The mass and energy of the matter particle as the function of time can be derived through the integration of equations (11) and (12) as follows:

$$m_p(t) = m_p(0) e^{\beta_1 H t} \tag{13}$$

$$E_p(t) = E_p(0)\, e^{\beta_1 H t} \tag{14}$$

where $m_p(0)$ and $E_p(0)$ are the mass and energy of the matter particle at its state of the lowest mass and energy at $t = 0$.

Remembering H is approximately $2.29 \times 10^{-18}\ [s^{-1}]$ (Zhang, 2021a) and $0 < \beta_1 \leq 1$. Therefore, during a relatively short period of time, for instance, days or years, the mass and energy increasing are extremely tiny. However, the tiny change of mass and energy accompanies an inward force, the force leads to contracting, vibrating and spinning of the matter particle around its equilibrium position because the interacting with photons with 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 (Ahn *et al.*, 2018). Linear polarization causes the silica particles to vibrate along the line of polarization while circular polarization causes the silica particles to spin. This may help to explain the

spinning and vibrating of the galaxies, the stars, the planets, and elementary particles. The contracting, vibrating, and spinning of the compositions of the matter particle induce internal friction forces, which cause the increase of the internal temperature and pressure. This increase of temperature and pressure inside the matter particle trigger off expanding and radiation, therefore, photons are released into surrounding space. Part of the energy and mass absorbed is emitted out. It can be predicted that the total energy radiated will be at the maximum while the radius of the matter particle is at its minimum and the total energy radiated will be at the minimum while its radius is at the maximum.

While the author searched literature for supporting evidence, it was found that the above prediction has been confirmed by the quantitative measurement of the relation between the total irradiance and the radius variations of the Sun (Pap *et al.*, 2001) and the amplitude of the fluctuation is approximately 0.015%. It shall be viewed as a supporting evidence of the dynamic circulation and equilibrium of the immersed matter particle with the thermal bath of the Super photon ocean. To maintain a relatively stable state of temperature and movement (including the spinning and the orbital velocity) the matter particle needs absorbing mass and energy through interacting with the thermal bath of the Super photon ocean at its surrounding, which means $0 < \beta_1 \leq 1$. The matter particle also emits photons because of compressing, frictions, and radiations. The mass and energy radiated can be slightly more or less than the mass and energy absorbed, which causes a mass and energy oscillation of the matter particle. A dynamic circulation and equilibrium state with fluctuation will be achieved. Flavour oscillation observed in neutrinos (Cai *et al.*, 2017) may be taken as an evidence of immersed matter particles that undergo two-way energy exchange with the thermal bath of the Super photon ocean having local fluctuations.

The secret of the dynamic circulation and equilibrium of mass and energy of the Universe is uncovered. Quantitative details of the mechanism need further research. For a normal photon, it releases a Super photon every cycle, its wavelength increases cycle by cycle slowly. It is the normal photons that are expanding, it is not the space itself. The matter particles absorb mass and energy through interacting with the thermal bath of the Super photon ocean to maintain their characterized temperatures and movements. And the matter particles release mass and energy by radiations, the released mass and energy mainly as photons, which eventually return the mass and energy to the free space by releasing Super photons every cycle while travelling at light speed to achieve mass and energy balance with the thermal bath of the vast Super photon ocean. The nuclear reactions and element generations inside the centre of galaxies and inside stars are probably merely by-processes because of the impinging of photons, neutrinos, and cosmic rays from all directions, and the high temperature and high pressure induced by impinging and frictions, which worth further research.

For a general illustration in a parable, all the galaxies, stars and planets are music instruments with different keys and strings, meanwhile, the Super photons, the normal photons, neutrinos and cosmic rays flowing towards the music instruments are the fingers of a glorious musician. All sorts of emitted matters, visible and invisible lights are like melodies spew out from the music instruments. It is interesting that the melodies can eventually turn back to the wonderful fingers of the glorious musician. Matter particles with different size and mass absorb and release different range of frequency and wavelength of photons to sustain their characterized movements and temperatures, and achieve dynamic equilibriums with their surrounding spaces such as the thermal bath of the vast Super photon ocean. Dynamic equilibriums are achieved, which is manifested by the relatively stationary spectrums of radiations from the galaxies, the stars, the planets, the fundamental particles and elements, with their characteristic range of temperatures, colours, brightness, and movements.

Although we are still lacking of technologies to detect a Super photon particle directly, we are capable to figure out the mass and energy balance of galaxies, stars, and planets. The Super photon particles are mainly either single Super photon particles or packets of Super photon particles as the normal photon particles in the free space. However, when they are approaching the mass centre of the galaxies, stars, and planets, a large percentage of them would pack together in superposition and change appearance to detectable normal photons and matter particles. For instance, we are able to prove the energy balance of the Earth through measuring and calculating the energy absorbed by the Earth and the energy emitted by the Earth. Certainly, through measuring and calculating the energy and mass flowing towards the Sun and the energy and mass the Sun radiated, we will be able to prove approximately the energy and mass balance of the Sun in average, although there are small fluctuations as observed on the total irradiance variations of the Sun (Pap *et al.*, 2001). Another exciting point is that Newton's law of gravitation in the Solar System, the Tully-Fisher law, and the Modified Newtonian Dynamics relation and acceleration in Galaxies can be derived from the Super photon theory quantitatively, which can help us to gain deeper insight into the origin of the Universal gravitation.

As shown schematically in Figure 1, we define r_C to represent the radius of the effective interacting cross-

section area ($\sigma_p = 4\pi r_C^2 = R_0 m_p$) of the matter particle with a mass m_p, hence,

$$r_C = \sqrt{\frac{R_0 m_p}{4\pi}} \tag{15}$$

Outside the ball of the effective radius r_C, there will be a random distribution of the Super photon particles. From equation (8) written above, the number of the Super photon particles flowing through the effective interacting cross-section area ($4\pi r_C^2$) towards the matter particle during the period Δt is

$$\Delta N = \beta_1 \rho_n \sigma_p \, c \, \Delta t = \beta_1 R_0 \rho_n m_p \, c \, \Delta t \tag{16}$$

Because the matter particle is in a dynamic equilibrium with its surrounding, around the effective interacting radius, the number of Super photon particles flowing towards the matter particle should be approximately 50% of the total number of Super photon particles to maintain a random distribution of the Super photon particles in average, hence, $\beta_1 \approx 0.5$ (fluctuating around 0.5 with an average at 0.5). At a distance $r \leq r_C$ from the matter centre, the fluid towards the matter particle must carry the same number of Super photon particles, but flow through a smaller area, if we define the local numerical density of Super photon particles as $\rho_n(r)$, i.e.

$$4\pi r^2 \rho_n(r) \, c = \beta_1 R_0 \rho_n m_p \, c \tag{17}$$

The local numerical density with a local gradient of the Super photon particles around the matter particle as a function of r is therefore,

$$\rho_n(r) = \frac{\beta_1 R_0 m_p \rho_n}{4\pi r^2} \tag{18}$$

Similar to equation (16) but applied at the radius r, the inward flowing rate of the Super photon particles is

$$\frac{dN}{dt} = \rho_n(r) \, \sigma_p \, c = R_0 \rho_n(r) m_p \, c \tag{19}$$

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

$$F = -\frac{dp}{dt} = -p_s \frac{dN}{dt} = -\frac{\beta_1 R_0^2 c^2 \rho_0}{4\pi} \frac{m_p^2}{r^2} \tag{20}$$

The force in equation (20) represents the Universal Gravitation force between the centre mass m_p and an equivalent effective mass ($-m_p$), which represents the average counter interactions from the rest of the Universe through the vast Super photon ocean to achieve an energy and force balance. The negative sign in front of m_p simply means when the centre m_p of the matter particle is absorbing the Super photons and contracting, the equivalent effective mass of the rest of the Universe ($-m_p$) is releasing the Super photons and expanding. While the centre m_p of the matter particle is releasing the Super photons and expanding, the equivalent effective mass ($-m_p$) is absorbing the Super photons and contracting. There is a mass and energy balance across the Universe. If locally two matter particles with different masses interact with each other, like the Sun and the Earth, a net gravitational attracting force is induced between them because they shield each other in the ocean of roaming Super photon particles. Hence, they tend to become closer to each other. If the Sun and the Earth are viewed together as a whole, the contracting and local increasing of the density of mass and energy happens, thus a counter force emerged to cancel out the attracting force. These reactions are for achieving a dynamic equilibrium of mass and energy and to maintain relatively stable distribution of mass and energy on a cosmological scale. Detailed analysis and calculation will be done in next section.

Now let us compare equation (20) with Newton's law of gravitation, they are the same if we assign that

$$G = \frac{\beta_1 R_0^2 c^2 \rho_0}{4\pi} \tag{21}$$

By using equation (5), we get

$$G = \frac{\beta_1 R_0 H c}{4\pi} = \frac{\beta_1 H^2}{4\pi \rho_0} \tag{22}$$

The Universal Gravitational Constant may be interpreted as the interacting and coupling constant of a matter particle with the rest of the Universe through its interacting with the vast 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 from equation (22). For fully understanding its implications, further research is worthwhile. By inserting $H \approx 2.29 \times 10^{-18} [\mathrm{s}^{-1}]$, $G \approx 6.6739 \times 10^{-11}$ [m^3/kg s^2] and $\beta_1 \approx 0.5$ into equation (22), the average mass density of Super photons on a cosmology scale as a Universal constant can be derived as follows:

$$\rho_0 \approx 3.13 \times 10^{-27} \text{ [kg/m}^3\text{]} \tag{23}$$

The value of the Universal constant R_0, the ratio between the effective cross-section area and the inertial mass of a photon particle (applicable to the Super photon as well) can be estimated as follows:

$$R_0 \approx 2.44 \text{ [m}^2\text{/kg]} \tag{24}$$

Then we can derive that

$$G \approx 1.273 \times 10^{25} H^2 \quad (25)$$

The accuracy of the numbers in equations (23), (24), and (25) depends on the accuracy of the values of G and H. Having ρ_0 and R_0 at hand, we can do some interesting calculations. As an example, let us start from using equation (15)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 (Woolfson, 2000), the total mass in the Solar System is approximately 1.99×10^{30}. Inserting this value and R_0 into equation (15), we get $r_C \approx 6.21 \times 10^{14}$ [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] (Littmann, 2004). Our calculation of $r_C \approx 6.21 \times 10^{14}$ [m] sits approximately in the middle of these estimated radius based on the observations and calculations.

Regarding the Milky Way Galaxy, recent studies (Phelps *et al*., 2013; Kafle *et al*., 2014) indicate a range in mass, as large as 4.5×10^{12} $M_\odot$ and as small as $8 \times 10^{11} M_\odot$, where $M_\odot$ is the standard mass of the Sun. If we take both the values, which are approximately from 1.59 to 8.95×10^{42} [kg], and insert them into equation (15), we have $r_C$from 5.56×10^{20} to 1.31×10^{21} [m]. The Milky Way is the second-largest galaxy in the Local Group, with its stellar disk approximately 30 kpc in the 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 can reach a diameter of 46 to 55 kpc (Xu *et al*., 2015). The radius based on a diameter from 30 kpc to 55 kpc are between approximately 9.27×10^{20} and 1.70×10^{21} [m], which are in good agreement with our calculated values from equation (15), which is between 5.56×10^{20} and 1.31×10^{21} [m].

Vice versa, the total mass based on the observed effective radius may be estimated. For instance, if we use the observed approximately 9.27×10^{20} [m] and 1.7×10^{21} [m] as the effective radius, the estimated mass of the Milky Way from equation (15) would be between 2.22×10^{12} $M_\odot$and 7.48×10^{12} $M_\odot$. The dimensions and masses of other galaxies and stars may be estimated in the same way.

The gravitational force between two bodies, the generalised law of Universal Gravitation, the Tully-Fisher law and the Modified Newtonian Dynamics

The total momentum rate carried by the Super photon particles from background space to the body of a matter particle corresponds to a limited force from equations (4), (5), (8), and (16) as follows:

$$F_L(m_p) = -p_s \frac{dN}{dt} = -\frac{h}{\lambda_s} \beta_1 R_0 \rho_n m_p c = -cH\beta_1 m_p \quad (26)$$

Specifically, for the Sun (with $\beta_1 \approx 0.5$ at dynamic equilibrium state) there is:

$$F_L(M_{Sun}) = -cH\beta_1 M_{Sun} \approx -6.83 \times 10^{20} N \quad (27)$$

The value obtained with formula (27) can be compared with the following gravitational force on the Earth from the Sun according to Newton's Law:

$$F = -\frac{G\ M_{Sun} M_E}{r^2} \approx -3.54 \times 10^{22} N \quad (28)$$

This would imply that the Earth-Sun system 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 the Super photon particles absorbed by the matter particles in each of the two participating bodies and the number of interactions that takes place between the Super photons and the two participating bodies. Each matter particle absorbs the Super photon particles corresponding to the following rate of:

$$\frac{dN}{dt} = \beta_1 R_0 m_p c \rho_n = \frac{\beta_1 H m_p}{m_s} \quad (29)$$

where m_s is the mass of the Super photon particle, m_p is the mass of the matter particle.

Specifically, the m_p would be the mass of the Earth if we aim to calculate the gravitational force between the Earth and the Sun. Let us imagine a Super photon in the Sun-Earth two-body system while it interacts with the Earth. The Earth absorbs $\beta_1 H \frac{m_E}{m_s} \Delta t$ Super photon particles from its surrounding space during the time interval of Δt, meanwhile the Earth interacts with a total of $R_0 \rho_n(r) m_p\, c\, \Delta t$ Super photons directed towards the Sun. From equation (18), for the Sun-Earth system

$\rho_n(r) = \frac{\beta_1 R_0 M_{Sun}\, \rho_n}{4\pi r^2}$. There must be a small percentage β_2 $(0 < \beta_2 < 1)$ of the Super photon particles absorbed by the Earth but not of the Super photon particles flowing towards the Sun. Hence, the probability for absorption by the Earth is P_{abs} defined by

$$P_{abs} = \frac{\beta_1 H\, \Delta t m_p/m_s}{\beta_1\beta_2 H\, \Delta t\, m_p/m_s + R_0\rho_n(r) m_p\, c\, \Delta t} \quad (30)$$

The item containing the percentage β_2 in the denominator of equation (30) is for avoiding double counting. As a result, equation (30) can be simplified to:

$$P_{abs} = \frac{1}{\beta_2 + \frac{R_0\rho_{n(r)} c\, m_s}{H\beta_1}} = \frac{1}{\beta_2 + \frac{R_0 M_{Sun}}{4\pi r^2}} \quad (31)$$

The probability for interaction without absorption is $P_I = 1 - P_{abs}$. Inserting the numerical values of M_{Sun} (the mass of the Sun) and r (the distance between the Sun and the Earth), it can be calculated that $\frac{R_0 M_{Sun}}{4\pi r^2} \approx 1.7 \times 10^7$. As we know $0 < \beta_2 < 1$, the small percentage β_2 can be neglected in comparison with 1.7×10^7, for the Sun-Earth system, $P_{abs} \approx 1/(1.7 \times 10^7) \approx 5.9 \times 10^{-8}$ and $P_I \approx 1$. Therefore, as an average, the Super photon particles in the flow towards the Sun would interact with the Earth-Sun system approximately 1.7×10^7 times, and each interaction would supply the momentum of $p_s = m_s c$ to the Earth-Sun system directed towards the Sun from the Earth. It may be noted here that the wavelength of the Super photon is comparable with the one in the observable Universe. Therefore, the discussed interactions may take place simultaneously over long distances. Our Universe is entangled together with a gigantic number of the Super photons with super long wavelengths. For wider applications, M represents the centre mass inside the system, like the M_{Sun} for the Solar System. So, equation (31) can be generalised as follows:

$$P_{abs} = \frac{1}{\beta_2 + \frac{R_0 M}{4\pi r^2}} \quad (32)$$

In accordance with equations (22), (26), (29), and (31) written above, the total force acting in between the Earth and the Sun can be derived as follows:

$$F = -\frac{1}{P_{abs}} cH\beta_1 M_E \quad (33)$$

$$= -cH\beta_1\beta_2 M_E - \frac{G\, M_{Sun} M_E}{r^2} \approx -\frac{G\, M_{Sun} M_E}{r^2}$$

where M_E is the mass of the Earth. Therefore, for a two-body system interacting via the gravitation, the equation of Newton's law of gravitation is an ideal approximation while $cH\beta_1\beta_2 M_E \ll \frac{G\, M_{Sun} M_E}{r^2}$, which is the case in the Solar System. For wider applications, M represents the mass of the centre body, m represents the mass of the obiter, and r represents the distance between them. So, equation (33) becomes

$$F = -cH\beta_1\beta_2 m - \frac{GMm}{r^2} \quad (34)$$

Equation (34) may be called the generalised law of Universal Gravitation of a two-body system. The generalised acceleration a of the two-body system can be derived from equation (34) by dividing the mass of the obiter, i.e.

$$a = -cH\beta_1\beta_2 - \frac{GM}{r^2} = a_0 + a_N = \eta a_N \quad (35)$$

The Newtonian acceleration a_N is

$$a_N = -\frac{GM}{r^2} \quad (36)$$

The Universal acceleration $a_0$is

$$a_0 = -cH\beta_1\beta_2 \quad (37)$$

and

$$\eta = 1 + \frac{a_0}{a_N} = 1 + \frac{cH\beta_1\beta_2 r^2}{GM} \quad (38)$$

The minus sign in equations (33)-(37) simply means that the direction of the force is towards the centre. Because $0 \le \beta_1 \le 1$ and $0 < \beta_2 < 1$, from equation (37), the absolute value of the Universal acceleration $|a_0| < c\,H \approx 6.86 \times 10^{-10}$ [m/s^2]. Inserting $\beta_1 \approx 0.5$, 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, considering one of six faces in a cubic), the calculated $|a_0|$ is approximately 0.57×10^{-10} [m/s^2]. For stars rotating with the velocity v around its rotational axis located in the galaxy centre, the centripetal acceleration $(-\frac{v^2}{r})$ must be equal to the acceleration from equation (35), hence,

$$v^2 = cH\beta_1\beta_2 r + \frac{GM}{r} = -a_0 r + \frac{GM}{r} \quad (39)$$

Therefore,

$$v^4 = a_0^2 r^2 - 2GMa_0 + (\frac{GM}{r})^2 \quad (40)$$

If $\frac{G\,M}{r} \gg |a_0 r|$, which is the case of the Solar System, it can be derived from equation (39) that $v^2 \approx \frac{G\,M}{r}$ (the Virial relation, which has been 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 the Super photons, $\frac{\rho_n(r)}{\rho_n} = \frac{G\,M}{c\,H\,r^2} \approx \beta_1$, which leads to:

$$r^2 \approx \frac{G\,M}{c\,H\,\beta_1} \tag{41}$$

Combining equations (37), (40), and (41), we have

$$v^4 \approx a_0^2 r^2 - 2GMa_0 = GM|a_0|(2+\beta_2) \tag{42}$$

$$= GMa_M$$

Equation (42) reveals the Tully-Fisher law (Binney *et al.*, 2008) and the modified Newtonian dynamics (MoND) proposed in 1983 (Milgrom, 1983a, 1983b). a_M is the acceleration of the MoND, $a_M \approx 1.24 \times 10^{-10}\ [\mathrm{m/s^2}]$ according to Milgrom if taking the Hubble constant as approximately 70.8 $[\mathrm{km\,s^{-1}Mpc^{-1}}]$, which is in good agreement with the theoretical calculation from the Super photon theory with equations (37) and (42).

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 inertial mass M of the galaxy, it is obtained that $v_f^4 \propto M$. This is well-known as the Tully-Fisher law, which is a widely applicable relation and it is originated from the empirical fitting of astronomical observations and calculations. This type of rotation curve differs drastically from that of the planets rotating around the Sun, whose orbital speed, according to the Newtonian mechanics and the 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 inertial mass M and the velocity at the flat end of the rotation curve v_f.

In 1983, Milgrom interpreted the Tully-Fisher law as an indication of a deviation from the Newtonian gravitation, claiming the MoND (Milgrom, 1983a, 1983b; Binney *et al.*, 2008). Milgrom hypothesized that this relation should hold exactly, thus interpreting it as an inductive law of nature instead of an empirical relation. 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 relations, which have been sought after for over thirty years as stated by McGaugh (2011) and (Hass, EPJ de. 2018. The 'constant Lagrangian' fit of galaxy rotation curves as caused by cosmic space expansion under energy conservation conditions. Pre-print. https://vixra.org/pdf/1805.0342v1.pdf). Taking into account the distribution of the observable inertial masses, the rotation curve of Galaxies will be able to be fully determined accurately without the assumption of dark matter. If the universe is neither expanding continuously nor expanding in accelerating, the adoption of the assumption of dark energy becomes unnecessary as well.

Further supporting evidences of the Super photon theory, the origin of the CMBR and the theoretic determination of the temperature and the spectrum of the CMBR

There may be a doubt that how a photon particle can travel at a constant speed c inside the free space with a viscous friction force. The explanation is that the photon particle behaves like a tiny spin rocket that releases an extremely tiny fragment of mass and energy every cycle to combat the viscous friction force and maintain the constant speed of propagation. Let us do a simple calculation, first assuming that v is the speed of the photon particle with an inertial mass of m travelling through the free space with a viscous friction force F_{vis}. According to equations (1) and (2), for keeping a constant speed of v, the average energy dissipation $< E_{DIS} >$ of the photon particle within one second of time to combat the friction force must be equal to

$$< E_{DIS} > = \frac{1}{2}|F_{vis} \cdot v| = \frac{1}{2}R_m v^2 = \frac{R_m}{2m}mv^2 \tag{43}$$

$$= Hmv^2$$

Within the short period of one second, the frequency of the photon (f) can be viewed as a constant value. Hence, the photon totally spins as many as f-cycles within the period of one second. According to the Super photon theory, the photon releases a Super photon every cycle with the energy of hH. Employing the Planck-Einstein equation $hf = mc^2$, it can be derived that the energy releasing of the photon particle within the period of one second of time must be

$$< E_{DIS} > = Hhf = Hmc^2 \tag{44}$$

The energy releasing of the photon particle within the period of one second must be the average energy dissipation $< E_{DIS} >$ of the photon within one second, hence equalling equations (43) and (44), we can derive

$v = \pm c$: the photon particle in the free space can indeed propagate at a constant speed c. From an electromagnetic point of view, the speed of photons in the free space is a constant $\sqrt{\frac{1}{\varepsilon_0 \mu_0}}$ because ε_0 is the electric constant of the free space, and μ_0 is the magnetic constant of the free space. These two constants imply that there is substance inside the free space. The speed of light is determined by the intrinsic properties of the substance inside the free space. Interestingly, Maxwell derived the expressions for the dielectric constant and the magnetic permeability of the free space in terms of transverse elasticity and density of a subtle substance inside the free space, i.e. the aether (Maxwell, 1865; Rubik and Jabs, 2018). It is not well-known that Einstein called for a relativistic aether in his 1920 speech given at the University of Leiden (Rubik and Jabs, 2018), namely he proclaimed in German that "According to the General Theory of Relativity, space without aether is unthinkable."

Now it is theoretically derived that the subtle substance in the free space is an interactive thermal bath of the vast Super photon ocean spreading all over the observable Universe. The subtle substance in the vast space of a vacuum such as the interactive thermal bath of the vast Super photon ocean is worth for further research. As far as we already know, the subtle substance inside the vast Super photon ocean has an elastic modulus, a stress tensor, a shear tensor, a dielectric constant, a magnetic permeability coefficient, a gravitic constant, a cogravitic (torsionic) constant, a gravitoelectric constant, a cogravitoelectric (torsionoelectric) constant, a gravitomagnetic constant, a cogravitomagnetic (torsionomagnetic) constant (Zakharenko, 2020), a magnetic susceptibility and a characteristic electromagnetic wave impedance of 376.73 Ohms.

From an electromagnetic perspective, electromagnetic waves propagate through a medium containing the substance with an impedance must experience energy dissipation. From a mechanical perspective, for the photon particles roaming at light speed together with cosmic rays and neutrinos through the interactive thermal bath of the vast Super photon ocean there must be frictions and, as a result, energy dissipations. Therefore, there must be energy fluctuations according to the Fluctuation-dissipation theorem (Kubo, 1966; Kardar and Golestanian, 1999). While cosmic rays, neutrinos, and high-energy photons are travelling through the thermal bath of the vast Super photon ocean locally, the weak interactions will lead to a linear increase of the energy of the thermal bath of the vast Super photon ocean locally above its dynamic equilibrium of energy level transiently. Consequently, a tendency of relaxing to its original energy level builds up. While the process of relaxing to the dynamic equilibrium of energy level happens, the CMBR is emitted (Zhang, 2021b). The energy fluctuations of the thermal bath of the vast Super photon ocean caused by cosmic rays, neutrinos, and high-energy photons locally travelling through must be the origin of the spectrum of the CMBR. Hence, the origin of the CMBR must be local and nonredshifted, thus it can preserve its black-body radiation spectrum.

There is an excellent large-scale homogeneity because of the dynamic equilibrium between the immersed travelling particles and the vast thermal bath of the giant Super photon ocean across the observable Universe. A piece of supporting evidence is as follows: the Pierre Auger Collaboration discovered that the anisotropy signal of cosmic rays appears to be consistent with the sources of cosmic rays in a cosmic-ray frame coincident with the reference frame of the CMBR (Aab *et al*., 2017). The author believes that the CMBR is the manifestation of the energy fluctuations of the thermal bath of the vast Super photon ocean, the weak afterglow of the free space where cosmic rays, neutrinos, and high-energy photons are locally travelling through. The weak anisotropy of the CMBR must be linked with the anisotropy local distribution of cosmic rays, neutrinos, and high-energy photons, which must be a promising direction for further research to validate.

Now let us determine the temperature and the spectrum of the CMBR theoretically. The amplitude of the energy fluctuation $(\Delta E_V / E_V)$ of a unit volume of the free space can be estimated based on information from (Assis and Neves, 1995; Pap *et al*., 2001; Bradt, 2008; Huang *et al*., 2012; Leff, 2015; Cai *et al*., 2017; Hill *et al*., 2018; Batista *et al*., 2019), which must be approximately 0.015%. The average mass density of Super photons in the free space is known from equation (23) as $\rho_0 \approx 3.13 \times 10^{-27}$ [kg/m^3]. Employing the Stephan-Boltzmann law for the cavity black-body radiation (Bradt, 2008) and the Mass-Energy equation, it infers that

$$\frac{4\sigma}{c} T^4 \approx \frac{\Delta E_V}{E_V} \rho_0 c^2 \tag{45}$$

where σ is the Stephan-Boltzmann constant, c is the speed of light in the free space.

Substituting all these values into equation (45), the temperature of the CMBR can be determined as $T \approx 2.73$ [K] theoretically, which is a nice match to the measured value by COBE's instruments (Bradt, 2008). The theoretic modelling of the fluctuation-dissipation theorem may be traced back to the Rayleigh-Jeans law, Wien radiation formula, and Planck radiation formula for the interpretation of the blackbody radiation spectrum (Boya, 2003). The thermal bath of the vast Super photon ocean is a perfect cavity blackbody because it fulfils two conditions: (*) The bath is in a thermodynamic

equilibrium at a relatively stable temperature, (**) The external perturbation from the week interactions between the thermal bath of the vast Super photon ocean and the cosmic rays, neutrinos, and high-energy photons travelling through locally is in the linear response regime because the viscosity coefficient of the free space is extremely low. Hence, it can be asserted from the fluctuation-dissipation theorem that the spectrum of the CMBR obeys the Planck radiation formula and have an excellent match with the radiation spectrum of an ideal blackbody at the CMBR temperature of approximately 2.73 [K]. The normal photons of starlight can be treated approximately as an ideal gas, the amplitude of the energy fluctuation of the free space because of the normal photons can be theoretically calculated (Leff, 2015) as follows:

$$\frac{\Delta E_V}{E_V} \approx \frac{\delta N}{N} \approx \sqrt{\frac{1.369}{2.029 \times 10^7 T^3}} \approx 0.00557\% \tag{46}$$

According to the work by Assis and Neves (1995), the energy density of the flux of cosmic rays is comparable with the energy density of the starlight (the normal photons). So, the amplitude of the fluctuation of the free space must be doubled to 0.011% approximately by including the influence of the cosmic rays. If adding further the estimated small amount of energy fluctuation caused by high energy neutrinos (Cai *et al.*, 2017; Batista *et al.*, 2019), the total amplitude of the fluctuation of the free space must be approximately 0.015%. The fluctuation-dissipation theorem is a powerful tool in interrelating the interactions between the thermal bath of the vast Super photon ocean and the immersed travellers such as cosmic rays, neutrinos, fundamental particles, elements, molecules, planets, stars, and galaxies.

An experiment is proposed which may distinguish the Super photon theory from the theories of expanding Universe and Big-Bang cosmology. First, suppose that we have a well-shielded vacuum chamber, inner surface coated with graphite, with two well-aligned and transparent windows at two opposite sides, locating in a laboratory at a constant low temperature. If we shine different electromagnetic waves through the chamber with well-controlled vacuum environment and measure the temperature fluctuations, and associate secondary radiations inside the chamber, what can we expect to get? If we shine intense X-rays or γ-rays through it, there will be a detectable temperature fluctuation and associate secondary radiations, according to the Super photon theory because the energy dissipation must be able to reach a measurable level. If we shine intense radio waves with wavelength of tens of centimetres through it, there must have no detectable temperature change because the energy dissipation is at a negligible low level. However, according to the theories based on massless photons travelling through frictionless vacuum with no energy dissipation, like the theory of General Relativity, Expanding Universe, and Big-Bang cosmology, there will be no measurable difference no matter what kind of photons shinning though it. The author is confident that the proposed experiment will be able to demonstrate clearly the limitations of General Relativity, Expanding Universe, and Big-Bang cosmology that are based on massless photons travelling through frictionless vacuum with no energy dissipation.

Concerning many assumptions dependent on the cosmological models, such assumptions employed during the analyses of astronomical observational data create confusions. For instance, the cosmology models based on the General Relativity take into account the effect of time dilation (Melia and Maier, 2013). However, the time dilation effect is not generally applicable, no time dilation effect was observed in the light curves of quasars and in duration measures of gamma-ray bursts (Hawkins, 2010; Kocevski and Petrosian, 2013; Littlejohns and Butler, 2014). The time dilation effect of Supernova Ia light curves can be explained as clock retardation because of the local increase of viscosity, or being the signature of some special evolutionary process (Drell *et al.*, 2000), or cosmology-dependent assumptions made during the analyses of the light curves (Crawford, 2017). Big-Bang cosmological model claims that the CMBR is composed by photons that is a remnant from an early stage of the Universe, known as relic radiation dating back to the epoch of recombination (photon decoupling) with a redshift value of approximately 1100. It is a questionable hypothesis that those photons can travel in space containing a variety of matter particles for such a long time through such a long distance without being absorbed and without being scattered.

It is well-known that matter particles of a variety of size and temperature spread all over the Universe from the very distant past, up to current; they absorb and scatter photons, and re-emit photons in a spectrum of their own characters. Hence, photons must have mean and maximum free travel path lengths, also mean and maximum free travel times. The free path length and the free travel time of a certain spectrum of photons must fall in a statistic distribution around a mean value. This is the reason why the most distant astronomical object observed in the Universe such as the galaxy GN-z11 has a redshift value of just below 11.1, which is the largest confirmed observable redshift value of any astronomical object (Oesch *et al.*, 2016). There is the redshift value of no larger than 12 that was reported for any observable astronomical object. The Universe becomes opaque to observers beyond a distance with a maximum value of redshift below 12. If the photons that existed at the time of photon decoupling and afterwards have been propagating unimpeded ever since and stretched by the

space expanding as assumed in the Big-Bang model, we must be able to observe a range of redshift values much higher than 12 but less than 1100. It is a seriously flawed argument to disprove the Tired-Light models based on the wrong assumption of an infinitely large redshift value for a nonexpanding Universe. The nonexpanding Universe Tired-Light model making a superior fit on observational data of eight cosmology tests was reported by LaViolette (2021).

CONCLUSION

The Super photon is treated as a fundamental unit of mass and energy in dynamic circulation. Through the analysing of the interactions among the Super photons, normal photons, immersed concrete matter particles, and the thermal bath of the vast Super photon ocean, the Super photon theory is developed quantitatively. Gravitational waves are proposed as periodic density and pressure oscillations of the Super photon particles propagating through the vast Super photon ocean. The equation of a mass and its effective interacting radius is derived 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 their known masses, or vice visa. The calculated results are in good agreement with the estimated values based on the astronomical observations and calculations. The Universal Gravitational Constant is derived from the Super photon theory and it is interpreted as the interacting and coupling constant of an immersed matter particle with the rest of the Universe through the thermal bath of the vast Super photon ocean. The correlation between the Universal Gravitational constant and the Hubble constant is deduced theoretically.

The mysteries behind the dynamic circulation and equilibrium of energy and mass of the Universe are discussed, supporting evidences, demonstrating signs and validation methods are presented. Flavour oscillation observed in neutrinos is taken as an evidence of immersed matter particles that undergo two-way energy exchange with the thermal bath of the Super photon ocean with local fluctuations. Immersed matter particles can absorb the roaming Super photons, normal photons, neutrinos, and cosmic rays thus mass and energy from the thermal bath of the vast Super photon ocean because they locate at places with low potential energies. They convert the absorbed energy to kinetic energy and higher-grade thermal energy through internal interactions to sustain their characteristic movements and temperatures. Immersed matter particles emit mass and energy to their surrounding spaces to achieve dynamic circulation and equilibrium. Immersed matter particles with different size and mass absorb and emit photons of different ranges of frequencies, demonstrating relatively stable characteristic masses, temperatures, colours, brightness, and movements, which manifests the state of dynamic equilibrium achieved.

The generalised law of Universal Gravitation is derived while applying the Super photon theory to the two-body system interacting via gravity. Thereafter, the Virial relation within the Solar System, the Tully-Fisher law, and the Modified Newtonian Dynamics relation and acceleration within galaxies are derived theoretically. The cosmological insights into the origins of both the Modified Newtonian Dynamics and the Tully-Fisher laws, which have been sought after for over thirty years, are revealed quantitatively. The temperature and the spectrum of the CMBR are explained theoretically and determined accurately using the Super photon theory together with the fluctuation-dissipation theorem. The capability of a photon particle with an inertial mass travelling at a constant speed c inside the free space with a viscous friction force is theoretically verified. The speed of light is determined by the intrinsic properties of the substance inside the free space. An experiment is proposed, which may further distinguish the Super photon theory from the theories of Expanding Universe and Big-Bang cosmology in a simple way. Time dilation effect is not generally applicable, it may be alternatively explained as clock retardation because of the local increase of viscosity.

The Super photon theory is still in its stage of infancy. However, the author believes that the theory has a huge potential to be further developed to explain phenomena that have plagued the physical world for many years. Wider research directions and frontiers may be further developed. For instance, it is necessary to better understand the interacting and recirculating of photons, neutrinos, cosmic rays, and all sorts of immersed matter particles in the thermal bath of the vast Super photon ocean quantitatively. It may help in the understanding of the mechanisms of the production and the stability of fundamental particles and elements, predicting the relative abundance of the elements in the Universe. Further development of the Super photon theory together with the fluctuation-dissipation theorem may help to develop a unified theory of physics, which would be applicable in both the microcosm and the macrocosm.

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