Canadian Journal of Pure and Applied Sciences
Vol. 15, No. 2, pp. 5247-5252, June 2021
Online ISSN: 1920-3853; Print ISSN: 1715-9997
Available online at www.cjpas.net

THE DYNAMIC CIRCULATION OF MIXED TWO-FLUID PHOTONS

Wenzhong David Zhang
Hembury Avenue, Manchester, UK

ABSTRACT

There is a vast thermal bath of photons in the Universe. A new description is proposed as mixed two-fluid photons. A theoretical illustration is provided for photon particles from the analysing of the spectrum of the Cosmic Background Microwave Radiation and the estimation of the Lambda-point transition temperature of super-fluidity by the application of the London formula obtained in 1938. For photons with wavelength long enough and with number density high enough, for instance, Super photons, it is feasible that they can be in the quantum liquid state of super-fluidity, although the interactions between them are weak, and the temperatures of their environments are not low. The detection of the unexpectedly deep absorption profile of radio background spectrum and that local areas in free space can be warmed up or cooled down to a temperature distribution by artificially controlled or temporarily appeared intense flux of high energy photons are listed as supportive evidences of Super photon theory and mixed two-fluid photons.The general form of the Einstein-Smoluchowski-Sutherland relation is derived for a specified volume of space. A mathematic frame for the dynamic circulation of mixed two-fluid photons with fluctuation is developed quantitatively. A significant rediscovering is that a photon particle in the time and spatial domain is the superposition of a conjugate pair of single frequency photon waves in the frequency domain. The similarity between mixed two-fluid photons and two-fluid liquid helium at super-fluidity is compared briefly, which comprise yet more evidence to support the theory of the dynamic circulation of mixed two-fluid photons.

Keywords: Mixed two-fluid photons, Super photon, Bose-Einstein condensation, dynamic circulation of photons, Super-fluidity, conjugate pair of photons.

INTRODUCTION

Our understanding of our Universe and our knowledge about it are a consequence of our observations during the last millennia of the quanta of electromagnetic wave radiation (photons). The photons can be actually observed in a wide range of wavelengths. According to the scientific background on the Nobel prize in physics, Nobel Committee for physics, 2017, these studies have provided us in abundance with many knowledge. These knowledge are about not only planets, stars, and galaxies but also the origins of structure, the evolution and possibly the fate of our Universe. The Planck constant introduced for the grasp of the photons' properties has become the pillar of modern quantum physics (Oldershaw, 2013; Planck, 1900; Planck, 1901). It is possible to state that small progressive steps in the direction of grasping of the photon nature always lead to significant scientific and technological progresses. In this article, a profound alternative in the understanding of photons and the foundation theory of physics has been developed.

The Bose-Einstein condensation of photon particles

It has been theoretically verified that moving particles in a vacuum experience a force resembling friction through interacting with electromagnetic fields in a vacuum (Sonnleitner *et al*., 2017; Manjavacas and García De Abajo, 2010; Kardar and Golestanian, 1999). Furthermore, this frictional force can cause a change in momentum due to a dissipation in energy and mass while the velocity remains constant. Recently, from a mechanical perspective, based on a lightly damped oscillator model for the propagation of photon particles in the free space, an equation was theoretically derived displaying the exponential relationship between cosmic redshift z and the Hubble constant H (Zhang, 2021), which was in good agreement with a wide range of astronomical observations (Marosi, 2019; LaViolette, 1986).

The energy dissipated by a photon during one cycle is elicited as the product of the Planck constant and the Hubble constant. The tiny fragment of the energy dissipated per photon in each cycle is defined as a Super photon. The Super photon is a fundamental unit of energy and mass in dynamic circulation. In fact, interacting, friction, and energy dissipation are ubiquitous for particles including photon particles travelling through the free space of a vacuum (Zhang, 2021; Sonnleitner *et al*.,

Corresponding author e-mail: WenzhongZhang2008@gmail.com

2017; Manjavacas and García De Abajo, 2010; Kardar and Golestanian, 1999). Even from an electromagnetic perspective, photons are propagating bundles of alternating electromagnetic waves and the vast free space of a vacuum is a weak electromagnetic field with fluctuations. As a result, there should be weak interactions between them. The vast number of photons in the free space interacts with each other and they are in a state of massive quantum occupation number. Hence, it would surely lead to the Bose-Einstein condensation. A percentage of photons will sink into the ground state of the quantum liquid of super-fluidity. The author proposes a new description as mixed two-fluid photons through inspirations from the theory of two-fluid liquid helium at super-fluidity. A theoretic illustration is provided as follows.

According to the London formula (Poluektov, 2017; Beau, 2009; London, 1938) for the λ-point transition temperature of super-fluidity (T_λ), it is possible to write down that

$$T = T_\lambda \approx \left(\frac{n}{\zeta(3/2)}\right)^{2/3} \frac{h^2}{2\pi k_B M} \tag{1}$$

where h is the Planck constant, k_B is the Boltzmann constant, the parameter M for the inertial mass of photon particles in the time and spatial domain will be evaluated below, and $\zeta(3/2) \approx 2.612$, $\pi \approx 3.1416$. For the photon particles, $n = 2.029 \times 10^7 T^3$ (Bradt, 2008), $T = T_\lambda$ is the λ-point transition temperature of super-fluidity, it shall be no higher than the Cosmic Background Microwave Radiation (CMBR) temperature, because at the CMBR temperature, an ideal black-body radiation spectrum of normal photons at excited states can be detected (Assis and Neves, 1995), see also Lumen Learning 2017, https://courses.lumenlearning.com/astronomy/chapter/the-cosmic-microwave-background/. As an initial estimation, the λ-point transition temperature of super-fluidity T_λ might be approximately 2.7 K.

Substituting the above values into equation (1), the equivalent inertial mass of the photon particle at the λ-point transition temperature can be derived as $M \sim 5.36 \times 10^{-40}$ kg. Consequently, the wavelength of the single frequency photon (half of the equivalent mass of the photon particle in time and spatial domain, which will be explained in the following section) can be calculated as approximately 0.825 cm or its frequency as approximately 36.3 GHz. This wavelength of 0.825 cm is longer than the longest wavelength that can be seen from the CMBR spectrum and this frequency of 36.3 GHz is lower than the lowest frequency that can be seen from the CMBR spectrum (Bradt, 2008). At the wavelengths of approximately no longer than 0.825 cm, or at the frequencies of approximately no lower than 36.3 GHz, the photons have energies high enough to be in excited states, which can be detected either in the CMBR spectrum or other spectrums of photons (Bradt, 2008; Assis and Neves, 1995; Hill *et al*., 2018). However, above a certain wavelength that shall be approximately no shorter than 0.825 cm, or below a certain frequency that shall be approximately no higher than 36.3 GHz, it could be envisaged that a percentage of the photons will have wavelengths long enough to be in the ground state of the quantum liquid of super-fluidity because of the Bose-Einstein condensation. However, especially for photons with wavelengths long enough and with number density high enough, for instance, Super photons, it is feasible that they could be in the ground state of the quantum liquid state of super-fluidity, although the interactions between them are weak, and the temperatures of their environments are not low. Furthermore, it is well-known that relatively regular distribution of other particles could enhance the Bose-Einstein condensation of photons that have long enough wavelengths (Basov *et al*., 2021). An evidence to support the possibility of the Bose-Einstein condensation of photons in a vacuum was reported recently (Langford, 2021), while the theoretical prediction of the existence of the Bose-Einstein condensation of photons in a vacuum has been made available to public online as pre-printsin June 2020. It is reasonable to speculate that the state of super-fluidity of photons with extremely long wavelengths existed in the vast space. Our knowledge about waves with extremely long wavelengths is particularly limited. Hence, there shall be two-fluid photons in the vast thermal bath of space: one fluid is the propagation of normal photons in excited states; there is another fluid of photons in the ground state of the quantum liquid of super-fluidity because of the Bose-Einstein condensation, which is still not fully comprehended by us yet.

It may be predicted that there shall be a narrow energy band gap between the ground state of the quantum liquid of super-fluidity of photons and the nearby-excited states of energy levels of normal photons. Therefore, there shall be a strong absorbing profile of photons with energies equal to or slightly larger than the energy band gap between these two states of photons. It is quite reasonable to believe that the supporting evidence has been detected in 2018 by the finding of the unexpectedly deep absorption profile of the radio background spectrum centred at a frequency of 78 MHz and has a best-fitting full-width at half-maximum of 19 MHz (Bowman *et al*., 2018). When high energy photons, cosmic rays, and neutrinos travelling through the vast thermal bath of mixed two-fluid photons, the weak interactions between them will lead to an increase of the energy of the thermal bath of photons linearly above its dynamic equilibrium of energy level transiently, a tendency of relaxation to its original energy level builds up. While the process of relaxation to the dynamic equilibrium of energy happens, the CMBR is emitted. The energy fluctuations of the thermal bath of mixed two-fluid photons caused by high energy photons, cosmic rays, and high energy neutrinos travelling through shall be the origin of the spectrum of the CMBR. Hence, the CMBR shall be local and non red-shifted. Consequently, 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 mixed two-fluid photons across the 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 weak anisotropy of the CMBR is linked with the local anisotropic distribution of high energy photons, cosmic rays, and high energy neutrinos, which shall be a promising direction for further research to validate.The spectrum and temperature of CMBR can be predicted accurately from the combination of the Super photon theory and the fluctuation-dissipation theorem, which will be reported in the future.

It could be predicted that the photons with wavelengths longer than a few centimetres (e.g. radio waves) will have distinctly different effects on space, in comparison with the photons that have much shorter wavelengths (e.g. *X*-rays or γ-rays). Suppose that we shine lights with different wavelengths from a satellite through a local area of space, then measure the temperature fluctuation and associate secondary radiation, what can we expect? If we shine extra intense *X*-rays or γ-rays for a period of time, there shall be a detectable temperature increase and associate secondary radiation because the total energy dissipations of the high energy photons are large enough to excite some photons from the thermal bath of mixed two-fluid photons, according to the Super photon theory (Zhang, 2021). If we stop the shining, the temperature will cool back to the general CMBR temperature due to the strong tendency to relax to the equilibrium state of the thermal bath of mixed two-fluid photons. We already have the technology to map local CMBR spectrum and temperature, we should be able to detect the difference caused by the shining of extra intense *X*-rays or γ-rays within a local area of space. Otherwise, if we shine intense radio waves with wavelengths of tens of centimetres long through a local area of space, there shall be no detectable temperature change because the energy dissipation is at a negligible low level, according to the Super photon theory (Zhang, 2021). It is not difficult to envisage that a local area of free space can be warmed up or cooled down a tiny bit by artificially controlled or temporarily appeared flux of intense *X*-rays or γ-rays. However, according to the theories based on photons travelling through frictionless space with no energy dissipation, like the Expanding Universe hypothesis and the Big Bang cosmology, there will be no measurable difference no matter what kind of lights shining through the space. The author is confident that this proposed experiment will prove that the energy dissipation of intense flux of high energy photons in space is detectable, and it will demonstrate clearly the limitations of the Expanding Universe hypothesis and the Big Bang cosmology.

The dynamic circulation of mixed two-fluid of photons

There shall be a potential energy $U(r)$ for a photon particle propagating along the transmitting path (r) of the photon particle. Consequently, a driving force $F(r) = -\nabla U(r)$is generated due to the potential energy gradient, and it shall be able to cancel out the weak friction force between the two-fluid photons to enable the propagation of the photon particle. Therefore, if there is a flow of photon particles, then $\nabla U(r) \neq 0$. Consider a specified unit volume of space filled with photon particles and defined by the way that the photon particles have a local concentration $\rho(r)$. For the specified unit volume of space at a state of dynamic equilibrium with a relatively stable temperature, the net flow of energy should be equal to zero on average, although there will be fluctuations. The tendency of photon particles to get pulled towards places of lower potential energy will cause a drift current J_{drift}. The flux of photon particles due to the drift current shall be as follows:

$$J_{Drift} = -\rho\mu\nabla U \tag{2}$$

where $\rho(r)$ is the photon particle concentration, $\mu(r)$ is the mobility of the photon particles.

The potential gradient is $-\nabla U(r)$, the minus sign means that photon particles flow from higher to lower potential. To balance this tendency of the drift movement, the tendency of spreading out to achieve an even distribution due to diffusion leads to a diffusion current J_{diff}. The flow of photon particles due to the diffusion current is, by Fick's law, as follows:

$$J_{Diff} = -D\nabla\rho \tag{3}$$

where D is diffusion coefficient, the minus sign means that photon particles flow from higher to lower concentration. For photon particles, the area with higher concentrations is the area with lower potential energy, hence the two-way traffic is balanced to achieve a state of dynamic equilibrium. Now let us analyse in detail the dynamic equilibrium condition for a specified volume of space. First, on average, there will be no net flow, hence, $J_{drift} + J_{diff} = 0$. Second, if two locations have the same potential energy, they will have the same concentration (ρ). This means that the chain rule can be applied and we can get

$$\nabla\rho = \frac{d\rho}{dU}\nabla U \tag{4}$$

Therefore, at an equilibrium we have

$$-\rho\mu\nabla U - D\nabla\rho = -\left(\rho\mu + D\frac{d\rho}{dU}\right)\nabla U = J_{Drift} + J_{Diff} = 0 \tag{5}$$

As this expression holds at every position in space with a relatively stable temperature, and $\nabla U(r) \neq 0$ as discussed previously, therefore the general form of the Einstein-Smoluchowski-Sutherland relation (Kubo, 1966; Einstein, 1905; March and Tosi, 2002) can be derived as

$$\rho\mu + D\frac{d\rho}{dU} = 0 \tag{6}$$

$$D = -\mu\frac{\rho}{d\rho/dU} \tag{7}$$

For photon particles in the time and spatial domain, the relation between $\rho(r)$ and $U(r)$ can be modelled with the Maxwell-Boltzmann statistics, i.e.

$$\rho = Be^{-U/k_B T} \tag{8}$$

where B is a constant related to the total number of photon particles, k_B is the Boltzmann constant. Hence,

$$\frac{d\rho}{dU} = -\frac{\rho}{k_B T} \tag{9}$$

Substitute this equation into equation (7) that gives

$$D = \mu k_B T \tag{10}$$

which corresponds to the classical Einstein-Smoluchowski-Sutherland relation (March and Tosi, 2002). For the propagation of photon particles at the light speed c, distance $r = ct \geq 0$ (t is time) and $U(r) = -2pc = -2E(r)$, where p is the momentum of the single frequency photon, because the chemical potential of photon particles equals to zero (Mandl, 1991) and photon particles have two degrees of freedom. So, apply them together with $E \approx E_0\exp(-Ht)$ (Zhang, 2021; Marosi, 2019; LaViolette, 1986) that yields

$$U = -2E = -2E_0\, e^{-\frac{Hr}{c}} \tag{11}$$

where H is the Hubble constant, $H \approx R_m/2m$, R_m is the viscous resistance coefficient of space, m is the equivalent mass of a single frequency photon wave (Zhang, 2021).

Applying the fluctuation-dissipation theorem to photon particles in space (Kubo, 1966; Einstein, 1905; March and Tosi, 2002) leads to

$$\mu = \frac{1}{R_m} \approx \frac{1}{2Hm} \tag{12}$$

$$v = -\frac{dU/dr}{R_m} = \frac{2HE}{cR_m} \approx c \tag{13}$$

$$D = \frac{k_B\, T}{R_m} = \frac{k_B T}{MH} \tag{14}$$

where M is the inertial mass of the photon particle in the time and spatial domain.

From equation (11), it can be derived that the driving force due to the potential gradient is

$$F = -\nabla U = \frac{2HE}{c} = R_m c \tag{15}$$

Equation (15) in comparison with the viscous friction force of space $F_{vis} = -R_m c$ (Zhang, 2021) shows that the driving force because of the potential gradient is just able to cancel out the friction force between the two-fluid photons to enable the photons to propagate at a constant speed, which is in conformity with Newton's third law.

A step further, considering equation (14) together with $H \approx R_m/2m$ (Zhang, 2021), we have

$$M = 2m \tag{16}$$

This is a significant finding that the inertial mass M of the photon particle in the time and spatial domain is twice the equivalent mass m of the corresponded single frequency photon in the frequency domain. For a harmonic oscillator, the equation of the movement of the point particle with an inertial mass M in the time and spatial domain is a second order linear differential equation. Therefore, there are two linearly independent solutions in the frequency domain (Garret, 2017), the entire time history of the point mass M particle-spring system's response in the time and spatial domain can be described by using the super position of the two linearly independent solutions in the frequency domain. This implies that a photon particle in the time and spatial domain is the super position of a conjugate pair of the single frequency photons in the frequency domain. It is an obvious and significant rediscovering.

A simple calculation can derive the number density of normal photons at excited states versus temperature (Bradt, 2008) as follows:

$$\rho_n(T) \approx 2.029 \times 10^7 T^3 \tag{17}$$

There is higher number density of normal photons in the local area of space with higher temperature because this local area of space has lower potential energy. The dynamic circulation of photons may be illustrated clearly as follows: the photon particles of conjugated pairs of low frequency photons at the quantum liquid state of super-fluidity are drawn towards the hotspot space with higher temperature because it is the place with lower potential energy, according to the Maxwell-Boltzmann statistics. Consequently, low energy photon particles are drawn into this area with low potential energy and a high number density of photon particles accumulated, then the internal interacting can happen through all sorts of mechanisms, for instance, collisions, frictions, nucleosynthesis, etc., because of the high density, high temperature, and high pressure. The frequencies of some of the photons are raised up, the normal photons' density becomes high, and they have high enough energies to escape from the potential well. Consequently, the emitting of normal photons because of diffusion spreads out photons at excited states with high energy through ballistic propagation. Eventually a dynamic circulation and equilibrium is achieved, the net number for the flow of photons on average is equal to zero for a specified volume of space, although there are small photon-number fluctuations.

Interestingly, there is another similarity between mixed two-fluid photons and two-fluid liquid helium at super-fluidity: the astrophysical jets and the liquid helium fountain jets, which comprise yet more evidence to support the theory of the dynamic circulation of mixed two-fluid photons. If normal photons in excited states are viewed as an ideal gas under an ideal approximation, the amplitude of the energy and photon number fluctuation for a unit volume can be theoretically calculated (Leff, 2015) approximately as follows:

$$\frac{\Delta E_V}{E_V} \approx \frac{\delta N}{N} \approx \sqrt{\frac{1.369}{2.029 \times 10^7 T^3}} \tag{18}$$

Actually, there shall be three phases of photons existed. Phase 1 is for the normal photons that we are familiar with in excited states from radio waves to the γ-rays, which may be named the vapour phase of photons. Phase 2 is for the photons in quantum liquid state of super-fluidity discussed in this article, which may be named the liquid phase of photons. Phase 3 is for all the immersed travellers in space as cosmic rays (excluding photons), fundamental particles, elements, molecules, planets, stars, and galaxies that are blocks of mass (energy) in the time and spatial domain, which can be Fourier transformed to a sum (or integral) of sinusoidal components of waves in the frequency domain. Hence, they may be named the concrete phase of photons.

CONCLUSION

A profound alternative in the understanding of photons, the foundation theory of physics, and astronomical observations has been developed quantitatively. Photons interacting with each other to form a vast thermal bath and a new description of this process are proposed as mixed two-fluid photons. A theoretic illustration is provided from the analysing of the spectrum of the CMBR together with the estimation of the λ-point transition temperature of super-fluidity through the pioneered application of the London formula (London, 1938) for the photon particles. For photons with wavelength long enough and with number density high enough, for instance, Super photons, it is feasible that they can be in the quantum liquid state of super-fluidity because of the Bose-Einstein condensation, although the interactions between them are weak and the temperatures of their environments are not low. Relatively regular distribution of other particles can enhance the Bose-Einstein condensation of photons that have long enough wavelengths. The detection of the unexpectedly deep absorption profile of the radio background spectrum and that local areas in free space can be warmed up or cooled down to a temperature distribution by artificially controlled or temporarily appeared flux of intense X-rays or γ-rays are listed as supportive evidences of the proposed mixed two-fluid photons.The general form of the Einstein-Smoluchowski-Sutherland relation is derived for a specified volume of space for photons. Mathematical frames for the dynamic circulation and equilibrium of mixed two-fluid photons in the Universe are developed quantitatively. Amazingly, for the propagation of photons, the driving force because of the potential gradient is just able to cancel out the friction force between the flow of mixed two-fluid photons to enable the propagating of photons at some constant speed, which is in conformity with Newton's third law. A significant rediscovering is that a photon particle in the time and spatial domain is the wave superposition of a conjugate pair of photons in the frequency domain. The similarity between mixed two-fluid photons and two-fluid liquid helium at super-fluidity is compared briefly, which comprises yet more evidence to support the dynamic circulation of mixed two-fluid photons. Three phases of photons are proposed as the vapour, liquid, and concrete phases.

Further investigations are needed for the better understanding of the interactions of photons, neutrinos, cosmic rays, and all sorts of concrete particles immersed in the vast thermal bath of photons quantitatively at local areas of space with different temperature and pressure. These investigations will also help to advance our understanding of the mechanisms of nucleosynthesis, the stability of fundamental particles and elements, and in the predicting of the relative abundance of elements in the Universe. The Super photon theory is still in its stage of infancy. However, the author believes that the Super photon theory in combination with the fluctuation-dissipation theorem has a huge potential to be further developed to explain physical phenomena that have plagued the physical world for many years.

ACKNOWLEDGEMENT

The author gratefully acknowledges the encouragements and supports from my family, friends, and colleagues-researchersto these theoretical investigations.

REFERENCES

Aab, A., Abreu, P., Aglietta, M., Al Samarai, I., Albuquerque, IFM., Allekotte, I., Almela, A., Alvarez Castillo, J., Alvarez-Muñiz, J., Anastasi, GA., Anchordoqui, L., Andrada B. *et al*. 2017. Observation of a large-scale anisotropy in the arrival directions of cosmic rays above 8×10^{18} eV. Science. 357(6357):1266-1270. DOI: https://doi.org/10.1126/science.aan4338.

Assis, AKT. and Neves, MCD. 1995. History of the 2.7 K temperature prior to Penzias and Wilson. Apeiron. 2:79-84.

Basov, DN., Asenjo-Garcia, A., Schuck, PJ., Zhu, X. and Rubio, A. 2021. Polariton panorama. Nanophotonics (De Gruyter). 10(1):549-577. DOI: https://doi.org/10.1515/nanoph-2020-0449.

Beau, M. 2009. Scaling approach to existence of long cycles in Casimir boxes. Journal of Physics A: Mathematical and Theoretical. 42(23):235204 (24 pages). DOI: https://doi.org/10.1088/1751-8113/42/23/235204.

Bowman, JD., Rogers, AEE., Monsalve, RA., Mozdzen, TJ. and Mahesh, N. 2018. An absorption profile centred at 78 Megahertz in the sky-averaged spectrum. Nature. 555:67-70. DOI: https://doi.org/10.1038/nature25792.

Bradt, H. 2008. Astrophysics Processes: The Physics of Astronomical Phenomena. (1stedi.). Cambridge University Press, Cambridge, UK. pp. 534.

Einstein, A. 1905. On the motion of small particles suspended in liquids at rest required by the molecular-kinetic theory of heat. Annalen der Physik. 17:549-560.

Garret, SL. 2017. Understanding Acoustics. An Experimentalist's View of Acoustics and Vibration. Graduate Texts in Physics book series. Springer International Publishing AG. pp. 492. DOI: https://doi.org/10.1007/978-3-319-49978-9.

Hill, R., Masui, KW. and Scott, D. 2018. The spectrum of the Universe. Applied Spectroscopy. 72(5):663-688.

Kardar, M. and Golestanian, R. 1999. The "friction" of vacuum, and other fluctuation-induced forces. Reviews of Modern Physics. 71(4):1233-1247.

Kubo, R. 1966. The fluctuation-dissipation theorem. Reports on Progress in Physics. 29(1):255-284.

Langford, SA. 2021. A portion of vacuum-structure mass, energy and weight. Canadian Journal of Pure and Applied Sciences. 15(1):5169-5178.

La Violette, PA. 1986. Is the Universe really expanding? The Astrophysical Journal. 301(2):544-553.

Leff, HS. 2015. Fluctuations in particle number for a photon gas. American Journal of Physics. 83(4):362-365. DOI: https://doi.org/10.1119/1.4904322.

London, F. 1938. The λ-phenomenon of liquid helium and the Bose-Einstein degeneracy. Nature. 141:643-644. DOI: https://doi.org/10.1038/141643a0.

Mandl, F. 1991. Statistical Physics. (2ndedi.). John Wiley and Sons, Inc., New York, USA. pp. 402.

Manjavacas, A. and García De Abajo, FJ. 2010. Thermal and vacuum friction acting on rotating particles. Physical Review A. 82(6):063827.

March, NH. and Tosi, MP. 2002. Introduction to Liquid State Physics. (1st edi.). World Scientific Publishing Company. pp. 450.

Marosi, LA. 2019. 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):1-11. DOI: https://doi.org/10.4236/ijaa.2019.91001.

Oldershaw, RL. 2013. The hidden meaning of Planck's constant. Universal Journal of Physics and Application. 1(2):88-92.

Planck, M. 1900. On an improvement of Wien's equation for the spectrum. Annalen der Physik. 1:719-721.

Planck, M. 1901. On the law of the energy distribution in the normal spectrum. Annalen der Physik. 4:553-570.

Poluektov, YM. 2017. A simple model of Bose–Einstein condensation of interacting particles. Journal of Low Temperature Physics. 186:347-362. DOI: https://doi.org/10.1007/s10909-016-1715-5.

Sonnleitner, M., Trautmann, N. and Barnett, SM. 2017. Will a decaying atom feel a friction force. Physical Review Letters. 118(5):053601.

Zhang, WD. 2021. The foundation of an emerged Super photon theory. Canadian Journal of Pure and Applied Sciences. 15(2):In Press.

Received: March20, 2021; Revised: March 26, 2021;
Accepted: May 3, 2021