Light dispersion in space

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ABSTRACT

Considering an idea of F. Arago in 1853 regarding light dispersion through the light ether in the interstellar space, this paper presents a new idea on an alternative interpretation of the cosmological red shift of the galaxies in the universe. The model is based on an analogy with the temporal material dispersion that occurs with light in the optical fiber core. Since intergalactic space is transparent, according to the model, this phenomenon is related to the gravitational potential existing in the whole space. Thus, it is possible to find a new interpretation to Hubble's constant. In space, light undergoes a dispersion process in its path, which is interpreted by a red shift equation of the type $\Delta z = HL$, since $H = (d^2n/d\lambda^2\ \Delta v\ \Delta\lambda)$, where H means the Hubble constant, n is the refractive index of the intergalactic space, $\Delta\lambda$ is the spectral width of the extragalactic source, and Δv is the variation of the speed of light caused by the gravitational potential. We observe that this "constant" is governed by three new parameters. Light traveling the intergalactic space undergoes red shift due to this mechanism, while light amplitude decreases with time, and the wavelength always increases, thus producing the same type of behavior given by Hubble's Law. It can be demonstrated that the dark matter phenomenon is produced by the apparent speed of light of the stars on the periphery of the galaxies, without the existence of dark energy. Based on this new idea, the model of the universe is static, lacking expansion. Other phenomena may be interpreted based on this new model of the universe. We have what we call temporal gravitational dispersion of light in space produced by the variations of the speed of light, due to the presence of the gravitational potential in the whole space.

1. INTRODUCTION

It should be initially mentioned that there is a major analogy between the gravitational potential of Mechanics and the refractive index of Optics, as mentioned by E. Fermi [1]. We can state that, in the metrics, there is a fantastic analogy between gravitation and refraction, as illustrated in Figures 1(a) and 1(b). Taking only the metrics into consideration, we can introduce new paradigms in a field of Physics where there are major controversies, since this paper tries to introduce a new idea not taken into consideration until the present moment. It all can be started with the old issue of light dispersion in the intergalactic space.

The issue of light dispersion in the interstellar space is not new. It was postulated initially by Newton [2] in a letter to Flamsteed in 1691, where they discussed the issue of light rays with different wavelengths that propagated with exactly the same speed in the interstellar space. Based on this, light dispersion in this environment would or would not exist. However, F. Arago [3] was the first one to place this issue in a scientific manner in the interstellar space, arguing that the light rays with different colors should travel at the same speed whether in outer space or not. Arago showed that variable stars could present a difference in speed between violet and blue. In 1881, through interstellar space measurements and using Fizeau's method, Young found differences in speed between red and blue rays of light, finding a 1% excess speed between the blue and red light [4]. This result was immediately contested by Reyleigh [5]. There was a sudden interest in this field in 1908-1909, when Nordmann [6, 7], and Tikhoff [8] detected light dispersion in space when studying the light coming from Cepheidas Stars. These results were completely rejected by Lebedew [9, 10] and this type of study completely disappeared from the literature. Recently, Narlikar et. al. [11], Amoroso et. al. [12] and Vigier [13] have been involved with similar works but in a different way.

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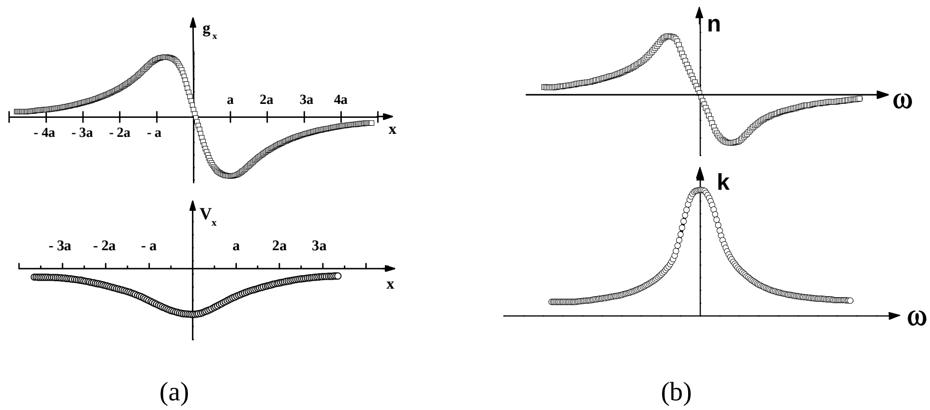

Figure 1. Analogy between Optics and Mechanics. (a) Gravitational field and gravitational potential between two bodies with mass m and (b) refractive index in a dielectric field.

In optics, light dispersion means the variation of the refractive index in relation to the wavelength, that is, $dn/d\lambda$. However, in the field of modern communication by optical fiber, dispersion means the second derivative of the refractive index in relation to the wavelength, that is, $d^2n/d\lambda^2$, which in modern literature is called temporal material dispersion, a phenomenon that occurs in the optical fiber core due to the different light speeds with different wavelengths in this dielectric environment [14, 15]. Physically this implies that the phase velocity of a plane wave traveling in the dielectric varies nonlinearly with the wavelength and consequently, a light pulse will broaden as it travel trough it.

As is known, in the optical fiber core, two rays of light travel at different speeds so that there is a time delay between them given by:

$$\Delta t = \frac{\lambda}{c}\frac{d^2 n}{d\lambda^2}\Delta\lambda L \quad (1)$$

where c = speed of light, λ = wavelength, $\Delta\lambda$ = spectral width, $d^2n/d\lambda^2$ = second derivative of the refractive index due to the wavelength, and L is the distance traveled by light. It is noticed that the delay is directly proportional to the distance traveled by light. When traveling through the fiber core, the light pulse widens within time, while its amplitude decreases within the same period of time. Figures 2 show this phenomenon in a simple and well-known manner. In Equation (1), if both terms are multiplied by a speed variation Δv, nothing changes, but:

$$\Delta t\ \Delta v = \frac{\lambda}{c}\left(\frac{d^2 n}{d\lambda^2}\Delta v\ \Delta\lambda\right)L \quad (2)$$

Naming the term:

$$H = \left(\frac{d^2 n}{d\lambda^2}\Delta v\ \Delta\lambda\right) \quad (3)$$

and the term:

$$\Delta\lambda = \Delta t\ \Delta v \quad (4)$$

we have the exact Hubble Law [13], that is:

$$\Delta\lambda = \frac{\lambda}{c} HL \tag{5}$$

or

$$\frac{\Delta\lambda}{\lambda} c = z = HL \tag{6}$$

It should be highlighted now that the H constant depends on three parameters: Δv is the variation of the speed of light, $d^2n/d\lambda^2$ is the dispersion power of the environment, and Δλ is the spectral width of the source, therefore not being a constant.

In 1911, Einstein [17] showed that a ray of light that travels close to a celestial body undergoes deflection on the side where the gravitational potential decreases, that is, on the side facing the celestial body, whose value is:

$$\alpha = \frac{2GM}{c^2 r} \tag{7}$$

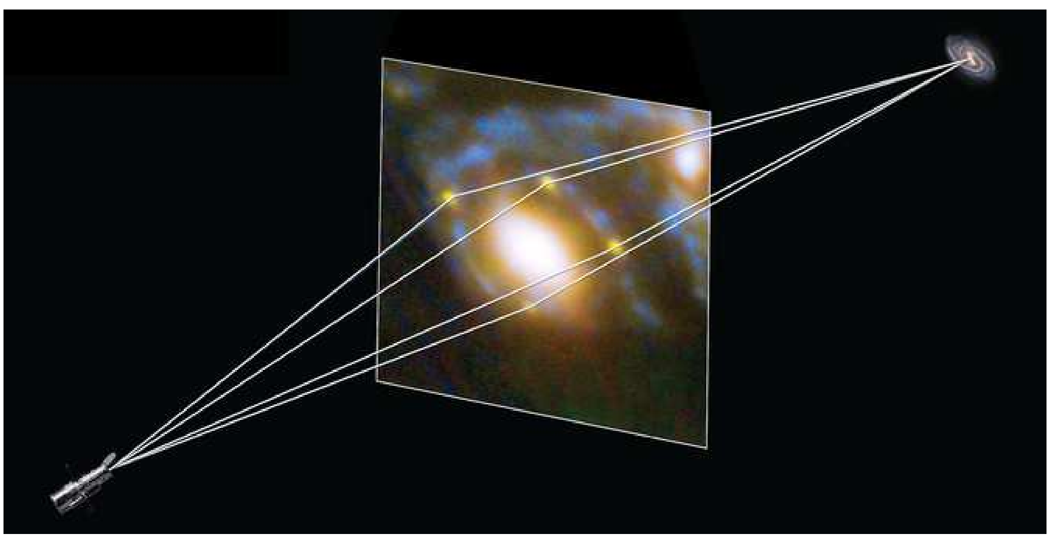

Figure 2. Hubble telescope observe the supernova by gravitational lens effect/NASA/ESA/GLASS/FrontierSNteam.

where G is the gravitational constant, M is the mass of the celestial body and r is the distance of the ray of light to the center of the celestial body. It also showed that the speed of this ray of light varies according to the expression below:

$$c = c_o\left(1 + \frac{\phi}{c^2}\right) \tag{8}$$

where ϕ is the gravitational potential, and c_o is the speed of light in vacuum. We might immediately infer that it is possible to have two rays of light very close to each other at different speeds, therefore the temporal material dispersion phenomenon might occur. Since space is transparent and free from matter, we will temporarily name this phenomenon as temporal gravitational dispersion of light in space. Considering the metrics, due to the analogy between Optics and Mechanics, the term $d^2n/d\lambda^2$ is better defined as d^2n/dr^2. Thus, expression (3) is better defined as:

$$H = \left(\frac{d^2 n}{dr^2} \Delta v \Delta \lambda \right) \tag{9}$$

which, for the present paper, corresponds to the red shift of light in intergalactic space. We observe that this “constant" is governed by three new parameters. Light traveling the intergalactic space undergoes red shift due to this mechanism, while light amplitude decreases within time, and the wavelength always increases, thus producing the same type of behavior given by the Hubble Law. We therefore state that the dark energy issue is non-existent and only have the broaden phenomena of light in the intergalactic space and so the curve behavior produced by this dispersion is analogous to the current Hubble curve [18].

Shapiro et. al. [19] in 1971 was measurement by radar observations yield a more stringent test of increase in echo times of radio signals sent from Earth and reflected from Mercury and Venus as show in Figure 3.

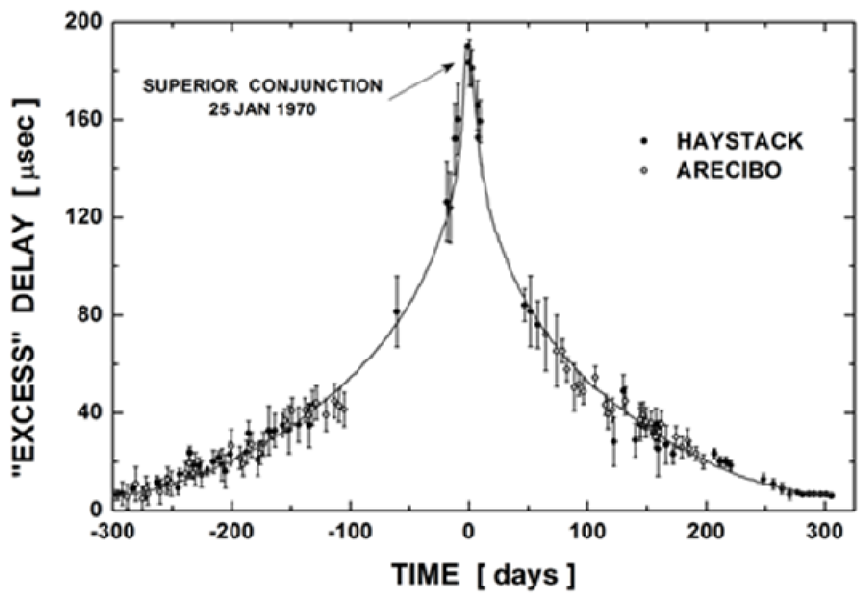

Figure 3. Typical sample of post-fit residuals for Earth-Venus time-delay measurements, displayed relative to the "excess" delays. Corrections were made for known topographic trends on Venus. The points represent the original estimates of the measurement [19].

We can see that always we have two rays with differences velocity, due the excess delay time due the gravitational dispersion near the surface of sun.

This model also can be explains the work of A. Arp [20, 21], where there might exist galaxies with different red shifts, but located practically at the same distance in relation to the observer.

In addition, we might explain the phenomenon of the existence or otherwise of dark energy, which occurs in the arms of the galaxies. Since the stars in the arms of the galaxies are hotter than those at the core, it might be stated that their spectral widths are greater because they are hotter, in addition to being located on the periphery of the galaxy, where terms d^2n/dr^2 and Δv are considered.

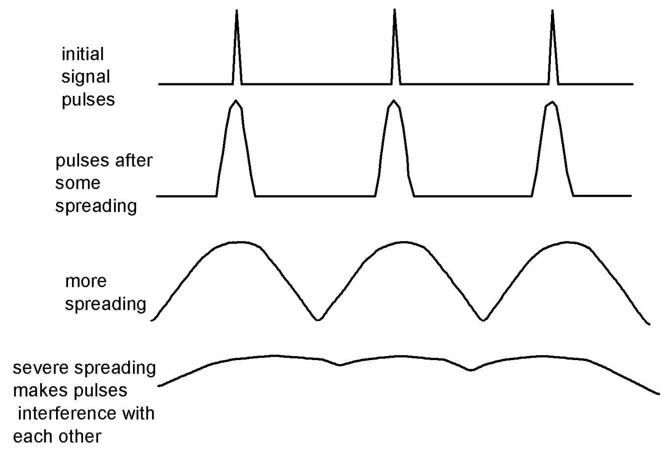

Figure 4. Analogy between the temporal dispersion in optical fiber and the gravitational dispersion of light in the extragalactic space. Mechanism of the temporal material dispersion of a train of pulses as they travel along of optical fiber. The longer the distance, the more the pulses stretch, until they overlap.

Based on the aforementioned, it might be stated that the light pulses, or considering the photon as a light pulse, are thrown into space with a greater length than those of the stars in the core of the galaxy. The phenomenon of apparent speed is therefore present. By using the formula of Doppler Effect we can note that the stars that approach the observer, due to the Doppler Effect, will present the phenomenon in which the speed of the star is constant, as well as the speed of those that are driven away, because now both λ and λ_o increase in the arms of the galaxies, that is, they present constant speed rather than the drop predicted by Kepler's Law.

On the other hand, the microwave background radiation issue is solved. This radiation comes from the light of galaxies located at infinite distances from the Earth when, due to the dispersion phenomenon that light undergoes, makes all pulses overlap and behave as thermalized pulses as show Figure 4.

2. CONCLUSION

This paper tries to present a new idea of the ancient controversy related to the red shift phenomenon which occurs in galaxies in the universe. This phenomenon is not produced by the Doppler Effect, but by an analogous phenomenon to the temporal material dispersion of light in its path through the intergalactic space. Therefore, issues such as dark energy and dark matter cease to exist. Based on this model, the universe is stationary with the galaxies, which have their own movements, without the need to introduce cosmological constants and other phenomena found in the standard models of the universe. The microwave background radiation phenomenon is, therefore, light coming from the galaxies located at infinite distances from the Earth, where their pulses overlap and transform into thermalized pulses as background radiation.

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