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A Short Discussion on the Gravitational Redshift in the Light of an Alleged Local Variability of the Planck Constant

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Abstract

The aim of this paper fundamentally lies in proposing an alternative explanation to the so-called gravitational redshift. The above-mentioned phenomenon, experimentally verified more than half a century ago, is commonly legitimised by means of Special Relativity. In our case, since time is considered as being absolute, we simply postulate a local variability of the Plank constant. Ultimately, we carry out an alternative deduction of the relation that expresses the gravitational redshift as a function of a parameter that, in our case, does not coincide with a Schwarzschild coordinate.

Keywords

Gravitational Redshift, Variable Planck Constant, Absoluteness of Time

1. Introduction

We hypothesize a closed Universe, homogeneous and isotropic, belonging to the well-known oscillatory class ("O Type" in Harrison's classification) [1].

More precisely, we postulate a Universe that (approximately) evolves following a simple harmonic motion whose pulsation is equal to the ratio between the speed of light and the mean radius (of curvature) [2].

Such a Universe, since it is involved in a cyclic evolution, cannot properly admit, obviously, either a beginning or an end. Nonetheless, the beginning of a new cycle can be conventionally fixed: very intuitively, we can establish that a new cycle ($t = 0$) starts every time the radius assumes a null value.

The evolution of the hypothesized Universe may be evidently characterized by four consecutive phases: an accelerated expansion, a decelerated expansion, a decelerated contraction, an accelerated contraction (as a consequence, it is quite evident how the Hubble parameter [3] may have assumed in the past, and could possibly still assume in the future, negative values). All the above-mentioned phases are clearly characterized by the same duration.

The existence of at least a further spatial dimension is contemplated [4]. Although the space we are allowed to perceive, when we are at rest, is curved, since it is identifiable with a hyper-sphere whose radius depends on our state of motion, the Universe in its entirety, herein assimilated to a four-dimensional ball, is to be considered as being flat. All the points are replaced by straight-line segments: in other terms, what we perceive as being a point is actually a straight-line segment crossing the centre of the above-mentioned 4-ball.

Time is considered as being absolute: on this subject, we highlight how this assumption, undoubtedly strong, has been elsewhere exploited to assign a different meaning [5] to the so-called Lorentz transformations [6] [7].

We consider the variations of cosmological distances as being exclusively metric: in other terms, we postulate that the amount of space between whatever couple of points remains the same with the passing of time (on this subject, it could be worth bearing in mind how Hubble himself started bringing into question the relation between the redshift and the recessional velocity of astronomical objects) [8].

More precisely, we hypothesize that the so-called cosmological redshift may be a phenomenon banally related to the conservation of energy.

As well known, the energy of a quantum of light can be expressed as the product between the value of its frequency and the Plank constant. On the one hand, as an alternative to the conventional interpretation of the cosmological redshift, we could accept that, in travelling through the interstellar vacuum, light may somehow "get tired", so as losing part of its energy [9] [10] [11]. On the other hand, we may simply imagine that the Plank constant could vary over time [12] [13]: consequently, just in order to preserve its energy, a photon could be forced into modifying its frequency.

In the light of the foregoing, the problem of the singularity at $t = 0$ [14] [15] [16] [17], although herein not discussed, may be faced with a different approach, starting from an alternative writing of the Friedmann-Lemaître equations [18], elsewhere deduced without using General Relativity [18], as a function of a Plank parameter.

Obviously, the alleged variability of the Planck constant could sound like a rather shocking hypothesis: nonetheless, it is worth bearing in mind how several physical quantities, initially considered as being constant, have been later classified as variables. The Hubble constant, to remain on the topic, faced exactly this fate, and quite soon it was downgraded, so to say, to the rank of parameter (whose current value is still the subject of investigation) [20] [21] [22]. Just to provide a further example, suffice it to think that even the so-called fine structure constant seems to be about to lose its constancy [23] [24] [25].

2. Discussion

In a previous paper [26], we proposed a simple qualitative model, finalized to describe, without using General Relativity, how mass warps space. Amongst other things, the model in question is characterized by two fundamental hypotheses: the absoluteness of time and the constancy of the proper radius. The latter imply that, very roughly, the measured distance between whatsoever couple of points remains the same if one of them acquires (a greater) mass. Actually, if mass were to really warp space, we would be forced into admitting that the shape of the Universe can be modified with respect to something else, taken as a reference. In the light of the previous remark, we may rather imagine that the "value" of space may be modified by the presence of a gravitational source. Once accepted that a test particle, that we perceive as being punctual, is actually characterized by a radial extension (we must bear in mind that the Universe has been identified with a 4-ball) [2] [4], we could simply state that the more we approach the gravitational source, the more the value of the radial extension decreases [26].

Let's denote with χ the angular distance (as perceived by an ideal observer placed right at the center of the 4-ball with which we identify our Universe) between a test particle and a gravitational source, considered as being punctual. In deducing the so-called "vacuum field solution" we have elsewhere found [26] the relation that expresses the radial coordinate of the above-mentioned particle, that coincides with its radial extension, as a function of the angular distance, as perceived by an ideal observer placed right at the center of the 4-ball with which we identify our Universe. If we denote with r the radial coordinate of the test particle, and with R_s the Schwarzschild Radius [27] related to the mass that produces the field, we have [26]:

$$r = R_s \sin\chi = \frac{2GM}{c^2}\sin\chi. \tag{1}$$

As usual, G represents the gravitational constant, M the mass of the singularity (that cannot be perceived in its entirety), and c the speed of light.

If we denote with g_{oo} the first component of the metric tensor, we can write the "weak field" expression for the gravitational potential, denoted by, as follows:

$$\phi = \frac{1}{2}c^2\left(1 - g_{00}\right). \tag{2}$$

In our case, we have [26]:

$$g_{00} = 1 - \frac{R_s}{R^*} = \sin^2\chi, \tag{3}$$

$$R^*\left(\chi\right) = \frac{R_s}{\cos^2\chi}. \tag{4}$$

It is fundamental to highlight how R^* does not represent a Schwarzschild coordinate (see also the solutions provided by Droste, Hilbert, and Brillouin) [28] [29] [30]. More precisely, the coordinate R^* arises from a simple parameterization: it appears both in the metric and at the denominator of the pseudo-Newtonian relation we have elsewhere obtained for the gravitational potential [26]. Most importantly, we clearly underline how R^* does not represent a real distance nor a real radius of curvature.

Let's consider two points in the field, denoted by P_e and P_o. The angular distances between the above-mentioned points and the gravitational singularity are, respectively, χ_e and χ_o. By virtue of Equation (1), with obvious meaning of the notation, we can write as follows:

$$r_e = R_s \sin \chi_e, \tag{5}$$

$$R_e^* = \frac{R_s}{\cos^2 \chi_e}, \tag{6}$$

$$r_o = R_s \sin \chi_o, \tag{7}$$

$$R_o^* = \frac{R_s}{\cos^2 \chi_o}. \tag{8}$$

In the introduction of this paper, we postulated the variability of the Planck constant over time. At this point, since we refuse to accept that time undergoes a dilation when we approach a gravitational source (the apparent time dilation may be related to the contraction of the orbits), we have to hypothesize that the Planck constant may be also locally variable (the possibility of a local variability of the Planck constant is anything but a novelty, and it represents a still outstanding issue) [31] [32] [33].

Let's suppose that a light impulse is emitted in P_e and received, after a certain time, in P_o. Since we want to speak in terms of redshift, we have to impose that $\chi_e < \chi_o$. If we accept the local variability of the Plank constant, intentionally ignoring, for simplicity, its variation over time (hypothesized in the introduction), we can write the following:

$$E_e = h(\chi_e)\nu(\chi_e) = h(r_e)\nu(r_e) = h(R_e^*)\nu(R_e^*) = h_e\nu_e, \tag{9}$$

$$E_o = h(\chi_o)\nu(\chi_o) = h(r_o)\nu(r_o) = h(R_o^*)\nu(R_o^*) = h_o\nu_o. \tag{10}$$

E_e represents the energy when the impulse is emitted, E_o the energy when the impulse is received, ν_e and ν_o the corresponding frequencies, h_e and h_o the Planck "constants", respectively, in P_e and P_o. Since the energy must be preserved ($E_e = E_o$), from Equations (9) and (10), we immediately obtain:

$$\nu_o = \frac{h_e}{h_o}\nu_e, \tag{11}$$

$$\lambda_o = \frac{h_o}{h_e}\lambda_e. \tag{12}$$

The redshift is commonly defined by means of the following dimensionless quantity:

$$z = \frac{\lambda_o - \lambda_e}{\lambda_e}. \tag{13}$$

However, we have to consider the particular case in which the signal is received by an observer placed at infinity. Bearing in mind that, according to Equation (4), the parameter R^* is equal to the Schwarzschild radius when $\chi = 0$, and it tends to infinity when χ tends to π/2, we can write:

$$z_{\infty} = \lim_{R_o^* \to \infty} \left[\frac{\lambda(R_o^*)}{\lambda(R_e^*)} - 1 \right] = \frac{\lambda(R_s)}{\lambda(r_e)} - 1 = \frac{\lambda(\pi/2)}{\lambda(\chi_e)} - 1. \quad (14)$$

By virtue of Equation (12), from the foregoing we immediately obtain:

$$z_{\infty} = \lim_{R_o^* \to \infty} \left[\frac{h(R_o^*)}{h(R_e^*)} - 1 \right] = \frac{\lambda(R_s)}{\lambda(r_e)} - 1 = \frac{h(\pi/2)}{h(\chi_e)} - 1. \quad (15)$$

Just to simplify and generalize the notation, we can replace χ_e with χ, and r_e with r, so obtaining:

$$z_{\infty} = \frac{h(\pi/2)}{h(\chi)} - 1 = \frac{h(R_s)}{h(r)} - 1. \quad (16)$$

If we impose a linear dependence between the Planck "constant" and the radial coordinate, we have:

$$z_{\infty} = \frac{h(R_s)}{h(r)} - 1 = \frac{R_s}{r} - 1. \quad (17)$$

From the previous, taking into account the Equations (1) and (3), we can finally write the following well-known relation:

$$z_{\infty} = \frac{1}{\sqrt{g_{00}}} - 1 = \frac{1}{\sqrt{1 - \frac{2GM}{c^2 R^*}}} - 1. \quad (18)$$

3. Further Remarks

We have elsewhere introduced the concept of dimensional thickness [4]. It has been previously claimed that the Universe we are allowed to perceive, when we are at rest, may be assimilated to a hypersphere (a three-dimensional curved space). Actually, the previous assertion is not entirely correct: in fact, the space we perceive should be rather identified with a hyper-spherical shell. In order to understand the previous assertion, suffice it to consider that we are undeniably used to identifying a paper sheet with a bi-dimensional surface. Nonetheless, we are well aware of the fact that a bi-dimensional surface represents nothing but a pure abstraction, and the above-mentioned sheet is evidently characterized by a thickness, whose value in no case should be considered as being null. To obtain the well-known expression for the gravitational redshift, we have hypothesized a linear dependence between the Planck constant and the radial coordinate of the point that emits the signal. It is worth specifying how, more correctly, we must imagine the Planck "constant" as being linearly dependent on the dimensional thickness that, in turn, is linearly dependent on the radial coordinate. This last dependence is really intuitive: very roughly, if space loses its value due to the presence of a gravitational singularity, the same must happen to the dimensional thickness that, in a few words, may be thought as being nothing but a (variable) "quantum of space".

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