

On Interpretations of Hubble's Law and the Bending of Light

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Currently, Hubble's law is often considered as the observational evidence of an expanding universe. It is shown that Hubble's Law need not be related to the notion of Doppler redshifts of the light from receding Galaxies. In the derivation of the receding velocity, an implicit assumption, which implies no expansion, must be used. Moreover, the notion of receding velocity is incompatible with the local light speeds used in deriving the light bending. The notion of an expanding universe is based on an unverified assumption that a local distance in a physical space is similar to that of a mathematical Riemannian space embedded in a higher dimensional flat space, and thus the physical meaning of coordinates would necessarily depend on the metric. However, this assumption has been proven as theoretically invalid. In fact, a physical space necessarily has a frame of reference, which has a Euclidean-like structure that is independent of the yet to be determined physical metric and thus cannot be such an embedded space. In conclusion, the notion of an expanding universe could be just a mathematical illusion.

1 Introduction

Currently, Hubble's law is often considered as the observational evidence of the expanding universe. This is done by considering Hubble's law essentially as a manifestation of the Doppler red shift of the light from the receding Galaxies [1]. Thus, the further a galaxies is from the Milky Way, the faster it appears to receding. However, Hubble himself rejected this interpretation and concluded in 1936 that the Galaxies are actually stationary [2]. In view of the fact that this interpretation of relating to the receding velocities is far from perfect [3], perhaps, it would be useful to reexamine how solid is such an interpretation in terms of general relativity and physics.

It will be shown that Hubble's Law need not be related to the Doppler redshifts of the light from receding Galaxies (section 2). It is pointed out, in the derivation of the receding velocity, an implicit assumption, which implies no expansion, must be used (section 3). Moreover, the receding velocity is incompatible with the light speeds used in deriving the light bending (section 4). In short, the notion of expanding universe is a production due to confusing notion of the coordinates and also due to inadequate understanding of a physical space. Thus, such a universe is unlikely related to the reality (section 5).

2 Hubble's law

Hubble discovered from light emitted by near by galaxies that the redshifts S are linearly proportion to the present distance L from the Milky Way as follows:

$$S = HL \quad (1)$$

where H is the Hubble constant although the redshifts of distant galaxies will deviate from this linear law with a slightly different constant. In terms of general relativity, it is well known that this law can be derived with the following metric [1, 3],

$$ds^2 = -d\tau^2 + a^2(\tau)(dx^2 + dy^2 + dz^2), \quad (2)$$

since

$$S = \frac{\lambda_2 - \lambda_1}{\lambda_1} = \frac{\omega_1}{\omega_2} - 1 = \frac{a(\tau_2)}{a(\tau_1)} - 1, \quad (3)$$

where ω_1 is the frequency of a photon emitted at event P_1 at time τ_1 , and ω_2 is the frequency of the photon observed at P_2 at time τ_2 [1]. Furthermore, for nearby galaxies, one has

$$a(\tau_2) \simeq a(\tau_1) + (\tau_2 - \tau_1)\dot{a}. \quad (4)$$

If

$$(\tau_2 - \tau_1) = L = \int_1^2 \sqrt{dx^2 + dy^2 + dz^2}, \quad (5)$$

then

$$S = \frac{\dot{a}}{a} L = HL, \quad \text{and} \quad H = \frac{\dot{a}}{a}. \quad (6)$$

Formula (5) is compatible with the calculation in the bending of light. Please note that Hubble's Law need not be related to the Doppler redshifts. Understandably, Hubble rejected such an interpretation himself [2]. In fact, there is actually no receding velocity since L is fixed (i. e., $dL/d\tau = 0$).

3 Hubble's law and the Doppler redshifts

On the other hand, if one chooses to define the distance between two points as

$$R = \int_1^2 a(\tau)\sqrt{dx^2 + dy^2 + dz^2} = a(\tau)L, \quad (7)$$

then

$$v = \frac{dR}{d\tau} = \frac{da}{d\tau}L + \frac{dL}{d\tau}a = \frac{da}{d\tau} \frac{R}{a} = HR, \quad \text{if} \quad \frac{dL}{d\tau} = 0. \quad (8)$$

According to relation (7), v would be the receding velocity. Note also that according to (7), (5) would have to change into $(\tau_2 - \tau_1) = R$, and (1) into $S = HR$. Thus,

$$v = S. \quad (9)$$

This means that the redshifts could be superficially considered as a Doppler effect. Thus, whether Hubble's Law represents the effects of an expanding universe is a matter of the interpretation of the local distance. From the above analysis, the crucial point is what is a valid physical velocity in a physical space.

It should be noted that $dL/dt = 0$ means that the space coordinates are independent of the metric. In other words, the physical space has a Euclidean-like structure [4], which is independent of time. However, since L between any two space-points is fixed, the notion of an expanding universe, if it means anything, is just an illusion. Moreover, the validity of (7) as the physical distance has no known experimental supports since it is not really measurable (see section 5). Moreover, a problem is that the notion of velocity in (8) would be incompatible with the light speeds in the calculation of light bending experiment.

4 The coordinates of an Einstein physical space

In mathematics, the Riemannian space is often embedded in a higher dimensional flat space [5]. Then the coordinates dx^μ are determined by the metric through the metric,

$$ds^2 = g_{\mu\nu} dx^\mu dx^\nu, \quad \text{or} \quad -g_{00}dt^2 + g_{ij} dx^i dx^j \quad (10)$$

such as the surface of a sphere in a three-dimensional Euclidean space. For a physical space, however, there are insufficient conditions to do so. Since the metric is a variable function, it is impossible to determine the coordinates with the metric. In view of this, the coordinates must be physically independent of the metric. As shown in metric (2), a physical space has a Euclidean-like structure as a frame of reference.⁽¹⁾ Moreover, it has been proven from the theoretical framework of general relativity [4] that a frame of reference with the Euclidean-like structure must exist for a physical space.

For a spherical mass distribution with the center at the origin, the metric with the isotropic gauge is,

$$ds^2 = -[(1 - Mk/2r)^2 / (1 + Mk/2r)^2] c^2 dt^2 + (1 + Mk/2r)^4 (dx^2 + dy^2 + dz^2), \quad (11)$$

where $k = G/c^2$ ($G = 6.67 \times 10^{-8} \text{erg} \times \text{cm} / \text{gm}^2$), M is the total mass, and $r = \sqrt{x^2 + y^2 + z^2}$. Then, if the equivalence

principle is satisfied, the light speeds are determined by $ds^2 = 0$ [6, 7], i. e.,

$$\frac{\sqrt{dx^2 + dy^2 + dz^2}}{dt} = c \frac{1 - M\kappa/2r}{[1 + M\kappa/2r]^3}. \quad (12)$$

However, such a definition of light speeds is incompatible with the definition of velocity (8) although compatible with (5). Since this light speed is supported by observations, (8) is invalid in physics. Nevertheless, Liu [8] has defined light speeds, which is more compatible with (8), as

$$\frac{\sqrt{g_{ij} dx^i dx^j}}{dt} = c \frac{1 - M\kappa/2r}{1 + M\kappa/2r} \quad (13)$$

for metric (11). However, (13) implies only half of the deflection implied by (12) [6, 7].

The above analysis also explains why many current theorists insist on that the light speeds are not defined even though Einstein defined them clearly in his 1916 paper as well as in his book, *The Meaning of Relativity*. They might argued that the light speeds are not well defined since diffeomorphic metrics give different sets of light speeds for the same frame of reference. However, they should note that Einstein defines light speeds after the assumption that his equivalence principle is satisfied [6, 7]. Different metric for the same frame of reference means only that at most only one of such metrics is physically valid [4], and therefore the definition of light speeds are, in principle, uniquely well-defined.

However, since the problem of a physical valid metric has not been solved, whether a light speed is valid remains a question. Nevertheless, it has been proven that the Maxwell-Newton Approximation gives the valid first order approximation of the physical metric, the first order of the physically valid light speeds are solved [4]. Since metric (11) is compatible with the Maxwell-Newton approximation, the first order of light speed (12) is valid in physics.

Thus, the groundless speculation that local light speeds are not well defined is proven incorrect. In essence, the velocity definition (8), which leads to the notion of the Doppler redshifts, has been rejected by experiments. Nevertheless, some skeptics might prefer to accept formula (6) after light speed (12) is confirmed by the experiment of local light speeds [4].

5 Discussions and Conclusions

A major problem in Einstein's theory, as pointed out by Whitehead [9] and Fock [10], the physical meaning of coordinates is ambiguous and confusing. In view of this, it is understandable that the notion in an embedded Riemannian space is used when the physical nature of the problem is not yet clear.⁽²⁾ A major difference between physics and mathematics is that the coordinates in physics must have physical meaning. Since Einstein is not a mathematician,

his natural step would be to utilize the existing theory of Riemannian space. However, as Whitehead [9] saw, this created a seemingly irreconcilable problem between coordinates of a curved space-time and physics.

Under such a circumstances, the notion of an expanding universe is created while an implicit assumption that restricts the universe as static is also used. This kind of inconsistency is expectedly inevitable because of contradictory principles, Einstein's equivalence principle that requires space-time coordinates have physical meaning and the "principle of covariance" that necessarily means that coordinates are arbitrary, are concurrently used in Einstein's theory [11]. Recently, it is proven [12] that Einstein's "principle of covariance" has no theoretical basis in physics or observational support beyond what is allowed by the principle of general relativity.⁽³⁾

This analysis demonstrates that the Hubble's Law is not necessarily related to the Doppler redshifts. It is also pointed out that the notion of an expanding universe is related to contradictory assumptions and thus is unlikely a physical possibility. Moreover, this kind notion of velocity is incompatible with the light speeds used in the calculation of light bending [6, 7].

In Einstein's theory of measurement, a local distance in a physical space is assumed to be similar to that of a mathematical Riemannian space embedded in a higher dimensional flat space, and thus the physical meaning of coordinates would necessarily depend on the metric. Recently, this unverified assumption is proven to be inconsistent with Einstein's notion of space contractions [13]. In other words, this unverified assumption contradicts Einstein's equivalence principle that the local space of a particle at free falling must be locally Minkowskian [7], from which he obtained the time dilation and space contractions.

In conclusion, the notion of an expanding universe is unlikely a physical reality, although metric (2) is only a model among other possibilities. Currently, there are three theoretical explanations for the cause to observed red shifts. They are: (1) the expanding universe; (2) Doppler redshifts; and (3) gravitational redshifts. In this paper, it has been shown that the current receding velocity of an expanding universe is only a theoretical illusion and is unrelated to the Doppler redshifts. If the notion of expanding universe cannot be explained satisfactorily, it is difficult to imagine that Doppler effects are the cause of observed Hubble's law. Moreover, this law also cannot be explained in terms of gravitational redshifts.

Then, one may ask if the observed gravitational redshifts are not due to an expanding universe, what causes such redshifts that are roughly proportional to the distances from the observer. One possibility is that the scatterings of a light ray along its path to the observer. In physics, it is known that different scatterings are common causes for losing energy of a particle, and for the case of photons it means redshifts. Since such an effect is so small, it must be the scattering of

a weak field. In fact, the inelastic scattering of light by the gravitational field has been speculated [14]. Unfortunately, to test such a conjecture is not possible because no current theory of gravity is capable of handling the inelastic scatterings of lights.

At present, Einstein's equation even does not have any dynamic solution [15, 16]. Thus, to solve this puzzle rigorously seems surely in the remote future. Nevertheless, the assumption that observed redshifts could be due to inelastic scatterings may help to explain some puzzles of observed facts [17]. For instance, it is known that younger objects such as star forming galaxies have higher intrinsic redshifts, and objects with the same path length to the observer have much different redshifts while all parts of the object have about the same amount of redshifts.⁽⁴⁾

A noted advancement of the Euclidean-like structure [4] is that notions used in a Euclidean space could be adapted much easier in general relativity. Many things would be calculated as if in a Euclidean space. On the other hand, the speculations related to the notion of an expanding universe [1] would cease to function, and physics should return to normal. Nevertheless, when a transformation between different frames of reference is considered, the physical space is clearly Riemannian as Einstein discovered.

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Endnotes

- ⁽¹⁾ A common problem is overlooking that the metric of a Riemannian space can actually be compatible with the space coordinates with the Euclidean-like structure. For example, the Schwarzschild solution in quasi-Minkowskian coordinates [18; p. 181] is,

$$ds^2 = -(1 - 2M\kappa/r)c^2 dt^2 + (1 - 2M\kappa/r)^{-1} dr^2 + r^2(d\theta^2 + \sin^2\theta d\varphi^2), \quad (1a)$$

where (r, θ, φ) transforms to (x, y, z) by,

$$\begin{aligned} x &= r \sin \theta \cos \varphi, & y &= r \sin \theta \sin \varphi, \\ \text{and } z &= r \cos \theta. \end{aligned} \quad (1b)$$

Coordinate transformation (1b) tells that the space coordinates satisfy the Pythagorean theorem. The Euclidean-like structure represents this fact, but avoids confusion with the notion of a Euclidean subspace determined by the metric. Metric (1a) and Euclidean-like structure (1b) are complementary to each other in the Einstein space. These space-time coordinates form not just a mathematical coordinate system

since a light speed ($ds^2 = 0$) is defined in terms of dx/dt , dy/dt , and dz/dt [19].

- (2) In the initial development of Riemannian geometry, the metric was identified formally with the notion of distance in analogy as the case of the Euclidean space. Such geometry is often illustrated with the surface of a sphere, a subspace embedded in a flat space [5]. Then, the distance is determined by the flat space and can be measured with a static method. For a general case, however, the issue of measurement was not addressed before Einstein's theory. In general relativity, according to Einstein's equivalence principle, the local distance represents the space contraction [7, 19], which is actually measured in a free fall local space [13]. Thus, this is a dynamic measurement since the measuring instrument is in a free fall state under the influence of gravity, while the Euclidean-like structure determines the static distance between two points in a frame of reference. Einstein's error is that he overlooked the free fall state, and thus has mistaken this dynamic local measurement as a static measurement.
- (3) If the "covariance principle" was valid, it has been shown that the "event of horizon" for a black hole could be just any arbitrary constant [20]. Zhou [21] is probably the earliest who spoke out against the "principle of covariance" and he pointed out, "The concept that coordinates don't matter in the interpretation of Einstein's theory necessarily leads to mathematical results which can hardly have a physical interpretation and are therefore a mystification of the theory." More recently, Morrison [12] commented that Einstein's "covariance principle" discontinuously separates special relativity from general relativity.
- (4) These two types of puzzles would be very difficult to be explained in terms of an expanding universe alone. One might object the scattering of gravitational field on the ground that the photon flight path would be deviated and the images blurred. However, although the scattering by random objects would make blurred images, it is not clear this is the case for a scattering by a weak field. Moreover, since the scattering in the path of photons by the weak gravitational field is very weak, the deviation from the path would not be noticeable, and this is different from the gravitational lenses effects that can be directly observed.

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