An observer-based referential that is consistent with cosmological observations

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Abstract

This article constitutes an alternative approach to the problem of the redshift of distant galaxies. We place ourselves in the static de Sitter space and propose that the uniform positive curvature of space imposes some distortion of the length of distant objects, as perceived by the observer. This effect becomes more important as the distance of the observed event increases, and have an effect on the measured wavelength of incoming photons. In order to render this effect physically consistent, we introduce an observer-based referential, in which the observer perceives its physical environment as being flat, which is the familiar way we apprehend the world. We postulate some natural rules applying in this referential which enables us to derive a formula for the redshift/distance relationship. This result is tested succesfully with recent catalogue. We then discuss the existence and characteristics of a Cosmic Microwave Background in this model, that is consistent with observations.

1 Introduction

The intuition of a static universe has led Albert Einstein in 1917 to consider a finite static solution of the equations of general relativity to be the universe we live in. He described a spatially closed universe of spherical curvature [3], requiring the introduction of a controversial cosmological constant that kept the universe from collapsing due to gravitational effects. Shortly after, this vision of the universe faced two major challenges. In 1930, Eddington was the first to consider the question of stability of Einstein world [4] and showed that it is unstable under certain types of small perturbations. This issue is still subject to investigations and is thought to be an important point to understand the early universe [5]. It is the discovery of the linear relation between the redshift of galaxies and their distance in the late twenties [6] that convinced Einstein, at the beginning reluctant, to finally change his mind and accept the growing consensus on models based on expansion of space [7],[8]. Such models [9], [15] suited quite well the small amount observational data yet available, but the existence of an initial spacetime singularity it requires raises important physical and philosophical questions. The discovery of a cosmic microwave background (CMB) made by Penzias and Wilson in 1964 [16] became a strong support for this theory, since its characteristics are compatible with a dense primordial plasma that emitted light shortly after the big bang. Its analysis is thought to provide important information on the state of the primordial universe. In 1998, an 'acceleration of the expansion of universe' was detected and surprised cosmologists [11]. This led to the introduction in the models of a dark energy that acts as a repulsive gravitational force, whose origin remains very speculative. Efforts have been made to combine all these considerations and the most accomplished result is the standard model of cosmology, so called ΛCDM. Alternative theories have been developed to explain the redshift of cosmological objects, such as tired light theory [10], but errors have been pointed out and the theory has never been commonly accepted and seem to be now completely abandoned [12]. In the framework of general relativity alone, if we neglect hypothetical physical processes that pump energy from light, the only possible explanation for this redshift is a mechanism that acts on the metric of spacetime. As for now, there is growing evidence that this standard cosmological model has fundamental flaws: thanks to enhanced precision of measurements, some tensions have become increasingly apparent.

We will here propose an alternative explanation for the redshift of galaxies. We will place ourselves in the (static) de Sitter space and postulate that the wavelength of photons (as well as their frequency) is affected by the radial curvature of spacetime, leading to a redshift that grows with the distance of the light source. In a first chapter, we will motivate this hypothesis and bring it a physical ground.

In this theory, the effect results from the fact that the observer perceives its environment as being flat, and performs measurements in a usual Galilean referential, which is the familiar way of representing his environment. This effect implies some distortion of observed distances that affects the nature of incoming light. Based on these assumptions, we derive a formula relating the redshift of photons to the distance of the emitting object. We then show that this relation is consistent with Hubble diagrams coming from Supernovae Ia data. Then we discuss the emergence in this model of a cosmic background radiation whose characteristics are consistent with that of the observed CMB.

2 An observer-based referential

In its famous 1905 paper [2], Albert Einstein writes:

> "*If a material point is at rest relatively to a system of co-ordinates, its position can be defined relatively thereto by the employment of rigid standards of measurement and the methods of Euclidean geometry, and can be expressed in Cartesian co-ordinates.*"

Ten years later, the development of general relativity challenged this view and introduced more sophisticated geometrical tools to describe the physical world. We here take the point of view of the observer to investigate the existence of a consistent referential in which Einstein's considerations apply. Let us consider the following situation: in a universe whose geometry is described by Einstein's field equations (possibly with a cosmological constant), lives an observer, whose fundamental nature is to create a consistent representation of its physical environment, in which he is able to measure quantities such as lengths and durations associated to events around him. This can be made by using a ruler, or a chronometer for example. By saying so, we implicitly suppose that in the observer's representation of the universe, space and time are split and can be tackled independently: when one measures lengths, one does not measure durations, and the other way around. We will refer to this principle as the *separation principle*. In Minkowskian spacetime and for objects in uniform linear motion with respect to the observer, direct comparison is not possible and a procedure was proposed by Einstein to determine the length of such an object, based on the constancy of the speed of light c. This procedure turns out to give a value that is different from the length one would measure directly by comparing the object with a ruler. This is the core of special relativity. A similar procedure allows to determine the distance between the observer and an object at rest: he can send a light ray in the direction of the object at time t_0, and wait for the light ray to be reflected back to him at time t_1. The distance d from the event s is then defined in the following way :

$$d(s) = c\frac{t_1 - t_0}{2}. \tag{1}$$

This definition of distance extends to more general spacetime geometries and is called *proper* distance in the context of a static universe. It can be thought of as the length of the shortest geodesic connecting the observer to the object.

Now that he is able to measure lengths and durations associated to events in its direct environment using his local coordinates and to determine the distance of an object, the observer may ask the following question: is there a procedure to assign lengths and durations to events situated at large distance d, and how to do so? In a flat spacetime, and if the object is at rest, the answer is trivial and this can be done by using of the tools of Euclidean geometry, as stated by Einstein. To provide an answer to this question in the more general set up of curved spacetime geometry, we will make a strong hypothesis. Let us consider the following construction: Let R_0 be the referential in which a geodesic connecting the observer to an observed object in the physical space is mapped, by a transformation T, into a straight line leaving the observer with the same direction as the geodesic, with respect to its local referential. We take T such that it preserves the distance between the observer and the object, in the sense that the proper distance in the physical world and the Euclidean distance in R_0 are equal. In R_0, a photon travelling from an object to the observer will follow straight lines and travel at a constant speed c. This referential is not obtained by a mere change of the coordinates describing the spacetime geometry, because we now impose in R_0 a linear geometrical structure, described by an Euclidean metric. In this referential, physical objects are represented stretched, deformed, eventually split and present in different locations of the referential. That corresponds exactly to the usual way we observe them with our telescopes and perceive our environment. For this reason, we will pose as a postulate that all the measures performed by the observer are performed in this representation referential R_0, and are therefore consistent with the rules of Euclidean geometry. The representation referential R_0 constitutes some kind of Euclidean projection of the spatial universe. Of course, for curved spacetime geometries, the lengths measured in R_0 are different from the ones measured in the object natural referential.

This assumption may seem surprising to the reader, but we will see that in the de Sitter universe, that has a closed spatial geometry, the distortion of lengths increases as the distance from the observer increases, in a way that is compatible with redshift measurements. To quantify this distortion of lengths, we introduce for each point x in a domain of definition included in R_0 a scaling factor $a(x)$, that is defined as the ratio between the infinitesimal length around the point x, as measured in its local natural referential, and an infinitesimal length around the point x in R_0, that can be determined using Euclidean geometry. For example, a bundle of light rays with infinitesimal solid angle $\delta\Omega$ can be sent in the direction of x, and $a(x)$ can be computed as the square root of the ratio between the infinitesimal area intersected by the bundle in the neighborhood of x in the natural referential around x and the area that has intersected the bundle in R_0. Equivalently, $a(x)$ can be defined as the ratio between the angular diameter distance d_A and the proper distance d for objects of infinitesimally small size. This scaling field is a priori non continuous, can contain singularities and domains where it is not defined (in a black hole region for example).

With the assumption that the speed of light is constant equal to c everywhere in R_0, the time component that has been discarded until now thanks to the separation principle can be restored by introducing a scaling factor that applies to infinitesimal durations associated to events represented at the point x. This scaling factor must be taken equal to the one for the spatial component $a(x)$, so that light travelling in the region of the observed event has velocity

$$v_0 = \frac{a(x)\delta l}{a(x)\delta\tau} = \frac{\delta x}{\delta\tau} = c, \tag{2}$$

where δl is the distance travelled by the photon and $\delta\tau$ is the interval of time it took, in local coordinates. Finally, in the observer's representation referential R_0, we will postulate that a photon keeps a constant wavelength while travelling along the geodesic connecting the source to the observer, as expected in a flat spacetime.

3 Cosmological considerations

3.1 de Sitter space

Let us from now on place ourselves in the de Sitter space of radius of curvature R. This universe has been introduced by de Sitter shortly after Einstein presented his static model. It has closed spatio-temporal geometry and is a solution of the field equations, provided a positive cosmological constant is introduced. It is obtained by setting the energy-impulsion tensor to 0. As no matter/energy is present in this universe, the question of its stability is irrelevant. Its metric is induced by the manifold

$$-x_0^2 + \sum_{i=1}^{4} x_i^2 = R^2,$$

where the x_i are Minkowskian coordinates.

By applying the procedure described in the preceding section, we obtain for the de Sitter space a scaling factor associated with an object at distance d equal to:

$$a(d) = \frac{d_A}{d} = \frac{R\sin(\frac{d}{R})}{d}. \tag{3}$$

This relation is easily obtained from spherical geometry and can be understood via the following heuristic argument: when one observes an object at a distance d, the object is embedded in a surface of observation that is a sphere of radius d. The observer has no sense of the curvature of space and for him, light seems to be arriving in a straight line trajectory, space looks flat from his perspective and the surface of observation is for him the area of a sphere in a flat space, that is $4\pi d^2$. In reality, the surface in which is embedded the object is smaller than this, as in spherical geometry, the area of spheres grows as $4\pi R^2\sin^2(\frac{d}{R})$ (see figure (3.1) for pictorial representation of the phenomena). This implies a distortion of areas of $s(d) = \frac{R^2\sin^2(\frac{d}{R})}{d^2}$ between the value in the object's proper referential and in R_0. This implies a distortion of all metric quantities by a factor $a(d) = \sqrt{s(d)}$ (as we find in equation (2a)). In figure 3.1, we propose a pictorial representation of the effect in dimension 2.

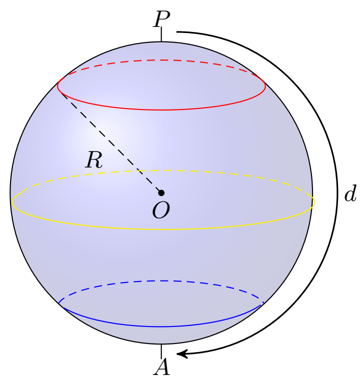
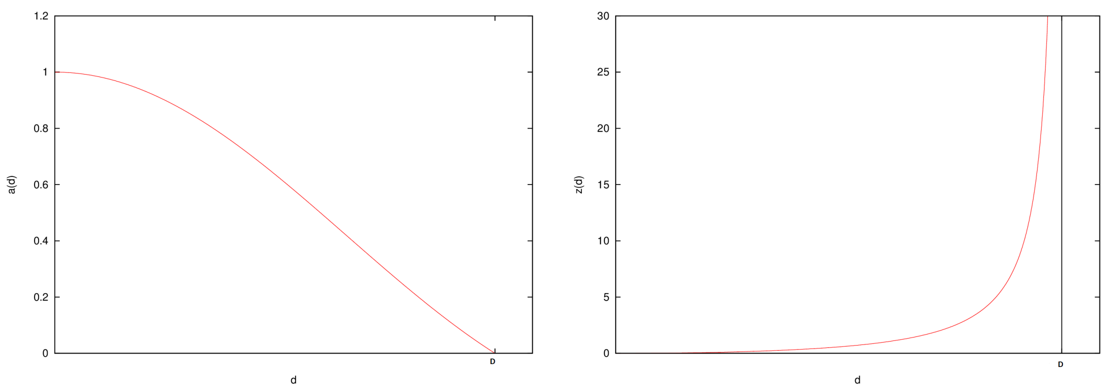


Figure 1: For an observer at position P, the surface of observation (in this 2-dimensional analogue, the perimeter of the circles) grows with distance d up to a certain distance and then decreases until degeneration when the antipode A is reached. The surface of observation then degenerates and space seems to vanish at this point.



(a) (b)

Figure 2: Evolution with proper distance of the scaling factor (left) and the redshift (right) in a de Sitter universe

3.2 Redshift/distance relation

Light coming from distant galaxies has a redshift $z(d)$ that can be computed by comparing the wavelength of photons arriving to us with its wavelength at emission. It is defined as

$$z(x) = \frac{\lambda_{ob}(x) - \lambda_{em}(x)}{\lambda_{em}(x)}, \tag{4}$$

where $\lambda_{ob}(x)$ is the observed wavelength and $\lambda_{em}(x)$ is the wavelength of the emitted photon in local coordinates. We have the following relation due to distortion of distances :

$$a(x) = \frac{\lambda_{em}(x)}{\lambda_{ob}(x)}. \tag{5}$$

Redshift z and scaling factor are then related in the following way :

$$z(x) = \frac{1}{a(x)} - 1. \tag{6}$$

In the case of a spatially closed universe, we get that the redshift associated to the distance d is:

$$z(d) = \frac{d}{Rsin(\frac{d}{R})} - 1. \tag{7}$$

A graphical representation of equation 7 can be seen in figure 2b.

It is now of interest to look at the behaviour of the derivative of the scaling factor, that in the case of an expanding universe is interpreted as its rate of expansion. The derivative of a is given by the formula :

$$a'(d) = \frac{cos(\frac{d}{R})}{d} - \frac{R}{d^2} sin(\frac{d}{R}). \tag{8}$$

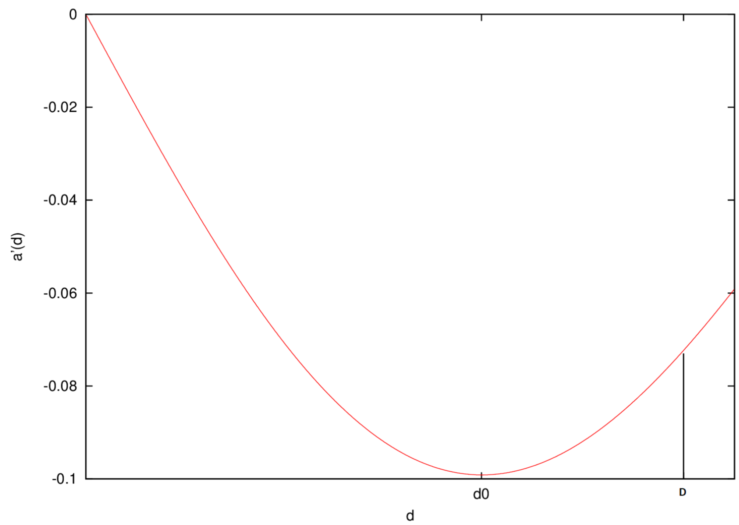


Figure 3: Evolution of the derivative of the scaling factor with proper distance

The study of the derivative of a shows a change of monotony at a certain distance d_0 and a' decreases with distance before that (see figure 3). Observations of type Ia Supernovae have pointed out this fact [15] and in the standard model, it is interpreted as an acceleration of the expansion of the universe, that started a few billion years ago. The mechanism proposed to explain such an acceleration involve some mysterious dark energy that derives the galaxies away [15]. In the present context, we do not have to refer to any kind of dark energy: the model predicts simply that behavior for a'.

We now test our model by examining the relation between redshift and distance. Estimating the distance of cosmological objects is a long standing issue [19], but two redshift-independent methods are commonly used. Both require some knowledge about the observed object. The luminosity distance is computed by comparing the flux of the light arriving to us with the luminosity of the object that is supposed to be known. Estimation of the angular diameter distance for its part requires some knowledge about the diameter of the observed object. The important discovery that type 1A supernovae all have the same luminosity and constitute standard candles provides a precious dataset to test our model. Let us determine now the relation between our distance d and the luminosity distance d_L, that is defined implicitly in the relation

$$F_{obs} = \frac{L}{4\pi d_L^2}. \tag{9}$$

Here, F_{obs} is the flux measured by the observer and L is the luminosity of the object in its local referential.

Let us consider an object situated at proper distance d from the observer, that emits n photons of energy $h\nu$ per unit of surface per unit of time, where all these quantities are expressed in the natural referential of the object. In the observer's referential, the situation is equivalent to the following: in a flat universe, an object at proper distance d is emitting n photons of energy $h\nu/(z+1)$ per $(z+1)^2$

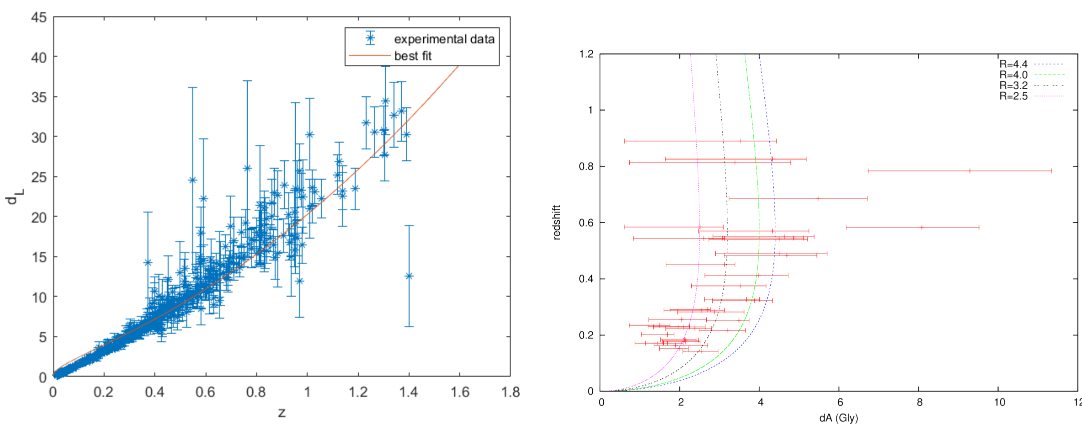
units of surface per $(z+1)$ units of time. Therefore the luminosity of the object in the observer's referential is $L_{obs} = L/(z+1)^4$. As in a flat universe, the measured flux follows the inverse square law, we have that

$$F_{obs} = \frac{L}{4\pi d^2 (z+1)^4}. \tag{10}$$

We can now relate our distance and the luminosity distance by the formula

$$d_L = d(z+1)^2. \tag{11}$$

Let us point out that the Etherington-Ellis reciprocity theorem does not hold in this situation: since $d = d_A(z+1)$, we have that $d_L = d_A(z+1)^3$. However, the different fits that we perform, both using the luminosity distance and the angular diameter distance seem to indicate a concordance between our results and observations. In figure (4a), we performed a fit of data using the Union 2 catalog [14]. The same general trend is observed between the theoretical curve and the observational data, but the fit for small values of z is not satisfying. This tension may be due to the fact that we considered a perfectly spherical universe, and did not consider possible small asphericity at a large scale, or more local geometry of spacetime, that surely affects the value of the redshift. In particular, we did not take into account the gravitational influence of the solar system, our galaxy or any other local structure. For larger distances, this effect may become negligible. For this reason, we discarded the closest galaxies and performed the χ^2 test only for the 257 most distant galaxies of the catalog, and the best fit is obtained for a value of R of around $R = 2.67$ Gly. That corresponds to a cosmological horizon at a distance $D = R\pi = 8.4$ Gly. This distance is of the same order of magnitude as estimates of the age of the universe in the standard model of cosmology [15]. In the right hand side of figure 4, we also plotted different fits for the angular diameter distance/redshift relation, where the data are taken from the hydrostatic equilibrium model in [18]. More precise analysis of this relation, taking into account a more realistic geometry of spacetime still needs to be performed.



(a) (b)

Figure 4: Left: Best fit of the model using the 257 most distant supernovae of the catalog. The best χ^2 fit is obtained for $R = 2.67$ Gly. Right: Comparison between theoretical curves and angular diameter distance data, for different values of R.

3.3 On the CMB

The Cosmic Microwave Background is a radiation detectable in all regions of the universe that has the property of being very regular in all directions in space, just showing some small anisotropies distributed with privileged angle scale [16]. The observed spectrum has a maximum of emission at $\Lambda \approx 2\ mm$, and is highly compatible with a black body that emitted light shortly after the big bang [23]. The existence and characteristics of the CMB is thought to be a strong evidence for a big bang scenario since it fits very well the predictions of ΛCDM [23], although very recent data analysis have pointed stronger and stronger tensions in this standard model [20]. The aim of this section is to show that the theory developed here may also be compatible with these observations.

3.3.1 Over the horizon

Until here, our study has been limited to distances smaller that $D = \pi R$, that corresponds to the apparent cosmological horizon. However, once the horizon passed, light continues its journey and the observer can see events from over the horizon. The area of the observation surface starts growing again and decreasing until degeneration and repeat this oscillatory pattern. In fact, we can extend our definition of distance to events over the horizon, so that it corresponds intuitively to the length of the trajectory of a photon from the object to the observer. The scaling factor is then given by:

$$a(d) = \left| \frac{R \sin(\frac{d}{R})}{d} \right|.$$

The absolute value is taken, because we do not consider orientation of lengths that might be inverted. The redshift observed for these objects is the following :

$$z(d) = \left| \frac{d}{R \sin(\frac{d}{R})} \right| - 1.$$

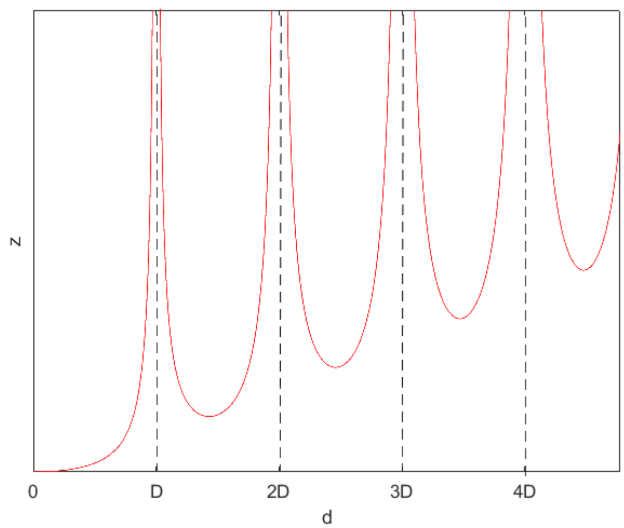


Figure 5: Evolution of the redshift with distance

In this static universe, we cannot explain the CMB by an extremely hot black body that emitted light in a primordial state of the universe. The radiation must be made out of light emitted by standard cosmological objects. Just by looking at the evolution of z, we can characterize two classes of sources that produce highly redshifted light, which could contribute to the CMB :

-Very old objects whose radiation has travelled around the universe many times before arriving to us, at huge distance from us. This type of sources will be refered as class 1.

-Objects that emitted the perceived light in the region of one pole of the 3-sphere (our current position or its antipode), whose distance is near a multiple of D. This type of objects will be refered as class 2.

We assume that the contribution of type 2 objects does not make up the essential of the microwave background, their proportion being negligible compared to type 1 objects. If we assume a homogenous universe, the global contribution in light of the infinity of highly redshifted type 1 objects would create a highly regular background radiation, with no privileged direction in the sky, that provides an insight into the eternity of the universe. The precise shape of the resulting spectrum will be discussed later.

3.3.2 Anisotropies

We must now explain the different levels of primary anisotropies of the radiation. We stated in the previous section that the global light emission of class 1 object should make up a very regular background, leaving no place for irregularities. These small perturbations could be explained by the presence of type 2 object (mostly galaxies) in the pole regions. Their highly redshifted light adds to the regular background and leaves some trace. Each pole, at different times, contributes to one level of anisotropy and explains the peaks in the angular power spectrum of the CMB temperature anisotropy. To formalize this mathematically we will first assume that the emission spectrum of a galaxy is centered around a most intense wavelength λ_0, with associated intensity I_0, quantities that we assume to be the same for every galaxy. We will also assume that the power spectrum of the CMB is reduced to its strongest wavelength Λ. These strong restrictions should still provide a model that is relevant for the study that we want to make, that is the characteristic angular scales of the anisotropies. To add to the regular background of wavelength Λ, the received light must also have wavelength Λ, and so the source must be at a distance d that satisfies the equation $\frac{\lambda_0}{a(d)} = \Lambda$, that is :

$$\lambda_0 \left| \frac{d}{Rsin(\frac{d}{R})} \right| = \Lambda \iff \frac{\lambda_0}{\Lambda} d =\mid R\sin(\frac{d}{R}) \mid . \tag{12}$$

Let us denote d_k and d'_k such solutions, ordered by increasing value.

For any k, d_k is typically close to one pole that we will call the pole k, that is at distance kD from us. The function $\frac{\lambda_0}{a(d)}$ is such that for any solution d_k, a nearby distance d'_k is also solution to equation 12. This is due to the 'bouncing' of the observation surface near a pole. These distances correspond to distances to the pole k of $l_k = kD - d_k$ and $l'_k = d'_k - kD$. Replacing in equation 12, we have that :

$$\begin{cases} \frac{\lambda_0}{\Lambda}(kD - l_k) =\mid R\sin(\frac{l_k}{R}) \mid \\ \\ \frac{\lambda_0}{\Lambda}(kD + l'_k) =\mid R\sin(\frac{l'_k}{R}) \mid \end{cases} , \tag{13}$$

But as l_k and l'_k are typically small compared to R, $\mid R\sin(\frac{l_k}{R}) \mid\approx l_k$ and $\mid R\sin(\frac{l'_k}{R}) \mid\approx l'_k$ so that the equation is equivalent to :

$$\begin{cases} \frac{\lambda_0}{\Lambda}(kD - l_k) = l_k \\ \\ \frac{\lambda_0}{\Lambda}(kD + l'_k) = l'_k \end{cases} , \tag{14}$$

Finally :

$$\begin{cases} l_k = \frac{kD}{\frac{\Lambda}{\lambda_0}+1} \\ \\ l'_k = \frac{kD}{\frac{\Lambda}{\lambda_0}-1} \end{cases} , \tag{15}$$

And as $\frac{\Lambda}{\lambda_0}$ has a big order of magnitude (around 10^4), l_k and l'_k correspond roughly to the same distance to the pole k, that we will call again l_k :

$$l_k = \frac{\lambda_0 kD}{\Lambda} \tag{16}$$

We see that l_k is growing linearly with k. Now that we have found the typical distance to the pole of these objects, we can estimate at what characteristic angle we are observing two of these dots. Let us call ξ the characteristic distance between two galaxy centers, in local coordinates. In fact, as the spectrum of both CMB and galaxies comport a wide range of wavelength, and galaxies can be quite heterogenous, galaxies that are not exactly at this distance but not too far would also leave some trace on the map, so ξ would rather be a parameter that depends on the density of galaxies in the region. The characteristic angle at which we observe two of these dots is given by :

$$\theta_{0,k} = \frac{\xi}{Rsin(\frac{l_k}{R})} = \frac{\xi\Lambda}{\lambda_0 kD}. \tag{17}$$

But as the surface of observation bounces on the pole, objects associated to d'_k also leave some trace, and this light, that has roughly the same characteristics as the first image (because they are roughly at the same distance l_k from the pole) also adds to the general background. If we suppose that the repartition of objects at d_k and d'_k are independent, we get that the characteristic angle at which we observe two of the dots for this pole is :

$$\theta_k = \frac{\theta_{0,k}}{2} = \frac{\xi\Lambda}{2\lambda_0 k D}. \tag{18}$$

These angles should correspond to the peak values in the anisotropy power spectrum, that is often expressed in term of multipode moment L_k:

$$L_k = \frac{\pi}{\theta_k} = \frac{2k\pi\lambda_0 D}{\Lambda\xi}. \tag{19}$$

Equation (19) shows a linear relation between L_k and k that is compatible with the results of the Plank collaboration [23]. We have made some approximations in our computations and quite strong restrictions to arrive to this result: in reality, the spectra of both galaxies and CMB are composed of a large band of wavelengths. Moreover, the characteristic distance between two galaxies depends on the local distribution of galaxies, that may not be the same for every pole region. In particular, the presence or not of a local group or a cluster of galaxies in the region of a pole can give significantly different values for ξ, and so for L_k. These facts can explain the eventual deviations between theory and observations.

Let us now compute the predicted order of magnitude of L_k to check the compatibility with observations. $\Lambda \approx 10^{-3}m$ and if we take $\lambda_0 \approx 7.10^{-7}m$, the ratio $\frac{\lambda_0}{\Lambda}$ has a value close to 7.10^{-4}. We have found that the value of D is approximately equal to $10^{10}ly$, and ξ is quite hard to estimate, but is of the order of a few tenth of Mpc in our local group [24], that is $3.10^5 ly$. The ratio $\frac{D}{\xi}$ with this value of x is 3.10^4, so we have that $L_k = \frac{2k\pi\lambda_0 D}{\Lambda\xi}$ is a few hundred times k. The orders of magnitude of the peaks locations and the gaps between them are compatible with the results found by the Planck collaboration [23], although a more detailed analysis is required.

3.3.3 Black body spectrum

Let us now discuss the observed spectrum of this radiation. So far, we have considered distances less than a few times D and assumed that photons were travelling along great circles of the 3-sphere. These assumptions may be relevant for nearby distances, but the more a photon has to travel to reach us, the more likely it is that its trajectory has been reflected or deviated by gravitational effects. In such cases, the relation between distance and redshift is not so clear anymore. Moreover, the longer a photon has to travel to reach us, the more likely it is that it will be absorbed by dust or other cosmological objects, having a dramatic effect on luminosity. These combined effects are such that after a certain distance, light arriving to us is so degraded that it has lost all structure and information about its origin. The essential of the CMB should be composed of such highly redshifted photons that have travelled an immeasurable amount of time in the intergalactic void before hitting our measurement device, and we make the conjecture here that the resulting spectrum of this radiation should be completely randomized and resemble thermal radiation.

4 Conclusion and comments

We have performed a detailed analysis of the notions of perception and measurement in general relativity, introducing an referential based on the observer that constitutes a representation of the physical world that he can comprehend and in which he can perform measurements. Such considerations turn out to be consistent with large scale observations, such as redshift/distance relation and the existence and characteristics of the CMB. It is also able to clear away questions raised by the existence of an initial spacetime singularity, and a dark energy that derives the galaxies dramatically away. More detailed theoretical works together with more complete data-based studies and a careful analysis of the CMB in the context of a static universe of spherical curvature could bring more support to this theory and refine estimations of the radius of the universe. Several complementary predictions could be verified experimentally on the short and longer run: the temperature of the CMB should not vary in time (it should be the case in the standard model), and the dots in the different levels of anisotropies of the CMB should move with a characteristic speed, as the objects they represent were moving when they emitted the light. The new generation of telescopes that will soon observe the highly redshifted universe could discover some large galactic structures, compatible with this model.

The statement that lengths and durations are not absolute properties of the observed object but depend on the referential in which they are measured is well established since the development of relativity. The relativity principle is here extended to distant objects in curved spacetime geometry, due to an Euclidean projection of the curved spacetime. We stress that this approach introduces a fundamental duality: the observer creates its own representation of the physical world that matches his everyday experience. This is reminiscent of quantum mechanics, where there is a world of non-locality, superposition and fuzziness that seems in contradiction with the world of observation that is composed of actual objects that are localized, separated and which can be apprehended.

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