3D MAP OF THE UNIVERSE - A BIG MISUNDERSTANDING (Wrong interpretation of the observable part of spacetime - distant galaxies are neither as old nor as big as we think)

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Abstract

It is impossible to create a correct 3D map of the observable part of the universe due to the fact that what we see around us is not a three-dimensional space. Each object we observe is distant from us not only in space but also in time. What we see is a fragment of spacetime, and if we try to imagine it as a three-dimensional space, various deformations and incorrect determinations of distances and sizes of distant objects occur.

Regardless of whether real space is curved or flat, the observed part of the universe can be modeled as system of spheres (which differ in the time it took for the light to reach us from a given sphere) distributed in a certain way in spacetime. In order to correctly imagine the observable part of the universe, a four-dimensional map is necessary. In this paper, I present one possible solution for constructing a 4D map of the universe. One may be surprised at how big the differences can be in comparison to a 3D map, which treats the observable part of the universe as three-dimensional space.

1 Introduction

There has appeared an information on the Internet that scientists have released the most accurate 3D map of the universe in history [3], [1] (credit: Berkeley Lab using data from DESI).

I would like to point out that what we see around us is not a 3D space and, therefore, it is not possible to create correct 3D map of the observable part of the universe.

Each object we see is distant from us not only in space but also in time. What we see around us is not three-dimensional space, but a certain part of spacetime.

In an expanding universe, the path of light through spacetime is curved, and space is constantly expanding, so the length of the light path from an object to an observer does not correspond to the distance from the object to the observer in space. In the case of objects that are very distant in time, at the time of sending the signal, the distance of objects in space from the place of the observer was very small (the present distance does not matter - the observed objects may no longer exist).

Immediately, there is problem with placing distant objects on a 3D map. If we place them at a distance corresponding to their distance in space at the moment of sending the observed light, they will be close to the observer, and in this case, we must assume that the light does not reach the observer along the shortest rectilinear path. If, on the other hand, we place them at a distance corresponding to the length of the light path from the object to the observer, then the distant areas will be stretched just as distant areas on a flat map of the globe are stretched. (Consequently, this leads to erroneous conclusions about the lack of matter, about the impossibility of contact between very distant objects seen at high angles, etc.) A four-dimensional map is needed to correctly imagine the observable part of the universe.

It is worth noting that the observable part of the universe looks almost the same, regardless of whether the real space is curved or not [6]. We can imagine the entire observable part of the universe as composed of spheres (which differ in the time it took for the light to travel from a given sphere to us), where each sphere can be as much a part of three-dimensional flat space as it can be a part of the surface of a four-dimensional sphere (or part of something else).

In this paper, I present one possible solution for constructing a 4D map of the universe. Regardless of whether my solution is right or wrong, the 3D map cannot be right and leads to misconceptions about the universe and its evolution.

2 Shape of the observable part of the universe

If we assume that what we see around us is a three-dimensional space, then it seems to us that the observable universe is spherical and at the greatest distance on a huge sphere, there are objects from which light has traveled to us for over 13 billion years. Due to the fact that the universe is expanding, at the moment, the radius of the observable universe, is assumed to be about 46 billion light years [5].

There is an impression as if beyond the border of the observable universe there was a space in which there are objects whose light has not reached us yet, but will reach us in the future (or will never reach us) [7].

If we assume that around us there is a flat three-dimensional space that is expanding, we come to a conclusion that objects seen at a great distance at a high angle cannot be in any contact with each other [8].

The situation looks completely different, if we realize that each observed object is distant from us not only in space but also in time. What we see around us is not three-dimensional space but a fragment of spacetime. The entire observable universe can be divided into spheres that differ in the radius in space and the time that the light needed to reach us from a given sphere.

Firstly, it is important to realize that spheres look the same, regardless of whether the space is curved or flat. A sphere cut from flat three-dimensional space looks the same as a sphere cut from the surface of a four-dimensional sphere.

Secondly, we have to realize that if the universe is expanding, it must contract when we go back in time. This means that the oldest spheres that seem huge to us, must be small. At the greatest distance in all directions there is the same point - the beginning of the universe [6].

Most people have trouble with imagining four dimensions. You can restrict yourself to a smaller number of dimensions, but you need to correctly combine the results of considerations with observation. If we restrict ourselves to two spatial dimensions, this means that we limit our observations to objects that are in the "one plane" that intersects the universe and contains the observer. I put the expression in "one plane" in quotation marks because the plane is only in our imagination, which treats the curved part of spacetime as a flat space. This "plane" is made up of circles that differ in the time it took for the light to reach us from objects in a given circle. If in our imagination we add time as an extra dimension, the circles form a cone. (This cone looks the same regardless of whether the space is curved or flat - circles cut out of the plane are the same as circles cut out of the surface of a sphere.) Taking into account the expansion of the universe, that is, the "contraction" when going back in time, ever older circles must "contract" more and more. The observable part of the universe, in this case, will be a part of the surface of deformed cone that has a vertex at the observer's location and 'closes' at the point 'opposite' to the observer at the beginning of the universe. This 'opposite' point could be seen looking in any direction, if the light from the beginning of the universe could be observed.

Let's try to go even further and restrict ourselves to only one spatial dimension. For the observer, this means that he can look at an object in any direction and restrict himself to a "straight line" (likewise as above, "straight line" is a straight line only in our imagination, which treats the curved part of spacetime as flat space), which connects given object with an observer. In spacetime, the "straight line" is curved. The diagram of the situation is shown in Figure 1.

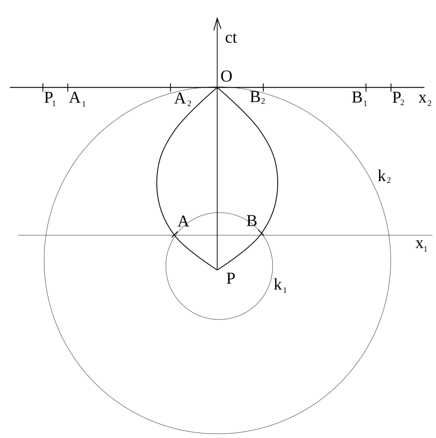

Figure 1:

In Figure 1, the observer is at point O. For the observer O, time runs from point P upwards. One-dimensional space can be flat (line x_2) or curved (e.g. circle k_2). In each case, the observer sees only one point from it, the point where he is located, and there is no possibility to directly check whether the space is curved or not. Everything he sees further away is also away from him in time.

The observable part of his universe is on two curves OAP and OBP (the shape of the curves only slightly depends on whether the space is curved or not). It is only necessary to realize that the observer does not see any curves, but the light that at the moment has reached the point O (and is at a distance of zero from it). On the basis of nerve impulses, which were caused by irritation of the retina with incoming photons - regardless of whether the space is curved or not - image of flat space is created in brain, as if all the objects that have been seen were on the line x_2 (this is how the observer imagines space).

Since we are considering one-dimensional space, the observer can see only one object on the left and one object on the right (the nearest objects on the OAP and OBP curves). Let's assume that these are the objects marked in Figures A and B.

If the observer creates a 1D map of the observable part of his universe, he only needs to determine distances at which to place objects A and B on a straight line.

But where to put the image of object A? At the point corresponding to the point A_1 (at a distance corresponding to the length of the light path from object A to the observer) or at the point A_2 (at the distance of the object A from the observer in space, disregarding the distance in time) or somewhere else?

In the case of one-dimensional space, it is not visible what deformations occur during construction of the map. It is quite clear, however, that the map will correspond to reality only to the distance where points A_1 and A_2 are close to each other.

In practice, there is an additional problem of how to determine the distances OA_1 and OA_2.

3 Determining the distribution of objects in spacetime

From observing the curved part of spacetime, it is not possible to directly determine whether the space is curved or not. The observable part of the universe looks very similar in both cases. There are arguments for both options. However, nothing stands in the way of analyzing both possibilities and trying different variants. (One could, for example, try to model the universe with cellular automata [9] or some other way.)

Personally, I'm inclined to believe that space is curved. My opinion is based on the belief that time and space are bound together in spacetime in such a way that it is impossible for space to increase more than the amount of time increased, which also implies that in finite time space must also be finite.

Einstein's equations describe the relationship between the curvature of space and mass, but space can also have curvature independent of mass (this is also one of possible interpretations of the cosmological constant in Einstein's equations).

In this paper, I focus on the analysis, assuming that the universe is a four-dimensional sphere whose radius increases in the Planck time t_P by the Planck length l_P. I have already dealt with this topic in the paper [4], but at that time, I was unable to calculate the propagation of light wave on the surface of an expanding four-dimensional sphere. However, only specific calculations make it possible to compare the model with observational data.

Let's check, therefore, what will be the distribution of objects in spacetime in our model and what light will reach the observer from them.

In order to make calculations, we will make the following assumptions:

1. we assume that the universe is in the shape of a four-dimensional sphere which at Planck time 1 t_P had radius of Planck length 1 l_P.

2. time increases "by leaps" by the value of Planck time t_P, and, at the same time, the radius of the universe increases by leaps by Planck length l_P.

3. light spreads across the surface of a sphere in all directions with the speed of Planck length l_P in Planck time t_P.

We still need some assumption that will allow us to determine the distance of the observed object on the basis of the observed light. Therefore, we assume:

4. As the universe expands, the wavelength of light increases in proportion to increase of the radius of the universe.

We can conduct the analysis for any moment. In this paper we assume that:

5. we analyze the universe at its age of about 13.8 billion years, particularly in the time of 8.073×10^{60} t_P.

On our assumptions, we can accurately calculate the shape of the observable part of the universe, that is, determine the distribution of the observed objects in spacetime.

In order to determine the location of a particular object, we do not need to study four-dimensional spacetime, but we can restrict ourselves to a cross-section through the universe, even just to the "line" connecting the observer with a given object. In this case, it is enough to restrict ourselves to a two-dimensional model of spacetime, in which the space will be an expanding circle.

I described such a model in the paper [4]. I will repeat some of my considerations here, but this time, we will develop the topic a little more broadly.

How light spreads during the first 4 t_P in such spacetime is shown in Figure 2.

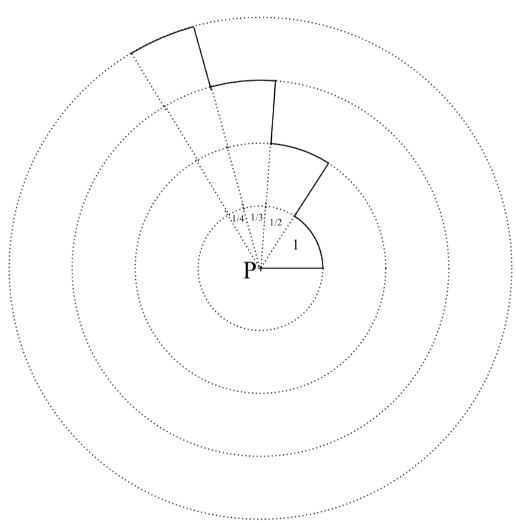

Figure 2:

At time 1 t_P spacetime has a radius of 1 l_P, and the light will travel a distance of 1 l_P, that is, it will travel a distance round the circumference of a circle corresponding to angle of

1 radian. During the second t_P, the light travels a distance of 1 l_P round the circumference of a circle of radius 2 l_P, that is, corresponding to angle of ½ radian. In the third t_P, the light travels a distance of 1 l_P round the circumference of a circle of radius 3 l_P, that is, corresponding to angle of 1/3 radian, and so on.

It can be seen that the angles corresponding to the distances that the light will travel round the circumference of expanding circle in individual steps form a harmonic series (which diverges to infinity), that is, the light will manage to reach any other point in space in a finite time from any point in space. (There are no causally disjoint areas.)

Now let's check what an observer located on a circle with a radius of 8.073 $\times 10^{60}$ l_P will see. From present space (a circle with a radius of 8.073 $\times 10^{60}$ l_P), he can see only two points (in opposite directions) at a distance of 1 l_P [distance corresponding to an angle of 1/(8.073 * 10^{60}) radian].

Further, we will restrict ourselves to only one direction (in the opposite direction everything will be analogous).

From space at time (8.073 $\times 10^{60}$ -1)t_P (i.e. on a circle with radius (8.073 $\times 10^{60}$ -1)l_P) the observer can see (assuming it is not obstructed by some closer object) a point in a position corresponding to the angle 1/ (8.073 $\times 10^{60}$) + 1/ (8.073 $\times 10^{60}$-1) radians. In this way, step by step, we can calculate the next points from which the light can reach the observer at a given moment. Figure 3 shows a part of spacetime in which the beginning of time is at point P and the observer is at point O. Some points from which light can reach the observer at a given moment are marked with crosses.

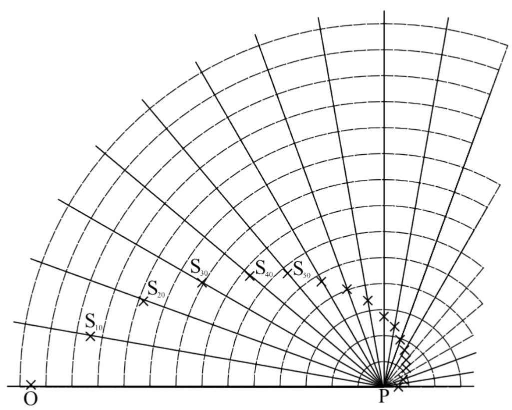

Figure 3:

How to calculate the location of a given object in spacetime will be shown on the example of the GN-z11 galaxy.

Again, we will restrict ourselves to a section through the universe, that includes the observer and the given galaxy (we should say "a section through the observable part of the universe, which we imagine as three-dimensional space").

Let's imagine the time axis perpendicular to the section plane. The beginning of time will be at a distance of 8.073 $\times 10^{60}$ l_P from the observer. A photon that reached the observer at a given moment covered only a distance of 1 l_P in his present space. Previously, it covered a distance of 1 l_P in a space with a radius of 8.073 $\times 10^{60}$ -1 l_P, etc. To determine radius of the sphere on which the observed object was located at the time of emission of the observed light, we will use change in the wavelength of the observed light (redshift).

The redshift of the galaxy GN-z11 is z = 11.1. If the radius of the universe during the observation is R_o, and the radius of the universe at the time of light emission is R_e, then according to our assumption [4] z = R_o/ R_e -1. For z = 11.1 and R_o = 8.073 $\times 10^{60}$ l_P, we get R_e = 8.073 $\times 10^{60}$ / 12.1 = 6.6719 $\times 10^{59}$ l_P (approximately). We get the radius of the universe at the time of emission of the signal (6.6719 $\times 10^{59}$ l_P), and, at the same time, the time that has elapsed since the beginning of the universe to the time of emission of the observed light (6.6719 $\times 10^{59}$ t_P), which is approximately 1.14 billion years (in contrast with the 0.4 billion years given in e.g. [2], which leads to doubt where the galaxy came from in such an early universe).

Due to the fact that angles corresponding to the distances that the light will travel round the circumference of the expanding circle in individual steps, form a harmonic series, we can accurately (with an accuracy of l_P) calculate the trajectory along which the photon reached the observer and the location of the observed object at the time of emission of the observed light.

According to our assumptions, if a photon from the beginning of the universe had been moving unrestrained in one direction round the circumference of an expanding circle, the radius of which is increasing by 1 l_P for every 1 t_P, until today it would cover the angle of

$\sum_{n=1}^{8.073*10^{60}} 1/n$ radians.

The angle between the observer and the GN-z11 galaxy during the emission of the observed light signal is obtained as

$\sum_{n=6.6719*10^{59}}^{8.073*10^{60}} 1/n$

which is approximately 2.49 radians, or 142.7 degrees, see: Figure 4.

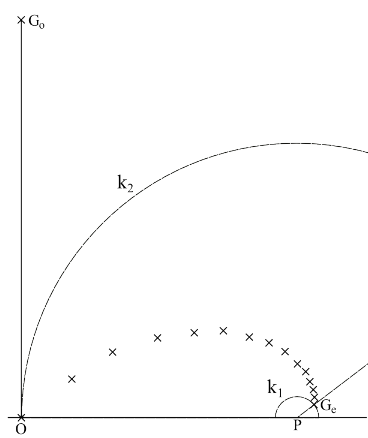

Figure 4:

In Figure 4, O is the observer, P is the beginning of time and the centre of spacetime, k_2 is the arc that is a part of present space, k_1 is the arc that is a part of space at the time of emission of the observed light signal, G_e is a cross on k1 which designates the location of the observed galaxy at the time of emission of the observed light signal (angle OPG_e is 2.49 radians), G_o is the cross which designates the location of the observed galaxy in viewer's imagination .

The observer sees only the light that has a distance of zero from him, and he imagines the observed object in flat space and that the object is located in the direction from which the light comes to him. In the figure, the light comes from above (however only on a section of the Planck length), and the observer imagines the observed object in this direction.

4 Observed brightness of distant objects

If we make a mistaken assumption that we observe three-dimensional, flat space, we also make mistaken assumption that the brightness of objects decreases along with increasing distance. We use cosmic distance ladder which can be very confusing. As a consequence, we get various accelerations, decelerations, and reaccelerations of the expansion of the universe.

If we make an assumption of similar absolute brightness of Type Ia supernovas, then let's see what will be their brightness that is observed for different locations of supernovas in spacetime.

Suppose we observed Type Ia supernova in the previously considered GN-z11 galaxy. We need to determine how a wave of light propagates through spacetime. Now it is no longer enough to make a cross-section of the universe, but we have to consider four dimensions.

First, I will show how the light spreads over the surface of a four-dimensional sphere. See: Figure 5.

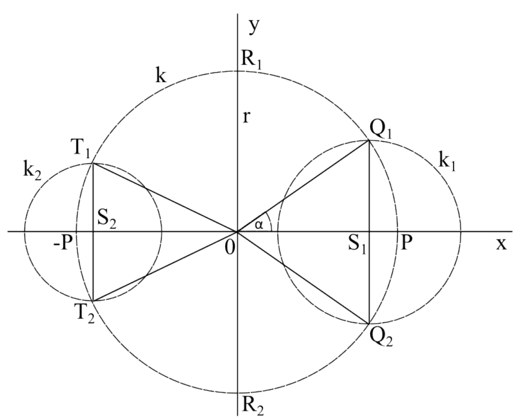

Figure 5:

We have a four-dimensional sphere with a radius of r and an XYZW coordinate system that has its origin in the centre of the sphere. Equation of the surface of sphere will then look like this:

$x^2 + y^2 + z^2 + w^2 = r^2$

In Figure 5, circle k represents a section through the sphere with xy plane. If at point P on the surface of a sphere a light signal is generated, it will propagate as a spherical wave upon the surface of a four-dimensional sphere. At the moment when the light reaches point Q_1 (and, at the same time, point Q_2), in the xy plane, a photon has traveled along the circle k the distance corresponding to the angle α. Radius of the spherical wave of the light will now be $r * sin\alpha$ (a cross-section through the surfaces of the sphere for $x = r * cos\alpha$). If there was an observer at Q_1, the observed brightness would correspond to the observed brightness at distance $r * sin\alpha$ in flat space.

The radius of the spherical wave of the light will increase until it reaches r (the radius of a four-dimensional sphere), and then it will decrease. The observed brightness at the moment when the light reaches points T_1 and T_2 will be as large as if the light signal came from the distance T_1S_2 in flat space.

Calculations for an expanding four-dimensional sphere can be done analogously. Let's go back to our example with the GN-z11 galaxy. Figure 6 shows the situation.

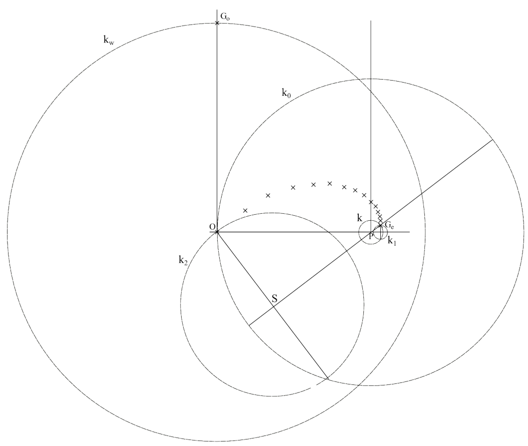

Figure 6:

In Figure 6, the observer is at point O on the circle k_0, which represents a cross-section through the present space (the surface of a four-dimensional sphere). The galaxy GN-z11 is located in the Figure 6 at the point G_e on the circle k, which presents a cross-section through the space during emission of the observed light signal. A spherical wave of light spreading from the moment of emission over the surface of an expanding four-dimensional sphere will have a radius of OS at the moment of reaching the observer O (in the figure, the circle k_2 presents a cross-section through the three-dimensional sphere corresponding to the spherical wave of light at the moment of reaching the observer O). It follows that if there were no depletions in brightness (caused, for example, by cosmic dust), the observed supernova brightness in the GN-z11 galaxy would be the same as if it was observed at OS distance in flat space.

We still have to think about how to combine our calculations with observation. Not violating the generality of the conclusions, we can assume that at the time of observation the observed galaxy GN-z11 is located directly above the observer. In the figure, the point G_o corresponds to this location. If the observer sees objects of the age of GN-z11 somewhere in the sky, at the time of emission of the observed light, they must have been on the sphere (which is a cross-section through the surface of a four-dimensional sphere) containing GN-z11 at the time of emission of the observed light.

In Figure 6, circle k1 presents a section through such a three-dimensional sphere. In the special case, if some luminous objects were located on the circle k_1, then the observer would imagine them on the circle k_w. (Again, the observer sees neither present space nor can he look in the direction of time. All he sees is the light that has reached his eye, and from this he forms an idea of flat three-dimensional space.)

5 The influence of matter on the shape of space and the propagation of light

Until now, we have thought of space as smooth surface of an expanding four-dimensional sphere, and we have not taken into account the relationship between matter and the curvature of space. In our model, the simplest way is to assume that time runs slower in places with a higher concentration of matter (with greater gravity). This will create “holes” on the surface of sphere. Under the influence of the expansion of space, there will also occur very ”empty” areas where time will accelerate, compared to areas with an average content of matter. The spread of light over such an undulating surface will be more complicated, and we will not analyze it in this paper. We just have to remember that it can cause some disturbances, and some corrections in calculations may be needed.

6 Summary

It is impossible to create a correct 3D map of the observable part of the universe due to the fact that what we see around us is not a three-dimensional space. We straighten a curved piece of spacetime in our imagination, and from the resulting deformations we create erroneous images of the universe.

In order to create a correct image of the universe, it is necessary to properly interpret data about the observed objects as objects in spacetime.

In this paper, I present one possible solution for constructing a 4D map of the universe. I made some assumptions that seemed reasonable to me and led to promising results (no cosmic inflation needed, no dark matter or dark energy needed, no horizon or causally disjoint regions, no Hubble constant problem, etc.). I tried to present a relatively simple image and I omitted some problems that would require a more detailed discussion. If you are interested in more detailed information, visit my website: improbable.info or write me an e-mail at the following address: jiri.szrajer@gmail.com.

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