Solution of the Horizon Problem

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Kurzfassung

In unserem Beitrag stellen wir eine Lösung des seit 1970 bekannten Horizontproblems vor, welches die Frage aufwirft, wie die Lichtwellen seit dem Zeitpunkt des Urknalls den Horizont des expandierenden Universums thermalisieren konnten. Unser Lösungsweg bedient sich Berechnungen, Diagrammen, sowie eines eigens entwickelten Zeitverlaufs. Diesen haben wir bereits in dem Beitrag „Solution of a Density Problem in the Early Universe“ in der Zeitschrift PhyDid B pp. 43-46 (Frühjahrstagung 2020) vorgestellt. In diesem Zeitverlauf nutzen wir dimensionale Übergänge, welche im direkten Zusammenhang zur Größe des Universums und der somit von den Lichtwellen zu überwindenden Distanz stehen. Dadurch können wir darstellen, wie durch die anfänglich großen Dimensionen, die Distanzen gering waren und die Lichtwellen früh den Horizont thermalisieren konnten.

Abstract

In our article we will show a solution for the horizon problem. The problem is known since 1970. It´s about the question how the light waves could thermalize the hole expanding universe since the big bang. Our solution will use calculations, diagrams and a new self-designed time evolution. We had shown this time evolution in the article “Solution of a Density Problem in the Early Universe” out of the journal PhyDid B pp. 43-46 (spring conference 2020). In this time evolution we use dimensional transitions, which are connected to the size of the universe. So it also is connected to the distance which has to be reached from the light. With those methods we can explain how the early big dimensions could take care for the small distances and how the light was able to thermalize the space within horizon.

1. Introduction

Since 1970 the horizon Problem exists. This describes the problem that the General Relativity Theory, GRT (Einstein, 1915), can´t describes how the light waves could thermalize the visible universe since the big bang.

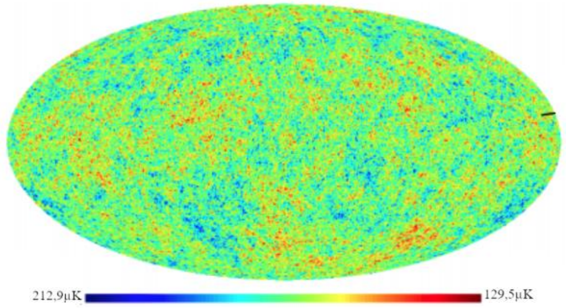

Fig. 1: Cosmic microwave background (Courtesy NASA/JPL-Caltech, Pietrobon 2012, 7 year WMAP)

This Fig. shows the cosmic microwave background of within the light horizon of the years 2001 to 2010. The Nasa indicates that the measurements have temperature fluctuations of maximum 200 micro kelvin. This confirms the horizon problem with the essential fact that the whole space within the light horizon is completely thermalized. In this article we will show different time evolutions and their capability to explain and solve the horizon problem. Our time evolutions show the evolution of the light horizon and the light path which is the covered track of light by time.

2. Methods and Calculations

2.1. Method

To decide whether a time evolution can solve the horizon problem it´s necessary to compare the length of the radius of the light horizon with the length of the light path. Because if the radius of the light horizon is longer than the light path, the light waves weren´t able to thermalize the whole space within the light horizon because they didn´t cross it completely. But if the lightpath in any time is equal or longer than the radius of the light horizon the light waves have crossed the whole light horizon and have thermalized it. So the horizon problem would be solved. This means it's necessary to compare the lengths of the radius of the light horizon and the light path in any time. Because the length of the radius of the light horizon is known (Carmesin, 2019 and Sawitzki with Carmesin 2021) it´s only necessary to calculate the lengths of the lightpath.

2.2. **Definitions and requirements**

For the calculations it is needful to use some known values like the following constants (Fig. 2).

Constants

r_LH	4,14E+26
cc	3,00E+08
L_P	1,62E-35
t_P	5,39E-44

Fig. 2: All used constants. r_{LH} is the current radius of the light horizon, cc the speed of light, L_P the Planck length and t_P the Planck time.

Further requirements for the calculations are the time and associated radius of the light horizon values (Carmesin, 2019 and Sawitzki with Carmesin, 2021). Also we need values to different used dimensions (Schöneberg with Carmesin, 2020) because they have direct influences of the lengths of the light path and radius of the light horizon. Dimensions are like a folded paper. In our third dimension the paper would be folded three times and if the density in our universe is getting higher until a critical density a dimensional transition occurs and the dimension changes into the next higher dimension. So in our example the paper would fold again and the distances between two points get much smaller.

2.3. **Calculations**

To calculate the light path in a special time period it´s necessary to multiply the speed of light with the difference of the start time value and end time value of this period. Because the universe expands since the big bang (Hubble, 1929) and the expanding affects all paths in the universe, it´s required to apply this on the light path. After that we get the expanded light path in a special time period. Because the light didn´t move only in a special period but the whole time since the begin of the universe it´s needful to add all of these periods since the big bang to the time period with the redshifted (Einstein, 1915) recording of the cosmic microwave background together. So now we get the final time path to compare with the radius of the light horizon. (Fig. 3).

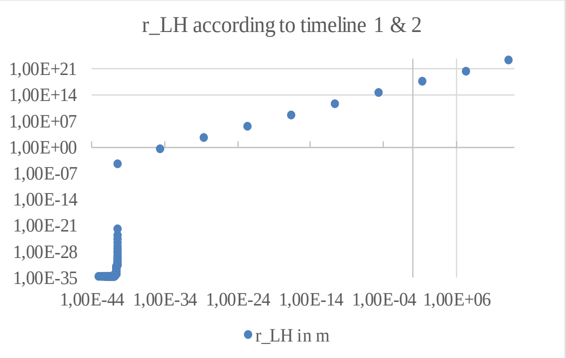

Fig. 3: Diagram of the length of the radius of the light horizon according to the time of the time evolution 1 and 2. The x-axis shows the time in Planck time and the y-axis the matching radius of the light horizon in meter.

2.4 **Evolution of the light horizon**

The evolution of the light horizon is composed of different calculations and time evolutions. So the upper part of Fig. 3 (Fig. 4) is a derivation of the GRT (Heeren, Sawitzki and Carmesin, 2020).

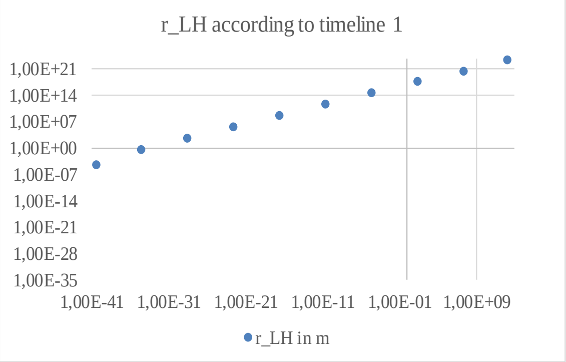

Fig. 4: Diagram of the length of the radius of the light horizon according to the time of the time evolution 1. The x-axis shows the time in Planck time and the y-axis the matching radius of the light horizon in meter.

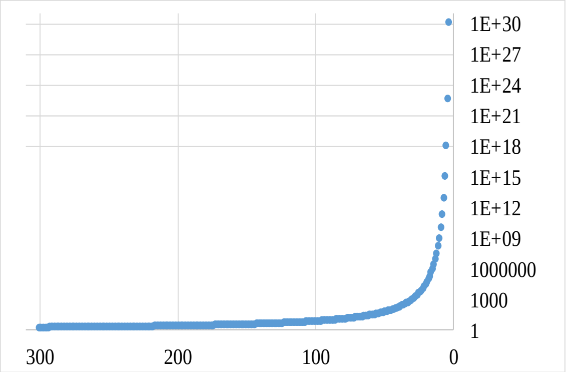

Fig. 5: Graph of the dimensional transitions and matching distance enlargements of the lower part of the graph in Fig. 3. On the x-axis are the dimensions and on the y-axis the length of the light horizon.

The lower part of the graph in Fig. 3 is composed of the time and radius of the light horizon values (Carmesin 2019). Further this part includes dimensional transitions and resulting great distance changes (Fig. 5) (Schöneberg with Carmesin, 2020).

3. **Tested time evolutions**

3.1. **Time evolution 1**

The first time evolution is described of the GRT and a replication of known information to compare it with the other time evolutions. It shows an evolution in the third dimension, which is stopped at a certain point (begin of the upper part of the graph in Fig. 3) because it reached the maximal density, the half Planck density. So this time evolution is limited that it never could reach the minimal observable length (Heeren, Sawitzki and Carmesin, 2020), the Planck length (begin lower part of the graph in Fig. 3). After the use of the explained calculation we can see that the horizon problem isn´t solved by this time evolution. This shows the following diagram (Fig. 6) because every time the lightpath is shorter than the radius of the light horizon.

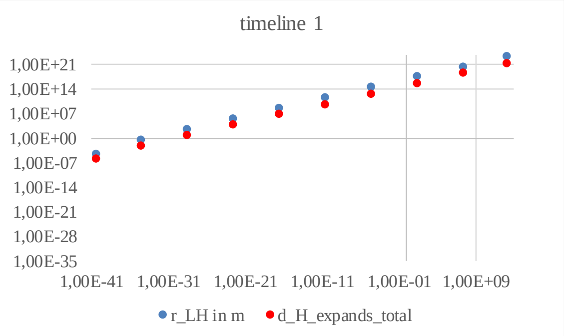

Fig. 6: Diagram of the time evolution 1. The x-axis shows the time in Planck times and the y-axis the length in meter. The blue graph represents the radius of the light horizon and the red graph the light path.

3.2. **Time evolution 2**

This time evolution also describes the evolution of the light horizon according to the GRT. The difference this time is that it also uses the distance enlargements by the dimensional transitions which begins at the 301st dimension and ends at the 3rd dimension (Fig. 5). The values in this time evolution are based on an approximation of two particles (Carmesin 2019). It is important that dimensional transitions always occur at critical densities, this means that this time evolution doesn´t have the problem of the limitation by the maximal density. After the calculations the diagram (Fig. 7) shows us that this time evolution can solve the horizon problem, because the length of the lightpath is always longer than the length of radius of the light horizon.

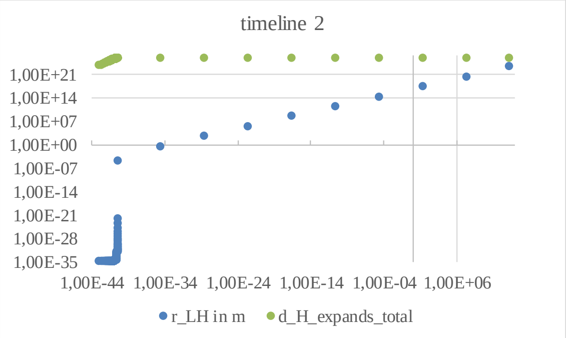

Fig. 7: Diagram of the time evolution 2. The x-axis shows the time in Planck times and the y-axis the length in meter. The blue graph represents the radius of the light horizon and the green graph the light path.

3.3. **Time evolution 3**

The third time evolution describes a nearly similar evolution as the second. So it also describes the evolution of the light horizon according to the GRT supplemented by the dimensional transitions of the dimensions from the 301st to the 3rd. The only difference between those time evolutions is that their values are based on different approximations. So the values of this time evolution are based on a quantum gas which is a gas of quantum objects. Normally there are two quantum gases, the Fermi gas and the Bose gas. The Fermi gas is out of fermions and the Bose gas includes bosons. The difference is that much bosons can fill the same place but only one fermion can be in one place in the same state. Because the phase of dimensional transitions is in a density above a quarter Planck density also bosons can only stay solo in one place and the difference between the both quantum gases disappears. That means that the values don´t change by using different quantum gases and we can use these values according to an approximation of a Bose gas. The use of values with such an approximation enables the possibility of any accuracy which is in that case one with $2^{\text{Dimesnion}}$ particles. Because the calculation of the values needs much time we currently have the values of the dimension 3 to 32 (Sawitzki, Carmesin 2021). So probably the length of the light path will increase a lot, after adding the other values of the dimensions 33 to 301. But even without them, after calculating the light path, we can see that at the beginning the lightpath is much longer than the radius of the light horizon (Fig. 8). Furthermore, we can see that after a while the light horizon gets larger than the lightpath. But for the solution of the horizon problem it doesn´t change anything because if the lightpath is in some time larger than the radius of the light horizon the light has thermalized it. Even the light horizon gets larger by expanding, all distances in it will expand too and because all distances which get larger are thermalized, all new distances are also thermalized.

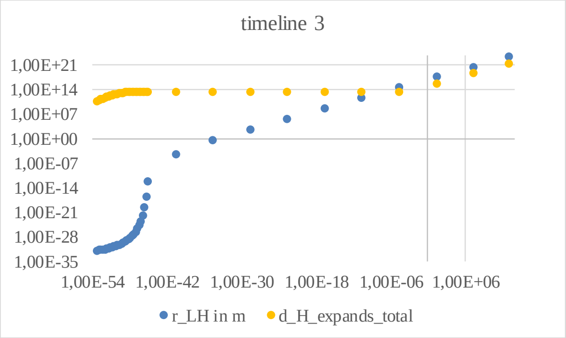

Fig. 8: Diagram of the time evolution 3. The x-axis shows the time in Planck times and the y-axis the length in meter. The blue graph represents the radius of the light horizon and the yellow graph the light path.

4. **Solutions**

The check of time evolution one to three shows that the time evolution one only according to the GRT can´t solve the horizon problem and meanwhile confirm it. But because in that case we got the same solution than the known information’s, we know that our calculations method was right. Also we got the solution that the time evolutions two and three which uses the GRT supplemented by the dimensional transitions can solve the horizon problem. This shows clearly that the solution of the horizon problem is provided by the dimensional transitions. Because the dimensional transitions are part of the quantum gravity we can conclude that the limitation of the GRT to the gravitation in the macrocosm is the cause of the horizon problem.

5. **Discussion of results**

The accuracy of the solution is very important. So the time evolution two has a limited accuracy because its values are based on an approximation of two particles. But because of the approximation of the time evolution 3 which is based on a Bose gas we know that the horizon problem is also solved at a high accuracy.

6. **Literature**

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