# Dynamics in the Early Universe

**Jonas Lieber[1] and Hans-Otto Carmesin[1,2,3]**

[1]Gymnasium Athenaeum, Harsefelder Straße 40, 21680 Stade
[2]Studienseminar Stade, Bahnhofstr. 5, 21682 Stade
[3]Universität Bremen, Fachbereich 1, Postfach 330440, 28334 Bremen
jonas.lieber@athenetz.de, hans-otto.carmesin@t-online.de

**Kurzfassung**

In diesem Beitrag setzen wir uns mit der Dynamik des frühen Universums auseinander. Dafür werden wir uns eine einfache Gleichung zur Berechnung herleiten und wir werden eine Methode zur Berechnung aufzeigen. Im Anschluss werden wir dann unsere Methode überprüfen und unsere Ergebnisse interpretieren. Anhand der Interpretation werden wir noch mögliche Verbesserungen und Anwendungsbereiche diskutieren.

**Abstract**

In this paper we treat the dynamics of the universe and we will derive an equation. The derivation is intended to show that the equation can be solved and we will test whether the results obtained contain errors. In the last part of the essay we will discuss the possibilities how our program can be used and in which cases it makes sense to use it.

## 1. Expansion of the universe

We will take a closer look at the expansion in the early universe. To do this, we calculate the extent of the Light Horizon over time, the largest distance we can observe on earth.
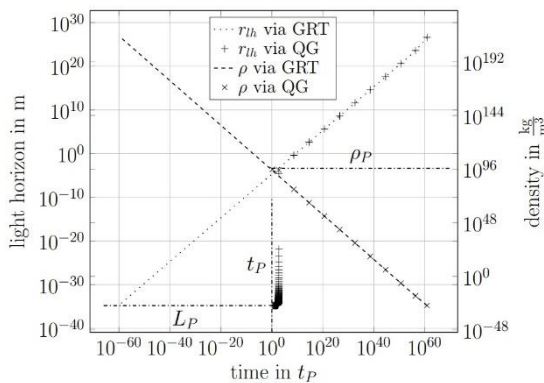


**Fig.1:** Graph that shows the evolution of the density and the extent of the Light Horizon in our universe (Carmesin (2021)).

Since equations can change throughout multiple factors, we will look at the Planck era and will look for an equation here.

To receive an equation that we can use later, we look at a ball with a radius that can be used as a model for our universe. For further additions, we need a formula that also depends on the density $\rho$ as it is not constant. We also need an equation that is not fixed in one dimension D. We use the following formula (Carmesin (2021)):

$$a = (2 * \rho)^{-\frac{1}{D+1}} \quad \{1\}$$

The dimension D changes at critical densities but is constant in the time periods between the transitions. In the next step, we take the derivative of equation {1} by time and by $\rho$. As we want to look at $\rho$ and its time evolution we have to combine both of those equations.

The derivation of a by $\rho$ can be calculated very quickly. For this we charge

$$\frac{da}{d\rho} = \left(-\frac{1}{D+1}\right) * 2 * (2 * \rho)^{-\frac{1}{D+1}-1} \quad \{2\}$$

from which we need the inverted value. We get

$$\frac{d\rho}{da} = -(D+1) * \frac{1}{2} * (2 * \rho)^{\frac{1}{D+1}+1} \quad \{3\}$$

as the rate of change of $\rho$ by a.

Since we don't have an equation that includes time, we cannot use our mathematical principles as we did before. We use an equation which describes the derivation of a with respect to time that follows from the EFLE and can be called as Hubble constant $\widetilde{H}_q$ (Carmesin (2019)). It also depends on $\rho$ which is important. We use

$$\widetilde{H}_q = (2 * \rho)^{\frac{D^2+D+2}{2*D+2}} \triangleq \frac{da}{dt} \quad \{4\}$$

and have our equation for the derivative of a by time.

Now we combine equations {3} and {4} with multiplication, so we get the derivative of $\rho$ by time after reducing the fractions. In the same step, we also simplify our equation by using power laws as we have the same bases 2 and $\rho$. We get

$$\frac{d\rho}{dt} = -(D+1) * \frac{1}{2} * (2 * \rho)^{\frac{1}{D+1}+1+\frac{D^2+D+2}{2*D+2}} \{5\}$$

as our final equation for the calculation.

In the equation, natural units such as the Planck density $\rho_P$ are used. Those values can be derived from the natural constants light speed c, gravitational constant G and the reduced Planck constant h. Throughout those values, it is also possible to derive a value for the Planck time $t_P$ which will also be important later on.

For the Planck density, we have a value of $5.155 * 10^{96}$ kg/m$^3$ which will be considered as 1 unit. It is important to know that the Planck density is double of the highest achievable density which should be reached at the time 0 when the Big Bang just happened.

For the Planck time, we have a value of $5.391 * 10^{-44}$ s. It is the smallest value of the time that we can possibly observe in a single measurement of a quantum object. Like the Planck density, it will be considered as 1 in the calculations.

## 2. Evolution to solve our equation

In the next step, we start with the calculation for our equation. Therefore, we have developed a program build in Java that is solving our problem numerically. We need a numerical method, as we want to advance our program in the future. Therefore, equation {5} can be added with equations for the quantization for example. All the variables and constants such as $\rho$ and D are initialized as variables. We use the Euler method as it is a quite simple numerical method. The starting time and the starting density have to be put in as parameters. Afterwards the program will generate at least one .csv table.

Our program contains the critical densities as a list as they are not variable and do not change in any situation. When a critical density is reached, we change the value of the dimension by at least 1.

## 3. Calculation and interpretation of the results

By using our program, we received more than 64 billion results in the timeline from around 598 $t_P$ to 534 $t_P$. We started with a value of 0.11579 $\rho_P$. We got a value that is not possible because it is way higher than $\rho_P$. It has happened due to a maximum number of dimensional transitions implemented. Realistic would have been dimensional transitions up to D = 301. We just had D = 55 as our final value. At 534 $t_P$, our program stopped as we reached more than the maximum possible density $\rho_P$ as we did not have enough dimensional transitions for going on.

Also, our equation {5} could be added by terms that make it more precise (Carmesin (2019)). Our critical densities are based on a calculation made with these terms.

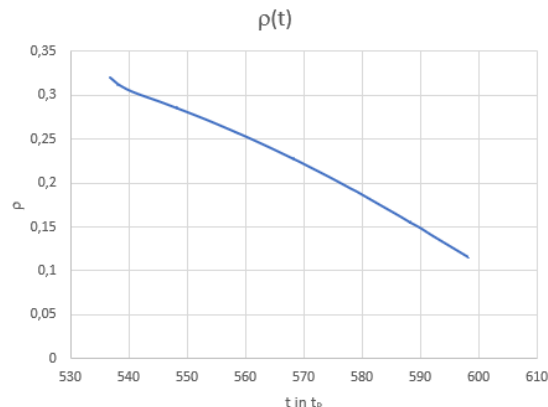Therefore, the results we received cannot be the exact values which are also proved by the density higher than $\rho_p$.



**Fig.2:** Graph of $\rho(t)$ we got using our program. The graph is made in the bounds of 534 $t_P$ to 598$t_P$.

Yet we got a lot of values that look quite realistic. Using Excel, we could create graphs that show time spans of 10 Planck times because we had problems showing more than 1 million values which was shown by inventing our program. By putting images of the different graphs next to each other we could still see graphs that show values that look possible at the first sight. Also, by adding more dimensional transitions to our calculation we could see that we could delay when we reached $\rho_p$. Still, we would have not reached the exact time evolution, which could already be seen in comparing with existing values we used for the dimensional transitions.

## 4. Develop a way to review our results

To check on our results we integrate equation {5}. We get an equation that can be used in the periods when D is constant. Therefore, we first simplify by substitution. Our factors on the right side, not containing $\rho$, will be called α, our exponent will be called β. We have

$$\frac{d\rho}{dt} = \alpha * \rho^\beta \{6\}$$

as our simplified equation.

In the next step, we have to separate our variables t and $\rho$. For that, we multiply with dt and divide by $\rho\beta$. In reality, $\rho\beta$ will only tend to 0 but does not reach it, so we can divide through it. We now have

$$\frac{d\rho}{\rho^\beta} = \alpha * dt \{7\}$$

as our equation that can be integrated. Since the variables are separated, we can define a precise primitive. We get

$$5. \frac{1}{-\beta+1} * \rho^{-\beta+1} = \alpha * t \{8\}$$

which we could use now. For what we want to check later, it would be better to have an expression in which t is separated. Therefore, we divide by $\alpha$. The result is a function from which we can get values for the time. We get

$$\frac{1}{-\beta+1} * \frac{1}{\alpha} * \rho^{-\beta+1} = t(\rho) \ \{9\}$$

which we now put our expressions for $\alpha$ and $\beta$, so we have

$$\frac{1}{\frac{-1}{D+1} - \frac{D^2+D+2}{2*D+2}} *$$

$$\frac{1}{\frac{-(D+1)}{2} * 2^{\frac{1}{D+1}+1+\frac{D^2+D+2}{2*D+2}}} * \rho^{-\frac{1}{D+1}-\frac{D^2+D+2}{2*D+2}}$$

$$= t(\rho) \ \{10\}$$

with the bounds of the time and $\rho$ where dimensional transitions have happened.

Since we want to have a look at the timespans we received with our program, we have to think of a method to receive $\Delta t$. A very simple way of doing so is to subtract $t(\rho1) - t(\rho2)$ in which $\rho1$ and $\rho2$ both are critical densities. We get

$$t(\rho1) - t(\rho2) = \Delta t \ \{11\}$$

that can be used to get the values for the timespans if the equation {10} is applied in the bounds. As one of the time bounds is fixed, we think of how we can get the other bound. For that, we remove $\Delta t$ from tc the time at which a dimensional transition has happened. We get

$$tc - \Delta t = tn \ \{12\}$$

for the new bound that will help to reduce mistakes that we got from our program.

## 5. **Checking the results**

Der Beitrag ist durch Überschriften nach der Dezimalklassifikation (z.B. 1., 1.1, 1.1.1, 1.1.1.1) (Formatvorlage: PhyDid-Überschrift 1-4) höchstens bis zur vierten Dezimale differenziert zu gliedern.

Literaturzitate werden in der für wissenschaftliche Zeitschriften üblichen Weise eingefügt (vgl. Hinweise gemäß DIN 1505 oder APA

(http://www.phydid.de/index.php/phydid-b/about/submissions#authorGuidelines).

Auch die Beschriftung von Diagrammen richtet sich nach den DIN- oder APAVorschriften.

Quellen zum Text werden bei DIN 1505 mit eckigen Klammern „[1]" durchnummeriert. Bei APA wird die Kurzreferenz im Text mit „(Nachname, 2016, S.10)" angegeben. In beiden Fällen folgt die ausführliche Quellenangabe im Literaturverzeichnis.

Anmerkungen zum Text werden durchnummeriert und am Ende des Beitrages angeführt.

Jedem Beitrag wird eine Kurzfassung des Artikels vorangestellt.

Die Beiträge werden in der Regel in Deutsch verfasst sein, eine Veröffentlichung in Englisch ist aber auch möglich.

## 6. **Interpretation**

In the previous calculations we got values that are not exactly the same. If the two values we compared to each other would have been the same, we could conclude from this that we didn't make any mistakes. As the values are not exactly the same, we have to check why problems occurred.

First, we check on our equations {5} and {10}. As {10} is directly made of {5}, then we have to check on {5} because mistakes can only be made at this point.

Since we cannot find a mistake at this point, we think about our method that we used to calculate. We used a numerical method because it is a simple way to solve a DEQ like we have it here. Problems that could occur using such a method are unprecise values, but one way of finding a solution. In comparison, our integration is very precise and just has the time bounds we solved with our numerical method. As we used fixed values for $\rho$, problems could have only occurred in the part containing t. Except for the first calculation we made in chapter 5), we used the time values we got from the calculation before. If we used the time values from the program itself, the difference would be even greater.

Also, we used the bounds that were written in our Excel table. Using our program, we had some test outputs that showed more precise values for t. We could see values for t that are more precise, up to ten more numbers. By using those numbers, we would probably get an even smaller difference.

In the end, it will probably be our numerical method, as the timespans that we would expect are larger in our equations {10} and {11}, a problem which can occur when you have numerical methods.

## 7. **Possible improvements**

We still do not have any exact values, so we can envision improvements that could be made.

One of the easiest ways to improve a numerical method, is to reduce the width we calculate with. In our case, we used to go 10-9 time units back per calculation. If we would advance that to 10-10 or even 10-11, we could get closer to the expected result.

Although this seems to be a good theory, it wouldn't be a good idea in practice. If we advanced with a

factor of $10^{-1}$ or $10^{-2}$ e.g., we would need a factor of $10^1$ or $10^2$ for the number of calculations. That also results in the time we need to run the calculation. For the calculation described in chapter 3) we needed around 2h 30mins as our computation time. Just by advancing with the factor 10, we would probably end up with 1 day of needed time. Therefore, this idea is no option.

We think of switching our numerical method. We hope that a multistep method, will allow us to perform less time-consuming and even more precise calculations.

But in the end, all of these improvements still won't fit exactly the time evolution that happened. For that, we need additional equations for the time the dimensional transitions need for example as already said before. Therefore, we have achieved one of the best possible results, in which we have a good relation between precise values and time expenditure, since our difference is close to zero.

Text-Beiträge werden im PDF-Format (les- und druckbar z.B. mit dem frei erhältlichen ADOBE-Acrobat-Reader®) publiziert. Es sollten daher reproduktionsreife Dokumente im PDF-Format eingereicht werden.

## 8. Summary

While the measurements of the expansion of the universe are not a too big mystery, calculating is still a very time-consuming process. Although our program is doing a good job by now, it's not finished as we don't have an exact time evolution. Still, this program gave us a good base. It is not impossible for us to determine the exact timetable, but we will continue to develop this.

## 9. Literature

Carmesin, Hans-Otto (2019): "Die Grundschwingungen des Universums – The Cosmic Unification". Berlin: Verlag Dr. Köster

Carmesin, Hans-Otto (2020): „The Universe Developing from Zero-Point Energy – Discovered by Making Photos, Experiments and Calculation". Berlin: Verlag Dr. Köster

Carmesin, Hans-Otto (2021): "Quanta of Spacetime Explain Observations, Dark Energy, Graviton and Nonlocality". Berlin: Verlag Dr. Köster