Termodynamics of the beginnig of the Big Bang

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Summary (Abstract)

Ideas about the Big Bang and their anchoring in theories connect the begging of the creation of the universe with the disintegration of the ″false″ vacuum, which is connected with the creation of spaceand time.

The present work derives, assuming the determined numerical density of primary particles in relation to the volume determined by the wavelenght of the particle and in relation to the smallest lenght determined by the Planck dimention, the eqation of the thermodynamics at the beginning of the Big Bang. That is, a description of the disintegration of the ″false″ vacuum. The equation also determines the conditions for the existance of the true vauum, especially the zero temperature of the environment of this vacuum.

Solving the equation determines the mass of the created universe and the initial temperature of the false vacuum environment from the known mass of the Higgs boson. The possibility of the development of the true vacuum state before the Big Bang also on the basis of particles other than the Higgs boson is discussed.

Keywords: Higgs boson, Big Bang

1. Introduction

Physical theories formally work in two „physical spaces“. Quantum physical space is essentially determined by the Compton‘s wavelength. The second physical space can be considered a gravitational space characterized by a gravitational radius. Both quantities have a meter dimension in the SI system. By dimensional analysis, using the same universal constants c (speed of light), h (Planks constant), G (gravitational constant) and the mass of the object, it is possible to arive at the physical space, the supoergravity space. Certain multiplicative properties of these quantities of physical spaces can be used to derive the equation of thermodynamics of the beginning of the Big Bang.

2. Fundamental quantities of physical spaces and their multiplicative relations

We denote the gravitational phusical space by the quantity R_g i.e. the gravitational radius

$$R_g = \frac{Gm_0}{c^2} \quad (1)$$

We denote the quantum physical space by the quantity $R_{q.}$

Otherwse denoted by the Compton wavelength λ_C.

$$R_q = \frac{h}{m_0 c} \quad (2)$$

I will denote supergravity quantum space R_{sq}

$$R_{sq} = \frac{h^2}{Gm_0^3} \quad (3)$$

The univeralconstant comon to the gravitational macroworld and the quantum microworld at the same time is apparently the Plancks length.

$$l_P = \sqrt{\frac{Gh}{c^3}} \quad (4).$$

A particle with this dimension can be considered the smallest black hole and at the same time the heaviest elementary particle with the Plancks mass.

If we multiply equations (1) and (2) we get

$$R_g R_q = \frac{Gh}{c^3} = l_P^2 \quad (5).$$

Similarly if we multiply equations (1) and (3) we get

$$R_g R_{sq} = \frac{h^2}{m_0^2 c^2} = R_q^2 \quad (6).$$

Multiplication of all three representaives of physical spaces than gives

$$R_g R_q R_{sq} = \frac{h^3}{m_0^3 c^3} \quad (7).$$

The inverted expression (6) appears in the Klein-Gordon wave function for bosons, while (2) is a part of Dirac wave function for fermions.

All the mentioned expressions are invarients of given physical spaces. In current physical theories, quantity does not stand out

$$R_q R_{sq} = \frac{h^3}{Gcm_0^4} \quad (8).$$

3. Deriviation of the equation of thermodynamics for false and true vacuum

Current ideas about the orogin of matter, or of material particles filling the observed part of the universe are based on unclear consitions prevailing at the begging of the birth of space and time from a specific state of singularity. That is, a state with infinte temperature and infinite density at a zero-dimentionpoint.
Such singular conditions are not needed for the derivation of the eqaution of thermodynamics, the solution of which leads to the description of the decay of the false vacuum in finite space and also to the solution, or determining the conditions for the existence of a true vacuum. A simple assumption that the mass of the universe is equal to a multiple N of the rest mass of e.g. the Higgs boson [1] is sufficent for the deriviation. In Eq.

$$m_V = Nm_{0H} \quad (9)$$

the number N expreses the numerical density of particles in a defined space and is given by the ration

$$N = \frac{R_g R_q R_{sq}}{l_P^3} = \frac{h^3}{m_0^3 c^3 l_P^3} \quad (10).$$

In equation (10), the third power of the invarient Compton wavelength appears. For a system of particles forming a false vacuum, whose mean speed of movement will be v, we rewrite equation (10) into a form with friction at a speed v and a relativistic mass mof particles depending on the speed v. Then the numerical density N is given by the volume ratio determined by the third power of the Broglie wavelength and the equation (10) switches to a form

$$N = \frac{h^3}{m^3 v^3 l_P^3} \quad (11).$$

The fundamental property of particlesis their duality. They can be understood as mass points with a gravitational radius (1), while

$$R_g << l_P \quad (12)$$

and also as wave particles described by Broglie's vave length

$$\lambda_B = \frac{h}{mv} \quad (13).$$

According to relationship (12), it can be expected that a particle with a gravitational radius Rg is with certainty located in the volume $l_P^3 >> R_g^3$. According to the wave dual state, the particle is also located in volume $\lambda_B{}^3$.

To find the numerical maximum particle density, it is enough to determine the ratio

$$N_B = \frac{\lambda_B^3}{l_P^3} \qquad (14).$$

For relativistic wavelength λ_B, i.e velocity $v \approx c$ will be

$$\lambda_B = \frac{h}{mv} = \frac{h}{\frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}v} \qquad (15).$$

We can then calculate the volume λ_B^3 as

$$\lambda_B^3 = \frac{h^3}{m_0^3 v^3}\left(1-\frac{v^2}{c^2}\right)\sqrt{1-\frac{v^2}{c^2}} \qquad (16).$$

For the mean velocity of particles in a thermodynamic system, the relation for small velocity holds $v << c$

$$E_k = \frac{1}{2}m_0 v^2 = \frac{3T}{2k} \qquad (17)$$ and from here

$$T = \frac{k m_0 v^2}{3} \qquad (18).$$

For speed comparable to the speed of light $v \approx c$ we have to use the expresion

$$T = \frac{2m_0}{3k}\left(\frac{1}{\sqrt{1-\frac{v^2}{c^2}}} - 1\right)c^2 \qquad (19).$$

From the above we can easily find the equality

$$\sqrt{1-\frac{v^2}{c^2}} = \frac{\frac{2m_0c^2}{3k}}{T+\frac{2m_0c^2}{3k}} \qquad (20).$$

After substituting into expression (16) and then λ_B^3 into expression (14), we obtain a thermodynamic equation for the mass of the universe m_V, where instead of indicating the rest mass of the particle *m0* we use only *m*.

$$\frac{h^3}{m^3 v^3 l_P^3}\cdot\frac{\frac{2mc^2}{3k}}{T+\frac{2mc^2}{3k}}\cdot\left(\frac{\frac{2mc^2}{3k}}{T+\frac{2mc^2}{3k}}\right)^2 = m_V \qquad (21).$$

After adjustment we obtain a cubic equation of the variable T in the form

$$T^3 + \frac{2}{k}mc^2T^2 + \frac{4}{3}\frac{1}{k^2}m^2c^4T + \frac{8}{27}\frac{1}{k^3}m^3c^6\left(1 - m^3v^3\frac{l_P^3}{h^3}m_V\right) = 0$$

(22).

4. Solving the equation for a false vacuum

The solution consists in fulfilling the conditon that the absolute term in equation (22) is equal to zero, i.e.

$$1 - m^3v^3\frac{l_P^3}{h^3}m_V = 0 \qquad (23),$$

Then the remainder of the equation will be equal to zero for certai values of temperature T. This remainder of the equation can then be rewritten in the form

$$T\left(T^2 + T_0T + \frac{1}{3}T_0^2\right) = 0 \qquad (24),$$

where $T_0 = \frac{2}{k}m_0c^2$.

Equation (24) has three roots. One real root $T_1=0$ and two complex, and when both combined resulting in

$T_2 = T_0\left(-1 + \frac{1}{\sqrt{3}}i\right)$ and $T_3 = T_0\left(-1 - \frac{1}{\sqrt{3}}i\right)$.

At these temperatures, the ″temperature″ part of equation (22) is equal to zero. In order for the equality of this entire equation to be fulfilled, condition (23) must also be filfilled. Two parameters must be inserted to satisfy this condition.

The particle mass parameter *m* and the mean velocity parameter *v* at the coresponding temperature of the system of these particles. Equation (23) will then determine the total mass of the universe, providing we accept the idea that the solution to equations (23) and (24) represent the decay of a false vacuum, then by substituting the resting mass of the Higgs boson for the mass of a particle and finding the temperature of these particles, the total mass of the future universe after the dacay of the false vacuum.

First, let's look for the answer to the following question. What is the temeperature of the false vacuum formed by Higgs bosons. The choice of theHiggs boson as representaive with zero spin is probably the most natural, since such particles are not subject to the exclusion principle like fermions and can accumulate with any density in alimited space.

The absolute value of the temperatures given by the complex expessions is

$|T_2| = |T_3| = 1{,}154700538\,T_0$.

Because the real part of the complex temperature T_2 resp. T_3 is $-T_0$ the teperature above absolute zero will be equal

$(1{,}154700538-1)\,T_0 = 0{,}154700538\,T_0$.

Then, in case of Higgs bosons excited above absolute zero, their temperature will be

$T_{nvH} = 0{,}154700538\frac{2}{k}m_Hc^2 = 4{,}49198301\cdot10^{14}$K.

For this temperature we can determine median particles velocity with mass m_H using the expression from (19)

$$v_H = 0{,}730406495c \qquad (25).$$

Then from equation (23) for the determined parameters m_H and v_H we get the mass of the universe.

$$m_V = \frac{h^3}{l_P^3}\cdot\frac{1}{m_H^3v_H^3} = 3{,}7620259\cdot10^{52}\ \text{[kg]}.$$

The mass of the universe determined in this way, or of an excited vacuum consisting exclusively of Higgs bosons represents the maximum mass limit, since the Higgs boson itself has a rest mass greater than other known particles with a longer lifetime than the Higgs boson.

To dermine the mass of the universe, it can be assumed that the false vacuum is a mixture of other particles including the Higgs boson. In the work intoroduced by the presentation under the title ″A small reflection on the Big Bang“ [3], two weights representing the false vacuum state were used. The first with a mass of 53.6188 GeV/c^2 as the upper graviton and the second with a mass of 8.93647 GeV/c^2 as the lower graviton. These wights were not chosen for thier own sake, but only because their mass ration to the mass of the electron are in agreement with the volume rations of certain regular polyhedra on four-dimentional space, as determined in the work "Quartic Equation and Proportions of Physical Reality" [4].
Worthy of attention is the comparison of twice the sum of the masses of a pair of these gravitons, i.e. 2(53.6188 + 8.93647) = 125.11054 GeV/c^2 with the mass of Higgs boson 125.09 ±0.24 (0.21 stat. ± 0.11 svst.) GeV/c^2 according to [4]. This gives the possibility of creating false vacuum conditions by gravitational condensation of gravitons whose mass will be maximumand at the same time the numerical density in space will be maximum.

5. Solving the equation for the right vacuum

If we put v=0 in equation (22), the absolute term of the equation will contain a combination of basic costants with the mass of the particle as in the other terms of the equation.

It will be in the form

$$T^3 + \frac{2}{k}mc^2T^2 + \frac{4}{3}\frac{1}{k^2}m^2c^4T + \frac{8}{27}\frac{1}{k^3}m^3c^6 = 0 \qquad (26).$$

Substituting $A = \frac{mc^2}{k}$ we convert equation (26) into the form

$$T^3 + 2AT^2 + \frac{4}{3}A^2T + \frac{8}{27}A^3 = 0 \qquad (27).$$

Solving this equation for reduced form gives a triple root

$$T_{R1,2,3}=0 \qquad (28),$$

while the solution of equation (27) has a triple root

$T_{1,2,3} = T_{R1,2,3} - \frac{2}{3}A$, tedy

$$T_{1,2,3} = -\frac{2mc^2}{3k} \qquad (29).$$

If we substitute a specifc value into (29). then for the mass of the Higgs boson, the „freezing“ temperature is

$- 9{,}678878 \cdot 10^{14}$ [K].

The result (28) can be understood as the existance of zero absolute temperature of the true vacuum in which frozen arbitrary particles are available whose negative temperature is given by expression (29).

Conclusion

From the derived thermodynamic equation of the begging of the Big Bang it can be concluded that that the Big Bang is not an exraordinary and entirely isolated process, since especially gravitons with the lowest mass can anywhere in the infinite space thay create and at any time in the infinite time they generate by theiir movement, create the conditions of the false vacuum. Higgs bosons whose mass is twice the mass of the pair of upper and lower gravitons in their most massive form can be considered representatives of the false vacuum. Teh use of equation (22) in the entire range of numbers desities lower than the maximum densites is left aside from the topic under discussion.

References:

[1] R.L. Workman et al. (Particle Data Group), to be published (2022)

[2] Lubomír Skála (Úvod do kvantové mechaniky), publikováno 2005

[3] https://youtu.be/YIGmOzxy9Yg a https://hvezdarna.kdjs-sedlcany.cz/files/Kvarticka-rovnice-a-proporce-fyzikalni-reality---publikace-CZE.pdf

[4] https://phys.org/news/2015-03-lhc-higgs-boson.html

Thanks

The author thanks Prof. RNDr. Michal Křížek and Vladimír Novotny, Chairman of the Cosmological Section of the Czech Astronomical Society and other members of this section for the first comments and others that will follow. From home, I would like to thank my daughter RNDr. for taking the time to critically read this article. Petra Innemanová Ph.D. and I also thank my grandsons Jakub, Martin, Šimon and the youngest Michael for their patience and attention in clarifying the content. A huge thanks goes to my friend George Jacko from Cheltenham for the effort he devoted to the translation from Czech to English.