

# **Non-Adiabatic Behaviour of the Early Cosmic Baryons Due to Vacuum Pressure Action: What Causes the Structure Formation in the Post-Recombination Era?**

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## **Abstract**

*In preceding papers we have shown that an initial Big-Bang explosion of the universe can not have happened as simply caused by a singularity of extremely hot, highly condensed cosmic matter due to the enhanced centripetal gravity field, enhanced by relativistic cosmic masses [1-3]. Instead, as we argue here, the initial "Bang" must have started from a pressurized cosmic vacuum. We analyse how to adequately describe this cosmic vacuum pressure and how to formulate the initial scale expansion of the universe as a reaction to it. We find that for a needed positive vacuum pressure the thermodynamic polytrope relation between vacuum energy density and vacuum pressure only allows for a range of the vacuum polytrope indices ξ of 3 ˂ ξvac ˂ 5. Furthermore we find that for the preferred value ξvac = 4 one can derive a complete description of the cosmic vacuum energy as function of the cosmic scale and the cosmic time with inclusion of a process of cosmic matter generation by a specific vacuum condensation process producing quantized matter. As result one obtains a matter universe well acquainted to all present day astronomers, however, without the need for an initial, material Big-Bang of a mass singularity. As a surprise, however, the Hubble expansion of the post-recombination universe under the action of cosmic vacuum pressure drives the baryonic distribution function into a more and more non-equilibrium shape with over-Maxwellian-ized populations of the high velocity wings demonstrating surprisingly enough that the cosmic matter temperatures in this expansion phase are in fact increasing, opposite to classical expectations which properly speaking would clearly predict adiabatic temperature decreases.*

**Keywords:** Big-Bang Cosmogony, Relativistic Pressure, Vacuum Energy

## **1. Even the Hottest Cosmic Matter would not Explode!**

We have shown in recent publications that an initial explosion of the virgin universe can at least not happen purely because of an extremely strong centripetal gravitational field in connection with a highly concentrated and extremely heated central mass singularity [1-3]. This is true even though one has to consider the natural centripetal material pressures which under these conditions certainly are enormous and somehow would enter definitely the cosmic game. But since the extremely hot cosmic matter has relativistic temperatures, this also leads to relativistically enhanced mass sources, and thus to even stronger centripetal gravitational fields connected with them. That may at first glance appear contra-visionary, but as can clearly be shown by the two cosmological Friedmann equations describing the cosmic scale R as function of the cosmic time t, it becomes evident, perhaps as a surprise, that the relativistically hot, enhanced cosmic matter increases the centripetal gravity field such that no explosive cosmic motion, but just the opposite - an implosion - would be caused [4,5]. The hotter the matter is in

the mass singularity, the more the situation resembles that of a singular "black hole". As shown by Fahr, only a medium that can realize a cosmic pressure without an initial singularity of relativistically hot matter can cause an initial explosion of the universe; this namely is the cosmic vacuum energy connected with a specific, positive vacuum pressure as we are demonstrating and specifying further down now.

#### **2. The Big-Bang Starts from A Pressurized Cosmic Vacuum**

Perhaps the best explanation of the problematic begin of our universe would be to assume that this universe does not at all start from a matter singularity, but rather from a vacuum singularity with no initial matter involved. The latter first is systematically generated when the metric of the universe is expanded connected with the conversion of vacuum energy into matter energy. The concept of a pressurized cosmic vacuum doing this job at this physical event has to start from the unavoidable thermodynamic condition that energy needs to be consumed in order to cause a blow-up of the universe. This means the fact has to be respected

that the action of the cosmic vacuum pressure  $p_{\text{vac}}$ , i.e the This prerequisite is fulfilled, if the foll positive work that has been carried out in blowing up the volume thermodynamic relation holds [8]: positive work that has been carried out in blowing up the volume<br>of a spherically symmetric universe, requests a loss of vacuum energy  $\epsilon_{\text{vac}}$  causing this change.

This prerequisite is fulfilled, if the following, well known thermodynamic relation holds [8]:

$$
\frac{d}{dR}(\epsilon_{vac}R^3) = -p_{vac}\frac{d}{dR}R^3
$$
 [1]

where *R* is the radial scale of the universe. As shown by Fahr this relation can be mathematically satisfied e.g. by [1] hown by Fahr this relation can be mathematically satisfied e.g. by [1] and the solution of the universe. As shown by Fahr this relation can be mathematically satisfied e.g. by [1]  $\blacksquare$ 

means the fact has to be respected that the action of the cosmic vacuum pressure pvac,

$$
\epsilon_{vac} = \epsilon_{vac,0} \cdot \left[\frac{R_0}{R}\right]^{\xi}
$$
 [2]

ich leads to the relation which icaus to the relation  $b^{\text{subich}}$  had to the relation which leads to the relation

 $\mathbf{w}$ 

$$
p_{vac} = -\frac{3-\xi}{3} \epsilon_{vac}
$$
 [3]

Here  $\xi$  is a pure number, namely the so-called, yet at present the initial expansion of the universe, it is unknown vacuum polytrope index  $\xi = \xi_{vac}$ . For normal, mono-<br>the following relation  $\xi_{vac} > 3$  holds for a posiatomic gases for example this index is given by the number and a positive vacuum pressure  $\frac{1}{2}$  = 5/3. In case of a vacuum pressure the exact value of the hereby must be requested  $\xi = 5/3$ . In case of a vacuum pressure the exact value of the hereby must be requested in analogy to prescribed at the reserve of the range of the range of permitted values of the dependence of th of permitted values can drastically be reduced. So, for a non-<br>function of the particle velocity v, - if symmetric velocity v, - if symmetri vanishing, positive cosmic vacuum pressure, needed to explain given by [9,10] corresponding number here, i.e.  $\xi = \xi_{vac}$ , is , however, not yet<br>known or physically pressure that this mapper that the range approximate the quantity "pressure" known or physically prescribed at this moment, though the range energy, i.e. a positive moment of the distribution  $\sum_{\text{vac}}$  and  $\sum_{\text{vac}}$  for a positive vacuum pressure. or permitted values can drastically be reducted. Bo, for a non-<br>vanishing nositive cosmic vacuum pressure, needed to evolain - given by [0,1] atomic gases for example this index is given by the number and a positive vacuum pressure. A positive<br> $\frac{5}{2}$  = 5/2. In ages of a viewing pressure the sugat value of the shappy must be requested in angles to the vanishing, positive cosmic vacuum pressure, needed to explain given by [9,1] or permitted values can drastically be reduced. So, for a non-<br>vanishing, positive cosmic vacuum pressure, needed to explain given by [9,10]

 $\alpha$  reduced. So, for a non-function of the particle velocity v, - if symmetric and isotropic - essure, needed to explain given by [9,10] so-called, yet at present the initial expansion of the universe, it is at least required that  $\frac{1}{\epsilon}$ the following relation *ξvac* ˃ 3 holds for a positive vacuum energy  $S_{\text{vac}}$ . For normal, mone and a positive vacuum pressure. A positive vacuum pressure is given by the number and a positive vacuum pressure. A positive vacuum pressure e the exact value of the hereby must be requested in analogy to the thermodynamic  $\zeta_{\text{vac}}$ , is , however, not yet pressure expressing the quantity "pressure" as the mean kinetic moment, though the range energy, i.e. a positive moment of the distribution function  $f(v)$  as given by [9,10]

$$
\int f(v) < mv^2/2 > v^2 dv = \frac{4\pi m}{3} \int f(v)v^4 dv > 0. \tag{4}
$$

Furthermore one can derive in addition from the second Friedmann equation for an initially expanding univ<br>only at the year beginning.  $R$  as its redial seeks and  $\ddot{R}$ . Othermore full,  $\sum_{i=1}^{n}$  and isotropic - given by  $\sum_{i=1}^{n}$  of  $\sum_{i=1}^{n}$  is the symmetric order  $\sum_{i=1}^{n}$ . Furthermore one can derive in addition from the second Friedmann equation for an initially expanding universe with vacuum energy Funderline one can derive in addition from the second Friedmann equation for an initially expanding universe w<br>only at the very beginning, R as its radial scale and  $\ddot{R} > 0$  the result [1]:<br> $\frac{8\pi G\rho_{\text{max}}}{\pi G} = \frac{4\pi$  $\frac{3}{2}$  from the different meaning  $\frac{3}{2}$  and  $\frac{3}{2}$  from  $\frac{3}{2}$ .

$$
\ddot{R}/R = \frac{8\pi G \rho_{vac}}{3} - \frac{4\pi G}{c^2} \left[\frac{\xi - 3}{3} \rho_{vac}c^2\right] = \frac{4\pi G}{3} \rho_{vac} \cdot \left[2 - (\xi - 3)\right]
$$
 [5]  
Which for  $\ddot{R} > 0$  leads to the request  $\xi_{vac} < 5$ . This then values  $\xi = 3$  and  $\xi = 5$  must be excluded for an expanding universe with

Furthermore  $K > 0$  leads to the request  $\xi_{vac} < 5$ . This then values  $\xi = 3$  and  $\xi = 5$  must be excluded for an expositive vacuum pressure, when causing an initial scale expansion. Hence the permitted range or values for the<br>index is given by:  $s<sub>g</sub>$  and  $s<sub>g</sub>$  and  $s<sub>g</sub>$ ). positive vacuum pressure, when causing an initial scale expansion. Hence the permitted range of values for the vacuum polytrope index is given by: index is given by: vacation of  $\mathcal{I}$   $\$ where the brackets hereby mean that the border values  $\mathcal{S}$  and  $\mathcal{S}$  and  $\mathcal{S}$  and  $\mathcal{S}$  and  $\mathcal{S}$  $\mathbf{3} \cdot \mathbf{3} \cdot \mathbf{4}$ 

$$
\xi_{vac}\epsilon[3,5[
$$

 $\zeta_{\text{vac}}(5)$ ,  $\zeta$ <br>where the brackets hereby mean that the border values  $\xi$ =3 and  $\xi$ =5 must be excluded for an expanding universe with positive<br>yacuum pressure, when causing an initial scale expansion. Hence the pe vacuum pressure, when causing an initial scale expansion. Hence the permitted range of values for the vacuum polytrope index is<br>given by:  $\mathbf{e}^{\text{max}}$  $\mathbf{e}^{\text{1}}$  scale the permitted range of values for the values for the values for the values for the values of values  $\mathbf{e}$ index is given by:  $\mu$ initial scale expansion. Hence the permitted range of values  $\mu$ given by: where the brackets hereby mean that the border values  $\mathcal{S}$  and  $\mathcal{S}$  and  $\mathcal{S}$  and  $\mathcal{S}$  and  $\mathcal{S}$ 

$$
3 < \xi_{\text{vac}} < 5 \tag{7}
$$

is result strongly suggests a value of  $\xi = 4$  which then yields a vacuum energy (see Eq. (2)) is result strongly suggests a value of  $\xi = 4$  which then yields a vacuum energy (see Eq. (2)) This result strongly suggests a value of  $\xi = 4$  which then yields a vacuum energy (see Eq. (2))

have at the beginning of cosmic time t 0 no cosmic matter at all compressed by its

$$
\epsilon_{vac}(R) = \epsilon_{vac,o} \cdot \left[\frac{R_0}{R}\right]^4
$$
\n[8]

Where  $\epsilon_{\text{vac, 0}} = \epsilon_{\text{vac, 0}} (R_0)$  is the vacuum energy density at the m here  $\epsilon_{vac,0} = \epsilon_{vac,0} (R_0)$  is the vacuum energy density at the means that we start with the initial vacuum energy density at the  $\epsilon_{vac}$  (R) and the cosmic matter energy density  $\epsilon_{ac}$  (R) and the cosmic matter energy d where  $\epsilon = \epsilon$  (R) is the vacuum energy density at the resensity that we start with the initial vacuum Figure  $\sum_{\text{vac}, 0}$   $\sum_{\text{vac}, 0}$  to the reaction initially explosive Big-Bang- universe one had the cosmic matter energy density  $\epsilon$  (R) and the cosmic matter energy density Where  $\epsilon_{\text{vac, 0}} = \epsilon_{\text{vac,0}}$  ( $R_0$ ) is the vacuum energy density at the means that we start with the initial vacuu reference scale  $R_0 = R_0$ .

In order to fulfill the request for an initially explosive Big-Bang-<br>
The conversion from vacuum energy into m order to ranni the request for an initially explosive Eig-Bang-<br>universe one had to have at the beginning of cosmic time  $t \rightarrow 0$  2015) could then for instance be descri no cosmic matter at all compressed by its gravitational pull in a relations [11,12]:<br>singularity, but only a dominating cosmic vacuum energy. This universe one had to have at the beginning of cosmic time  $t \to 0$  2015) could then for instance be described by the following<br>no cosmic matter at all compressed by its gravitational pull in a relations [11,12]: universe one had to have at the beginning of cosmic time  $t \to 0$  2015) could then for instance be described and the second service of the contract of the con  $m = 1$  means that with the initial vacuum energy density vacuum ene cosmic matter energy density mR0 0. The conversion from vacuum energy into matter ( Fahr and Heyl, 2007, Mach, 1912,  $\sum_{n=1}^{\infty}$  matter energy. This any executive solution and the vacuum energy density at the reference of the reference scale R0  $\alpha$  relations [11,12]: singularity, but only a dominating cosmic vacuum energy. This

cosmic matter energy density mR0 0.

erence scale  $R_0 = R_0$ .<br>  $\epsilon_{\text{vac},0} (R_0)$  and the cosmic matter energy density  $\epsilon_m (R_0) = 0$ . means that we start with the initial vacuum energeneals  $\epsilon$  (R) and the cosmic matter energy density  $\epsilon$ means that we start with the initial vacuum energ means that we start with the initial vacuum energy<br> $\epsilon$  (*R*) and the cosmic matter energy density  $\frac{V}{\sqrt{2}}$  is the vacuum energy density at the vacuum energy density at the reference scale R0  $\frac{V}{\sqrt{2}}$  $\begin{array}{ccc} \n\frac{1}{2} & \text{if } & \text{if }$  $h_{\text{max}}$  of cosmic time the beginning of cosmic matter at all compressed by its intervals of compressed by its intervals of contract  $\frac{1}{2}$ energy density at the means that we start with the initial vacuum energy density  $\epsilon_{\text{vac}} =$ <br> $(\ell_0)$  and the assume metter energy density  $\epsilon_{\ell_0}(R) = 0$ 

 $\mathbf{r} \rightarrow \mathbf{r}$ In order to fulfill the request for an initial the request for an initial to  $\theta$ ially explosive Big-Bang-<br>The conversion from vacuum energy into matter, (Aghirescu, ing of cosmic time  $t \to 0$  2015) could then for instance be described by the following relations [11,12]:

$$
\epsilon_{vac}(R,t) = \epsilon_{vac,0} \frac{R_0^4}{R^4} exp(-\alpha (t-t_0))
$$
\n[9]

and and and and and  $\frac{1}{1}$ 

and

$$
\epsilon_m(R,t) = \epsilon_{vac,0} - \epsilon_{vac}(R,t) = \epsilon_{vac,0} \frac{R_0^*}{R^4} (1 - exp(-\alpha(t - t_0)))
$$
\n[10]

<sup>R</sup><sup>4</sup> exp<sup>t</sup> <sup>t</sup>0 #

and

with  $R(t=t_0) = R_0$  and the coefficient  $\alpha$  implying something like the cosmic time period of a conversion of energy. The ratio  $m<sub>1</sub>$ with  $R(t)$  and the coefficient in planet implying something something something like the cosmic time  $p_{\text{min}}(t - t_0) - t_0$  and the coefficient  $\alpha$  implying sometiming like the cosmic time period of th  $R(t = t_0) = R_0$  and the coefficient  $\alpha$  implying something like the cosmic time period of a conversion of with  $R(t=t_0) = R_0$  and the coefficient  $\alpha$  implying something like the cosmic time period of a conversion of vacuum energy into matter energy.

energy. The ratio  

$$
\frac{\epsilon_m(R,t)}{\epsilon_{vac}(R,t)} = \frac{1 - exp(-\alpha(t - t_0))}{exp(-\alpha(t - t_0))} = exp(\alpha(t - t_0)) - 1
$$
 [11]

is not a cosmic constant but grows exponentially with cosmic time t. is not a cosmic constant but grows exponentially with cosmic time t. is not a cosmic constant but grows exponentially with cosmic time t. is not a cosmic constant but grows exponentially with cosmic time t. is not a cosmic constant but grows exponentially with cosmic time t.

 $W_{\text{max}}$  the above equations for  $\sigma_{\text{vac}}$  and  $\sigma_{\text{m}}$  integrated of parameters for  $\sigma_{\text{tot}}$  can be simply can be simply th the above equations for  $\epsilon_{\text{vac}}$  and  $\epsilon_m$  the time dependence of  $R(t)$  can be simply calculated with the 1st Fri With the above equations for  $\epsilon_{\text{vac}}$  and  $\epsilon_m$  the time dependence of  $R(t)$  can be simply calculated with the 1st Friedmann equation:

$$
\left(\frac{\dot{R}}{R}\right)^2 = \frac{8\pi G}{3c^2} \left(\epsilon_{vac}(R,t) + \epsilon_m(R,t)\right) = \frac{8\pi G}{3c^2} \epsilon_{vac,0} \frac{R_0^4}{R^4}
$$
\n[12]

This leads us to: This leads us to: This leads us to: This leads us to:  $T_{\text{max}}$  us to:

$$
\frac{\dot{R}}{R} = H = \sqrt{\frac{8\pi G}{3c^2} \epsilon_{vac,0}} \cdot (R_0/R)^2
$$
\n[13]

when then results in the following relation: Which then results in the following relation:

$$
\int_{R_0}^{R} \frac{dR}{R} \frac{1}{\sqrt{\frac{8\pi G}{3c^2} \epsilon_{vac,0}} \cdot (R_0/R)^2} = \int_{t_0}^{t} dt
$$
 [14]

ter integration of the above expression one finds: After integration of the above expression one finds: After integration of the above expression one finds: After integration of the above expression one finds:  $\mathcal{A}$  integration of the above expression one finds: After integration of the above expression one finds:

ter integration of the above expression one mass:  
\n
$$
\frac{1}{\sqrt{\frac{8\pi G}{3} \rho_{vac,0}} \cdot R_0^2} \cdot \frac{1}{2} [R^2 - R_0^2] = [t - t_0]
$$
\n[15]

finally for the normalized scale  $X = R/R_0$ : or finally for the normalized scale  $X = R/R_0$ :  $\sim$   $\frac{1}{\sqrt{2}}$   $\sim$ 

$$
\frac{1}{2}[X^2 - 1] = \sqrt{\frac{8\pi G}{3} \rho_{vac,0}} [t - t_0]
$$
 [16]

 $\mu$  introducing the  $\frac{3}{4} + t\tau_0$  one finds as a condensed relation between Cosmic scale and cosmic time: Introducing the Hubble time  $\tau_0$  and roughly identifying it with the recombination time  $\tau_0 = 1/\sqrt{\frac{8\pi G}{3} \rho_{vac,0}}$  $\sigma$ Introducing the Hubble time  $\frac{1}{100}$  and roughly identifying it with the recombination time  $\frac{1}{100}$   $\frac{8\pi G}{500}$  $= t/\tau_0$  one finds as a condensed relation between Cosmic scale and cosmic time: Introducing the Hubble time  $\tau_0$  and roughly identifying it with the recombination time  $\tau_0 = 1/\sqrt{\frac{8\pi G}{3}\rho_{vac,0}} = t_0$ , and setting Y

$$
X^2 = 2Y - 1\tag{17}
$$

recombination of baryonic Matter, how the scale R and the time over Maxwellian-ized high velocity wi t of the universe are further on related to each other.<br>
yacuum-driven Hubble expansion of t This relation defines for the given conditions after the into a more and more non-Maxwellian N<br>examplication of harmonic Matter handles and a Paul the time are not Manuellian in did high subscite mine recombination of baryonic matter, now the scale K and the time over maxwellian-ized high velocity will<br>t of the universe are further on related to each other. vacuum-driven Hubble expansion of t t of the universe are further on related to each other.<br>
latter phenomenon is due to expansion<br>
latter phenomenon is due to expanded

### 2 Thor 3. Thermodynamics under Vacuum-Driven Cosmic Expansion

Thermodynamics under vacuum-driven, expanding Hubble universe after the time of<br>The may want to see this result compared we of the conversion of the initial Maxwell-Boltzmann distribution relation: In a full gas kinetic study of the cosmic baryon gas behaviour in thermal pressure. The model of the cosmic baryon gas behaviour in thermal pressure! fact does increase by a total factor of 1. 8, due to occurence have decreased, namely according to t In a full gas kinetic study of the cosmic baryon gas behaviour in thermal pressure!<br>a vacuum-driven, expanding Hubble universe after the time of<br>recombination by Eshnit had been shown (see Einuse 2 there). One may went to ract does increase by a total factor of 1. 8, due to occurence have decreased, hamely according to the of the conversion of the initial Maxwell-Boltzmann distribution relation: expanding Hubble universe after the time of recombination by Fahr (2021) is the complete the combination between  $\frac{1}{2}$ recombination by Fahr it had been shown (see Figure 3 there) One may want to see this result compared w that the gas temperature during the expansion of the gas over 1, 2, 3, 4 Gigayears - instead of adiabatically decreasing - in instead an adiabatic expansion, then tem

 $\frac{21}{x^2}$  is the a more and more non-Movivellion NITE dins after the into a more and more non-Maxwellian NLTE- distribution with and direction the direction of the universe by the latter phenomenon is due to expansion of the universe by the over maxweman-ized nigh velocity wing populations under the<br>vacuum-driven Hubble expansion of the cosmic gas [13]. This over Maxwellian-ized high velocity wing populations under the action of the vacuum pressure, instead of by the action of the thermal pressure!

> have decreased, namely according to the following Poissonian One may want to see this result compared with the normal case, when the thermal pressure would be responsible and would drive instead an adiabatic expansion, then temperatures instead should relation:

$$
pV^{\lambda} = pR^{3\lambda} = const
$$
 [18]

we start from an age of the universe of  $\tau = 14$  Gigayears at recombination time  $t$  , then we obtain from the  $\tau$  $\frac{1}{\sqrt{2}}$ If we start from an age of the universe of  $\tau_0 = 14$  Gigayears at recombination time  $t_0$ , then we obtain from the upper equation (17):

$$
X^2 = (R/R_0)^2 = 2(t/\tau_0) - 1
$$
\n[19]

for times  $t_1, t_2, t_3, t_4 = 1, 2, 3, 4$  Gigayears after the recombination time  $t_0 = \tau_0$  that the following relations then for the t $t$ , t2, t3, t3, 2, 3, 3, 4 Given one often the recombination time t0  $\pm$  0 that the following relations then for allow  $r_1$ ,  $r_2$ ,  $r_3$ ,  $r_4$  and  $r_5$ ,  $r_7$  is equation to the fulfilled fulfilled fulfilled  $r_0$  and the following functions then should for times  $t_1$ ,  $t_2$ ,  $t_3$ ,  $t_4$  = 1, 2, 3, 4 Gigayears after the recombination time  $t_0 = \tau_0$  that the following relations then should be fulfilled:

$$
(R_1/R_0)^2 = 2(t_1/\tau_0) - 1 = 2 * 15/14 - 1 = 1.14
$$
 [20]

$$
(R_2/R_0)^2 = 2(t_2/\tau_0) - 1 = 2 * 16/14 - 1 = 1.28
$$
 [21]

$$
(R_3/R_0)^2 = 2(t_3/\tau_0) - 1 = 2 * 17/14 - 1 = 1.43
$$
 [22]

$$
(R_4/R_0)^2 = 2(t_4/\tau_0) - 1 = 2 \times 18/14 - 1 = 1.57
$$
 [23]

following the following results for the scale growth during this time. lding the following results for the scale growth during this time: yielding the following results for the scale growth during this time:

then we obtain from the upper equation (17):  $\frac{1}{2}$ 

$$
R_1 = R_0 \sqrt{1.14} \tag{24}
$$

$$
R_2 = R_0 \sqrt{1.28} \tag{25}
$$

$$
R_3 = R_0 \sqrt{1.43} \tag{26}
$$

$$
R_4 = R_0 \sqrt{1.57}
$$
 [27]

however, has the effect of increasing under vacuum-induced conditions, i.e. under an adiabatic Poisson NLTE conditions the baryonic temperatures by a factor  $1, 8$ . Maxwellian baryonic gas, leading via [14]:<br>[12] It would be interesting here to compare now this result. [13]. It would be interesting here to compare now this result cording to Figure 3 in Fahr this scale growth  $R_1 \rightarrow R_4$ , with what should happen under pure L nowever, has the effect of increasing under vacuum-mode conditions, i.e. under an adiabatic roissonial<br>NLTE conditions the baryonic temperatures by a factor 1, 8 Maxwellian baryonic gas, leading via [14]: [13]. It would be interesting here to compare now this result  $\frac{1}{4}$   $\frac{1}{4}$  According to Figure 3 in Fahr this scale growth  $R_1 \rightarrow R_4$ , with what should happen under pure LTE gas however has the effect of increasing under vacuum-induced conditions i.e. under an adiabatic Poisson

with what should happen under pure LTE gas dynamic adiabatic conditions, i.e. under an adiabatic Poissonìan expansion of the Maxwellian baryonic gas, leading via [14]:

$$
\frac{1}{T}\frac{dT}{dR} = -\frac{4}{3}R^2
$$
 [28]

 $\mathfrak{to}$ :  $\mathbf{t}_{\mathrm{max}}$ 

$$
T_i/T_0 = \exp[-4[(R_i^3/R_0^3) - 1)]]
$$
\n# [29]

 $t_{\rm eff}$ Ti/T<sup>0</sup> exp4Ri  $\overline{a}$  $\overline{1}$   $\overline{c}$   $\overline{1}$ which expresses the following "classical Poissonian" thermodynamic expectations for decreasing temperatures:

$$
T_1 = T_0 \exp[-4(1.14^{3/2} - 1)] \tag{30}
$$

$$
T_2 = T_0 \exp[-4(1.28^{3/2} - 1)] \tag{31}
$$

$$
T_3 = T_0 \exp[-4(1.43^{3/2} - 1)] \tag{32}
$$

$$
T_4 = T_0 \exp[-4(1.57^{3/2} - 1)] \tag{33}
$$

e above result would mean that instead of  $T<sub>1</sub> = 1.8T<sub>o</sub>$  one would via classic thermodynamics expect of only: of only:  $= 1.8T_0$  one would via classic thermodynamics expect to find a baryonic temperature of only:

$$
T_4 = T_0 * \exp[-4 * 1, 89] = 5.1 * 10^{-4}T_0
$$
 [34]

If in fact one had to agree to these vacuum-induced increased under normal, i.e. classic thermodynamic temperatures, then it would for sure need a thourough further settled to convincing results. Thus, the quest investigation in order to study whether after the recombination however, shall first be focused to in of baryonic matter - with afterwards increasing temperatures –<br>the callenge of cosmic matter to structured stellar and galactic clustering conductions. clusters could have happened at all. But since it is nowadays well We have shown in this paper above that known that even on the basis of classic Jeans structure formation the universe cannot be caused by a singulari theories it turns out, that stars like our Sun with masses of about cosmic matter, because the overdense 1 solar mass on the basis of these classic theories only can evolve extremely hot and highly relativistic. This v From pre-structured cosine matter or densities of  $\rho_H \simeq 10^2$  atoms. Such galactic metal gravity lied such cm<sup>3</sup>, while under normal galactic conditions of  $\rho_H \approx 10^2$ cm<sup>-3</sup> only the universe this way would be impeded Jeans masses of  $M > 100$  solar masses could have fragmented reflected in the two Friedmann differential eq<br>[15,16]. This clearly shows that even structure formation theory show here, an initial centrifugal, explosive even [15,16]. This clearly shows that even structure formation theory show here, an initial centrifugal, explosive even from pre-structured cosmic matter of densities of  $\rho_H \ge 10^6$  atoms/<br>cm<sup>3</sup>, while under normal galactic conditions of  $\rho \approx 10^2 \text{cm}^3$  only the universe this way would be impeded The above result would mean that instead of  $T_4 = 1.8T_0$  one would via classic thermodynamics expect to fir of only:<br>
of only:<br>  $T_4 = T_0 * \exp[-4 * 1, 89] = 5.1 * 10^{-4}T_0$ <br>
If in fact one had to agree to these vacuum-induced i the collapse of cosmic matter to structured stellar and galactic

under normal, i.e. classic thermodynamic conditions, is not yet settled to convincing results. Thus, the question posed above we, however, shall first be focused to in a forthcoming paper.

#### **4. Conclusions**

We have shown in this paper above that the initial explosion of the universe cannot be caused by a singularity of overdense, hot cosmic matter, because the overdense matter would have to be extremely hot and highly relativistic. This would, however, just strengthen the centripetal gravity field such that an expansion of the universe this way would be impeded which is also clearly reflected in the two Friedmann differential equations [1]. As we show here, an initial centrifugal, explosive event of the universe can only cosmically and physically be caused by a pressurized cosmic vacuum with properties that we derived above as function of the scale R and time t of the universe. However, for that to become true, one first had to clarify how the structure formation in the universe in the post-recombination period can be caused under increasing NLTE matter temperatures. We can show that a conversion process converting vacuum energy into quantized massive matter can be discussed which explains why at present times we find a partially materialized universe, however, why this universe contains stars, galaxies and clusters of galaxies and the final consequence of the ongoing vacuum energy decay at the ongoing expansion of the universe must be clarified at first.

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