Alternative Cosmological Model

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Abstract: All modern cosmological Big Bang models based on idea of transition from initial de Sitter world to the world of Friedman. But symmetries of Friedman and de Sitter spaces are quite fundamentally different. Although in both spaces the vacuum density can be function of time because of creating substance, but such quasi-static de Sitter space has to have symmetry, so high, as symmetry of the flat Mikulski space. In contrast to de Sitter, the Friedman space is expanding with sum density $\mu = \mu(t)$, where t axis must be strait perpendicular to hyper-surface of equal density, where sum density $\mu = const$. It makes to think, that this transition between de Sitter and Friedman spaces is not to be smooth, but has a character of global topological phase transition. So the point $t = 0$ marcs not a time of our Universe origin, but the origin of Friedman epoch in the history of our Universe after prehistory period of quantum de Sitter world.

1. Introduction: the history of the problem

Every early universe evolution model bases on Friedman equations for homogeneous medium with density μ and pressure $p = p(\mu)$. For system of units, where light velocity c=1, gravitational constant - G=8π6.67$_{10}{}^{-8}$ cm^3/(g sec^2) and space curvature - k can be positive or negative (in flat space model k= 0) Friedman equations have a view:

$$\dot{a}^2 = \frac{G}{3}\mu a^2 - k\,, \qquad \ddot{a} = -\frac{G}{6}(\mu + 3p)a \qquad (1)$$

For vacuumlike medium (de Sitter case), when $p= -\mu$, equation (1b) follows from (1a) after differentiation on t and so both equations lead to Robinson-Walker metric:

$$ds^2= dt^2 - a^2(t)\,[dr^2/(1- kr^2) + r^2(d\theta^2 + \sin^2\theta d\varphi^2)], \qquad (2)$$

where:

$$a(t)= a_o exp(Ht), \qquad (3)$$

H^2= Λ/3, where $\Lambda = \mu_v G$ - cosmological constant, μ_v - density of vacuumlike medium. According determination of the *event horizon* it delimits that part of the space from which we can ever (up to some time t_{max}) receive information about events taking place at time t:

$$R_e(t) = a(t)\int_t^{t_{max}} \frac{dt'}{a(t')} \qquad (4)$$

In de Sitter case with $a(t)= a_o exp(Ht)$, where H = const, we can receive $R_e(t) = H^{-1}$. The same result follows from de Sitter metric in the static form, which he received [1] right from Einstein equations (1):

$$ds^2= g(r)dt^2 - dr^2/g(r) - r^2(d\theta^2 + \sin^2\theta d\varphi^2), \qquad (5)$$

where:

$$g(r) = (r_d - r)(r_d + r)/r_d^2 \qquad (6)$$

and *de Sitter horizon* $r_d = H^{-1}$. So an observer in de Sitter space can look only those events that take place at a distance no farther away than r_d. This is completely analogous to the situation with *Schwarzwald horizon* for a black hole, from whose surface no information can escape. The difference is that an observer in de Sitter space will find himself effectively surrounded by a “black hole” located at a distance r_d. So all de Sitter space turns out to be divided on different arias with the range r_d, that can not be united in the common static coordinate system.

All modern cosmological Big Bang (BB) models based on idea of Sakharov [2] and Gliner [3, 4] that initial state of the Universe was the vacuumlike state of physical medium. The first nonsingular Friedman cosmological scenario was suggested by Gliner and Dymnikova in 1975 [5]. It was followed by Starobinsky inflation scenario [6], the latest variant of which, chaotic inflation scenario, developed by Linde [7], is the most popular nowadays. All inflation scenarios solve two of the main problems: the horizon and the flatness of space, because it assumes *inflation* or exponential expanding of initial small causally connected region a_o to much more then now observed size of the Universe.

Meanwhile Gliner and Dymnikova in their following papers [8,9] provided serious argumentation against such inflation idea. The main argument is that de Sitter world must really be static, and at any moment t its metric can be transformed to the static form by the Lemaitre-Robinson coordinate transformation:

$$q = r\, exp(Ht)/\sqrt{g(r)} \qquad \tau = t + r_d\, ln\, \sqrt{g(r)} \qquad (7)$$

In other words, dependence of transformed metric on t is the coordinate effect only and exponential expanding is really a fiction only. The other argument is following: if exponential expanding was real, the volume of space would increase exponentially also. So density of vacuumlike medium μ_v should also exponentially decrease and in result we had really no exponential dependence at all for a scale factor $a(t)$.

Instead of inflation scenario Gliner and Dymnikova developed their own nonsingular Friedman cosmological model, where they assumed, that emerging substance was created within the causally connected region a_o constrained by the de Sitter horizon r_d. Then state equation changes after substance creating from de Sitter form $p= — \mu_o$ to the final ultra relativistic state equation $p = \mu_I/3$ and in intermediate region it described phenomenologically:

$$p+\mu = {}^4/_3\, \mu_1(\mu_o - \mu)^\alpha/(\mu_o - \mu_I)^\alpha, \quad (8)$$

where μ_o – initial vacuum density, μ_I — density of energy for ultra relativistic photons. The parameter α can take values in the range 0<α<1 and presents the phenomenological characteristic of the transition speed. Gliner and Dymnikova obtained for $\alpha = {}^1/_2$:

$$a=a_0\, exp[B \sin (tc/a_0B)] \quad (9)$$

where the parameter B depends on μ_I and μ_o as

$$B= [\mu_o\, (\mu_o - \mu_I)]^{1/3} /2\, \mu_I \quad (10)$$

In initial moment at $tc < a_0B$ dependence (9) coincides with $a_o\exp(Ht)$, so it means, that this model really describes smooth transition from initial de Sitter world to the world of Friedman. But really symmetries of Friedman and de Sitter spaces are quite fundamentally different. Although in both spaces the vacuum density μ_v can be function of time because of creating substance, de Sitter space is to be quasi-static, if density of created substance is not so high and $\mu_s << \mu_v$. It is to be non expanding with sum density $\mu = \mu_s + \mu_v = const$ with symmetry so high, as symmetry of a flat Mikulski space, where election of t axis formally can be arbitrary [10]. The Friedman space in contrast is expanding with sum density $\mu = \mu(t)$, where t axis must be strait perpendicular to hyper-surface of equal density, where sum density $\mu = const$. It makes us to think, that this transition between de Sitter and Friedman spaces is not to be smooth like (8), but has a character of a global topological phase transition.

2. The global topological phase transition

Conditions for creating of real particles with mass m depend on field changing on a scale of the Compton wave length $\lambda_C = \hbar/mc$, where virtual particles are creating [11]. In de Sitter world for real particles creating we can demand that $r_d < \lambda_C$, where $r_d = H^{-1}$ is de Sitter horizon, so our Universe at its beginning looked like quasi-static de Sitter world, where some parameters, such as vacuum density μ_v and concentration of created particles of substance N_s, rather slowly changed. On the other hand created particles at $r_d < \lambda_C$ can easily go outside of de Sitter horizon r_d quantum mechanically, and after that they loose all the information about each other and all the interaction between them. So at low concentrations N_s each of created particles have no environment, and according to decoherence theory [12, 13] it must have maximum of quantum non-locality. Practically it is very close to Gliner statement in one of his last papers [14], that due to non-local character of quantum mechanic restriction of start area by small causally connected region a_o is mistakable, so global phase transition do not violate the principle of macroscopic causality. Really this scenario without doubtable inflation hypotheses can help us to solve problem horizon as well as problem of flatness, because the space here is flat from the beginning as in Alan Guth scenario [15].

Such phase transition can occur, when concentration N_s became high enough for particles' meeting and interaction inside of the area r_d or at $N_s \sim r_d^{-3}$. So the point $t = 0$ or $t \sim t_{Planck}$ (because really the time and space coordinates are the fuzzy values) marcs not a time of our Universe origin, but the origin of Friedman epoch in the history of our Universe after prehistory period of quantum de Sitter world. In de Sitter world creating of substance can go rather slowly, but in Friedman world all processes become to have an explosion character: most of created quarks and anti-quarks particles annihilated with producing radiation of neutrino and photons. (This phase transition is Big Bang really, where energy of vacuum transforms into substance and radiation).

3. Trial version and conclusions

According [16] modern meanings of relict photon and neutrino concentrations are respectively - N_r=450cm^{-3} and N_v=300cm^{-3}. If we suppose Friedman law for dust matter $a(t) \sim t^{2/3}$ from the moment of hydrogen recombination $t_1 \sim 4_{10}^{5}$ years (or 1.2_{10}^{13}sec after BB), the size of modern observed part of our Universe is $a_m \sim 1_{10}^{28}$cm (now age of our Universe t_m is about 1.4_{10}^{10} years =4.4_{10}^{17}sec) was $a_1 \sim 1_{10}^{25}$cm. So

$t_m/t_1=3.5_{10}^{4}$ and $a_m/a_1=1_{10}^{3}$. If modern meaning of substance density μ_m is close to critical meaning $\mu_c=4_{10}^{-30}$g cm^{-3}, at moment t_1 substance density was $\mu_1 \sim \mu_m(t_m/t_1)^2=1.2_{10}^{9}\ \mu_m \sim 7.35_{10}^{-21}$g cm^{-3}, concentration of relict photons N_{r1} was in $_{10}^{9}$ more, than modern meaning and the greatest scale in modern Universe - scale of super-gatherings ~ 100 Mpc = 3_{10}^{26}cm was about ~ 100 kpc = 3_{10}^{23}cm, or about modern sizes of galactics.

So at $t< t_1$ the substance in our Universe were much more homogeneous, than now, but galactic embryos already existed and were under high radiation pressure $p = \mu/3$ from their neighbors, because density of photon gas in this rage was much higher, than density of substance. Friedman law for photon gas *is* $a(t) \sim a_1(t_1/t)^{1/2}$ and so we can obtain that at Planck time $t_{Planck} \sim 5_{10}^{-44}$ *sec* ($t_1/t_{Planck} = 2.4_{10}^{56}$) concentration of relict photons and neutrino $N_r(t_{Planck})+N_\nu(t_{Planck})$ was about ~ 3_{10}^{96} cm^{-3} (very close to $N_{max}\sim l_{Pl}^{-3}=2.5_{10}^{98}cm^{-3}$ - maximal concentration in string theory [17]) and substance density $\mu_s(t_{Planck})$ was ~ $4.23_{10}^{92}g\ cm^{-3}$ (very close to Planck density $\mu_{Planck}=1/\hbar G^2=5_{10}^{93}g\ cm^{-3}$) and initial size of our Universe $a_o=a(t_{Pl})$ was to be ~ 6.5_{10}^{-4} cm, that is much more, than $l_{Pl}=1.6_{10}^{-33}$cm and 1_{10}^{-25}cm as well, which in different former variants of nonsingular cosmological model were interpreted as a start area a_o, delimiting classically causally connected region. In new model of quantum origin practically all the space of the early Universe in de Sitter world can be treated as the causally connected region because of quantum non-locality. After this transition the initial vacuum could be breaked up itself with creating dark matter as so called G-lumps [18,19] and the dark energy background (vacuumlike substance) as well. So in this result we can conclude that before time of Big Bang history our Universe could have a prehistory period of quantum de Sitter world.

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