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Thermodynamical and Quantum Gravitational Descriptions for Evolution of the Universe and Its Consequences

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Abstract Process of the dynamical evolution of the universe is explained by using thermodynamical laws and introducing quantum gravitational force [1].

$$F_{PN} = \frac{G_N \hbar}{c}\frac{M}{r^3}.$$

Moreover, by means of this Planck-Newtonian force one can give clear physical meaning of the Compton length of wave and the Planck length. It is shown that each elementary particles with a definite mass M corresponds quantum length, quantum metric, quantum surface and quantum volume. By using an elegant combination of four fundamental constants $\hbar, c, G_N$, and $\alpha = e^2/\hbar c = \frac{1}{137.03599}$ one can obtain mass value M_m of the magnetic monopole

$$M_m = \sqrt{\frac{\hbar c}{G_N}\frac{1}{\alpha}} = M_{Pl}\frac{1}{\sqrt{\alpha}},$$

where

$$M_{Pl} = \sqrt{\frac{\hbar c}{G_N}} = 2.177 \times 10^{-5} g$$

is the Planck mass.

Keywords Thermodynamical, Quantum Gravitational Descriptions

1. Introduction

The Big Bang is a real scientific theory about the universe started, and then made the stars and galaxies we see today. The universe began as a very hot, small and dense superforce (the mix of the four fundamental forces) with no stars, atoms, form or structure (called a singularity). Then about 13.6-13.8 billion years ago space expanded very quickly. The universe is still expanding today [1], and getting colder as well. As a whole, the universe is growing and the temperature is falling as time passes.

On the language of physicists a gigantic massive heat explosion leading to the Big Bang results due to quantum gravitational fluctuations at very small scale of spacetime. Numerical values of this scale are characterized by Planckian quantities:

- Planckian pressure

$$P_{Planck} = 4.63309 \times 10^{113} Pa, \tag{1}$$

- Planckian temperature

$$T_{Planck} = 1.417 \times 10^{32} K, \tag{2}$$

- Planckian length

$$L_{Planck} = 1.616228 \times 10^{-35} m, \tag{3}$$

- Planckian time

$$t_{Planck} = 5.4 \times 10^{-44} sec, \tag{4}$$

- Planck-Newtonian force [1]

$$F_{PN} = G_N \frac{\hbar}{c} \frac{M_U}{L_{Planck}^3} = 5.241 \times 10^{105} H, \tag{5}$$

where

$$M_U \sim 1.5 \times 10^{53} kg \tag{6}$$

is approximately total mass of our visible Universe.

2. Einstein's description of dynamical evolution of the universe

For the first time, Russian scientist Fridman in 1922 was shown that solution of the Einstein equation for some particular case describes non static evolution of the world. By this reason, in order to co-ordinate with the Fridman result Einstein added so-called cosmic term

$$\Lambda g_{\mu\nu} \tag{7}$$

into his equation. Here

$$\Lambda = 2.036 \times 10^{-35} sec^{-2}. \tag{8}$$

Then, after that the Einstein equation takes the form

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = 8\pi G_N T_{\mu\nu} + \Lambda g_{\mu\nu}. \tag{9}$$

For a peculiar ideal gas, the energy-momentum tensor has the form

$$T_{\mu\nu} = -p g_{\mu\nu} + (p + \rho) u_\mu u_\nu. \tag{10}$$

The metric tensor $g_{\mu\nu}$ defined by the equation (9) is expressed by Robertson-Walker's expression:

$$ds^2 = g_{\mu\nu} dx^\mu dx^\nu =$$

$$dt^2 - R^2(t) \left[\frac{dr^2}{1-kr^2} + r^2(d\theta^2 + \sin^2\theta d\varphi^2)\right] \tag{11}$$

where the constant curvature k takes three values: $+1, -1, 0$.

- If $k = +1$, then corresponding world is closed.
- If $k = -1$, then the world is open.
- If $k = 0$ then it gives a flat world.

Quantities ρ, p and u entering into the equation (10) correspond to an energy density, isotropic pressure and velocity $u = (1,0,0,0)$ which is equal to speed of an isotropic liquid.

Radius $R(t)$ of the always expanding universe is given by Hubble's equation:

$$\frac{k}{R^2} = H^2(\Omega - 1), \tag{12}$$

where $H = 100h \cdot km \cdot sec^{-1} M_{pc}^{-1}$ is called the Hubble constant, where the parameter h is defined from the experiment:

$$h = 0.67 \div 0.73. \tag{13}$$

Relation

$$\Omega = \frac{\rho}{\rho_k} \tag{14}$$

for two densities of energy is known as the cosmic density, where

$$\rho_c = \frac{3H^2}{8\pi G_N} = 1.05 \times 10^{-5} \cdot h^2 \frac{GeV}{sm^2} \tag{15}$$

is the critic density. At present time, the equation (12) can be written in the form

$$\frac{k}{R_0^2} = H_0^2(\Omega_m + \Omega_r + \Omega_v - 1). \tag{16}$$

Symbol "o"-means the present time scale. Here Ω_m, Ω_r, and $\Omega_v \sim \Lambda/3H^2$ correspond to the matter density which is not give pressure, density of relativistic particles and the vacuum density, respectively. So-called the vacuum energy or cosmic density entering into equation (16) gives basic contribution. However $\Omega_v \simeq 0.7u$, $\Omega_m \simeq 0.3$.

3. Numerical Values of Some Main Physical Quantities

- Mass of an electron:

$$m_e = 9.11 \times 10^{-31} kg. \tag{17}$$

- Average density of the universe:

$$\rho_U = 1 \times 10^{-27} \frac{kg}{m^3}. \tag{18}$$

Mass of an proton:

$$m_p = 1.673 \times 10^{-27} kg. \tag{19}$$

- Critic density of the universe:

$$\rho_k = 5 \times 10^{-27} \frac{kg}{m^3}. \tag{20}$$

- Temperature of the basic-background radiation:

$$t_0 = 2.725K. \tag{21}$$

- Speed of the light:

$$c = 2.998 \times 10^8 \frac{m}{sec}. \tag{22}$$

- The Bohr radius of an atom:

$$r_b = 5.29 \times 10^{-11} m. \tag{23}$$

- Distance between Sun and Earth:

$$r_{\Theta Đ'} = 1.5 \times 10^{11} m. \tag{24}$$

- Distance for which light travels during one year:

$$R_\gamma = 9.46 \times 10^{15} m. \tag{25}$$

- Half-value period of uranium:

$$t_{uranium}^{1/2} = 1.41 \times 10^{17} sec. \tag{26}$$

- If one can assume that age of the universe is equal to 13.7 billion years then

$$t_U^1 = 4.32 \times 10^{17} sec. \tag{27}$$

- If age of the universe to be 13.6 and 13.82 billion years, respectively, then

$$t_U^2 = 4.29 \times 10^{17} sec, \tag{28}$$
$$t_U^3 = 4.36 \times 10^{17} sec.$$

- Number of all stars in the Universe approximately is equal to

$$N_O = 7 \times 10^{22} \div 10^{24}. \tag{29}$$

- Diameter of the observed universe is

$$D_U = 8.8 \times 10^{26} m. \tag{30}$$

- Mass of the Sun:

$$m_\Theta = 2 \times 10^{30} kg. \tag{31}$$

- A black hole with highest mass:

$$M_{bh} = 3.6 \times 10^{40} kg. \tag{32}$$

- Total mass of the observed universe is

$$M_U = 1.5 \times 10^{53} kg. \tag{33}$$

- Number of elementary particles in the universe:

$$n \simeq 10^{86}.$$

- The Planckian density is

$$\rho_{Planck} = 5.1 \times 10^{96} \frac{kg}{m^3}. \tag{34}$$

4. Thermodynamical equation for an ideal liquid and gas

For liquid and gas without viscosity, basic thermodynamical equation has the standard form

$$PV = nRT \tag{35}$$

where the constant

$$R = 8.31 \frac{J}{mol \cdot K}, \tag{36}$$

is called the gas constant for all type of gas. Here

$$n = \frac{numberofel\ \ ementaryentitiesofgivenstudingsystem}{Avogadroconstant}, \tag{37}$$

where the Avogadro constant is equal to $n_A = 6.02 \times 10^{23} mol^{-1}$. The elementary entities must be specified and maybe atoms, molecules, ions, electrons, other particles, or specified groups of particles.
If some foreign elementary entities from any source do not enter in a given system then invariant form

$$\frac{PV}{T} = invariant \tag{38}$$

or

$$\frac{P_0 V_0}{T_0} = \frac{P_1 V_1}{T_1} = \cdots = \frac{P_n V_n}{T_n}, \tag{39}$$

is preserved for some numerical values of volume, pressure, temperature and at any time evolution of a system.

4.1. In the beginning of the Big Bang thermodynamical law does not fulfilled

It is assumed that total number of elementary entities or particles in the universe is 10^{86} and moreover, in the beginning of the Big Bang thermodynamical law (35) is valid then following equality holds:

$$P_{Planck}\, V_{Planck} = \lambda T_{Planck}\,. \tag{40}$$

From which one can find parameter λ:

$$\lambda = \frac{4.63\times10^{113}\frac{kg}{m^2}\frac{4\pi}{3}\cdot 4.22\times10^{-105}m^3}{1.41\times10^{32}K} = 5.8\times10^{-23}\frac{kg\cdot m}{K}. \tag{41}$$

Further, we propose that by using invariant property (39) after 3.6 billion years the thermodynamical law (35) also holds

$$P_\Theta V_\Theta = \lambda T_\Theta \tag{42}$$

where

$$V_\Theta = \frac{4\pi}{3}(1.295)^3\times10^{78}m^3 = 9.1\times10^{78}m^3, \quad T_\Theta = 2.725K.$$

From equation (42), we have

$$P_\Theta = \frac{\lambda T_\Theta}{V_\Theta} = 5.8\cdot10^{-23}\frac{kg\cdot m}{K}\times 2.725K\times\frac{3}{4\pi}\frac{10^{-78}}{(1.295)^3 m^3} = 1.74\times10^{-101}Pa \tag{43}$$

We see that quantity (43) has almost nonsense and therefore in the beginning of the Big Bang, thermodynamical law (35) does not valid.

4.2. For more later time from the Big Bang thermodynamical law is valid

Now we attent to find an average pressure of the universe at present time. Then from equation (35) one can obtain:

$$P_P V_P = nRT_p \tag{44}$$

where $n = 10^{86}$,

$$V_p = \frac{4\pi}{3}(1.295)^3\times10^{78}m^3 = 9.1\times10^{78}m^3, \tag{45}$$

$$T_p = 2.725K. \tag{46}$$

Therefore

$$P_p = \frac{10^{86}}{6.02\times10^{23}}mol\times\frac{1}{V_p}8.31\frac{J}{mol\cdot K}\times 2.725K = 4.13\times10^{-16}Pa. \tag{47}$$

On the other hand, by using experimental data [5] about an existence of the dark matter, one can find almost same result

$$P_U = P_p = -\rho_{DE} = -0.685\times1.878\times10^{-29}\times(0.67\div0.73)^2\cdot 9\times10^{13}Pa = -(5.2-6.2)10^{-16}Pa. \tag{48}$$

coinciding with (47). This is an average pressure of the universe per unit $1m^3$ volume.

5. Quantum gravitational force

In the previous paper [1], we have introduced the quantum gravitational force

$$F_{PN} = \frac{G_N \hbar}{c}\frac{M}{R^3}, \tag{49}$$

which is named the Planck-Newtonian force. Here M is mass of a considered body and R is a radius with respect to some center.

Example 1. Force for creation of the universe is given by

$$F_{PN}^{U} = \frac{G_N \hbar}{c}\frac{M_U}{L_{Pl}^3} = \frac{M_U}{L_{Pl}}c^2 = 5.241 \times 10^{105} H, \tag{50}$$

Example 2.

We know that, due to Hawking, around a black hole thermal radiation may be taking placed. Now we calculate energy of this radiation. We assume that quantum fluctuational process is appeared in a domain determined by the atomic size $R \sim R_{atom} \sim 10^{-10} m$ around of the black hole. Then for a super heavy black hole with mass $M_{bh} = 3.6 \times 10^{40} kg$, we have

$$F_{PN}^{bl} = 2.3473 \times 10^{-53} \frac{m^4}{c^2} \cdot \frac{3.6 \times 10^{40} kg}{10^{-30} m^3} = 8.45 \times 10^{17} H = 8.45 \times 10^{17} \frac{J}{m}. \tag{51}$$

It means that portion of the quantum gravitational force per unit length of the spacetime metric is given by

$$\mathcal{D} = \frac{F_{PN}^{bl}}{m} = 8.45 \times 10^{17} \frac{J}{m^2}. \tag{52}$$

From that quantity of radiation energy over all surface of the black hole defines as

$$E = D \cdot 4\pi R_{bl}^2, \qquad R_{bh} \sim 5.4 \times 10^{13} m. \tag{53}$$

Therefore, total energy of the Hawking thermal radiation is given by the formula

$$E_H = 3.1 \times 10^{46} J = 3.1 \times 10^{46} W \cdot sec. \tag{54}$$

For comparison, explosion of a supernova picks out an enormous quantity of energy, like

$$E_{sn} \sim 1.2 \times 10^{44} J. \tag{55}$$

This anomalous cosmic process was mentioned in an old Chinese book in 1054 year.

Example 3.

We know that at CERN accelerating energy is able to detect any physical processes taking place at distance $\lambda = 1 \times 10^{-18} m$ and therefore it can be caused quantum fluctuations in small spacetime domain determined by this distance. We assume that in this accelerating complex mini-black hole with mass $m_{pl} \sim 10^{-5} g$ would be appeared then

$$E^{lab} = \frac{F_{PN}^{lab}}{m} = 0.15 \frac{GeV}{cm^2} \tag{56}$$

Such quantity of energy may be pass through $1cm^2$-surface of the accelerator detector.

6. Some physical properties of the quantum gravitational force

6.1. Essence of the wave nature of elementary particles

It turns out that physical meaning of the wave nature of elementary particles follows from equality between Newtonian and quantum gravitational forces

$$G_N \frac{M^2}{r^2} = G_N \frac{\hbar}{c}\frac{M}{r^3}. \tag{57}$$

From which, we obtain the Compton length of wave:

$$r_C = \frac{\hbar}{Mc}. \tag{58}$$

This expression (58) and Einstein's formula for energy

$$E = mc^2 \tag{59}$$

together give basic characteristics of the wave property of elementary particles:

$$r_C = \lambda = \frac{\hbar}{mc}, \qquad E = \frac{1}{\lambda}\hbar c = \hbar\omega. \tag{60}$$

For an electron and proton it follows from the formula:

$$r_C^e = 3.86 \times 10^{-13} m, \tag{61}$$

and

$$r_C^p = 2.1 \times 10^{-16} m, \tag{62}$$

respectively. From this expression, in particular, we have force equality

$$F_N^e = F_{PN}^e = 3.72 \times 10^{-46} H, \tag{63}$$

for the electron.

6.2. Physical meaning of the Planck length

Let us consider the following equality

$$g\frac{mc^2}{r}e^{-mr} = \frac{G\hbar}{c}\frac{m}{r^3}, \tag{64}$$

for the Yukawa and quantum gravitational forces. Here $g \sim 1$, and $e^{-mr} \sim 1$ at small distances. Then, expression (64) gives

$$r = L_{Pl} = \sqrt{\frac{G\hbar}{c^3}}. \tag{65}$$

Moreover, the Planck length is determined by using following formula

$$\frac{mc^2}{r} = \frac{G\hbar}{c}\frac{m}{r^3}. \tag{66}$$

between equality of the centrifugal and quantum gravitational forces.

6.3. Quantum length, quantum metric, quantum surface and quantum volume

Let us consider the following equality condition

$$k_e\frac{q^2}{r^2} = \frac{G\hbar}{c}\frac{M_q}{r^3}, \tag{67}$$

between the Coulomb and quantum gravitational forces, where

$$k_e = 8.99 \times 10^9\,\frac{H\cdot m^2}{c^2},$$

$$q = 1.602 \times 10^{-19} C.$$

From the formula (67) we have

- for electron

$$r_e = \frac{G\hbar}{c}\frac{1}{k_e}\frac{M_e}{q^2} = 9.268 \times 10^{-56} m$$

or

$$M_e = \frac{(1.602)^2 \times 10^{-38} \cdot 8.99 \times 10^9}{2.3473 \times 10^{-53}}\frac{kg}{m} \cdot r_e = 9.83 \times 10^{24}\,\frac{kg}{m} \cdot r_e, \tag{68}$$

- for proton

$$M_p = 9.83 \times 10^{24}\,\frac{kg}{m} \cdot r_p, \tag{69}$$

Here

$$r_p = 1.702 \times 10^{-52} m.$$

On can write expressions (68) and (69) in another forms

$$r_e = 1.0167 \times 10^{-25}\,\frac{m}{kg} \cdot M_e, \tag{70}$$

$$r_p = 1.0167 \times 10^{-25}\,\frac{m}{kg} \cdot M_p. \tag{71}$$

Physical meaning of these formulas (68) and (69) is that for each electrical charged particle with mass M_i correspond quantum length r_i, quantum metric

$$r_i^2 = g_{kj}^{(i)} x^k x^j,$$

quantum surface S_i and quantum volume V_i, where

$$M_i = \Lambda r_i, \tag{72}$$

$$M_i = \Lambda\sqrt{g_{kj}^{(i)} x^k x^j}, \tag{73}$$

$$M_i = \Lambda\sqrt{S_i/S_1}, \tag{74}$$

$$M_i = \Lambda(V_i/V_1)^{1/3}, \tag{75}$$

Here

$$S_i = 4\pi r_i^2, \quad V_i = \frac{4\pi}{3} r_i^3,$$

$$S_1 = 4\pi, \qquad V_1 = \frac{4\pi}{3}.$$

$$\Lambda = \frac{k_e q^2 \cdot c}{G_N \hbar} = 9.83 \times 10^{24}\,\frac{kg}{m} \tag{76}$$

is universal quantum number for all particles i, $i = e, i = p$ and etc.

Notice that quantum bubble like domain determined by the radius r_i for each particles has more singular with respect to Planckian domain of the radius L_{Pl}. Maybe these domains are equivalent to singularities mentioned by Hawking and Penrose. But these singularities do not possess naked ones, and have finite sizes, corresponding to each particles.

6.4 Magnetic monopole

Equivalence between magnetic monopole and quantum gravitational forces [1]

$$\frac{\hbar c}{(e^2/\hbar c)}\frac{1}{r^2} = \frac{G_N \hbar}{c}\frac{M}{r^3} \tag{77}$$

gives beautiful relation:

$$M_p^2 = \frac{\hbar c}{G_N}(137.03599) = M_{Pl}^2\frac{1}{\alpha} \tag{78}$$

Here $\alpha = e^2/\hbar c = \frac{1}{137.03599}$ is the fine structure constant and

$$M_{Pl} = \sqrt{\frac{\hbar c}{G_N}} = 2.177 \times 10^{-5} g$$

is the Planck mass. From the formula (78) we have numerical value of magnetic monopole mass:

$$M_p = 2.5481 \times 10^{-7} kg \tag{79}$$

or

$$M_p = 1.4291 \times 10^{17}\frac{TeV}{c^2} \tag{80}$$

where

$$1kg = \frac{1}{1.783} \times 10^{36}\frac{eV}{c^2}. \tag{81}$$

6.5. Comparison between weak and quantum gravitational forces

Weak interaction is given by the Fermi constant

$$G_F^0 = \frac{G_F}{(\hbar c)^3} = \frac{\sqrt{2}}{8}\frac{g^2}{m_W^2} = 1.166 \times 10^{-5} GeV^{-2} = 4.543 \times 10^{14} J^{-2}.$$

Equality of these two forces follows from the formula

$$\frac{G_F}{R^4} = \frac{G_N \hbar}{c}\frac{m_W}{R^3}, \tag{82}$$

where m_W is the W- boson mass. From the formula (82) one can obtain distance for which two forces are unified:

$$R_{wq} = 4.269 \times 10^{15} m \tag{83}$$

or

$$E_{wq} = 7.4 \times 10^{-42} J = 4.62 \times 10^{-35} TeV, \tag{84}$$

where $1J = \frac{1}{1.602176} \times 10^{19} eV$. From this, we see that intensity or value of these two forces are almost equal within the experimental errors.

6.6. Driven force for the universe

Expanding universe is caused by the driven force [1]:

$$F_{DG} = \frac{G\hbar^2}{c^2}\frac{1}{r^4} = 1.21 \times 10^{44} H, \tag{85}$$

where $r = L_{Pl}$ is the Planckian length. Then equation motion of the universe is given by

$$1.21 \times 10^{44} H = M_U \cdot a_{\exp}, \tag{86}$$

$$M_U = 1.7438 \times 10^{53} kg$$

and

$$a_{\exp} = 6.94 \times 10^{-10}\frac{m}{sec^2}. \tag{87}$$

For example, due to this driving force during age of our universe its drift distance was acquired the value:

$$R_{drift} = \frac{1}{2} a_{\exp} \cdot t_U^2 = 0.6477 \times 10^{26} m = \frac{1}{2} R_p, \tag{88}$$

$t_U = 13.7 \times 10^9$ years,

or equivalently, its accelerating expansion occupies eight part of the present volume of universe:

$$V_{drift} = \frac{1}{8} V_U \quad (89)$$

In future, after 13.5 billion years volume of our universe will be increased two times. It means that we live in very accelerating world.

References

[1]. Kh. Namsrai "Derivation of Some Physical Characteristics of the Big Bang Theory " JSAER 2019 6(8):1-3.

[2]. Bojowald, M. Quantum Cosmology. In: Encyclopedia of Mathematical Physics Vol.4, pp153-158 (Eds. Francoise, J-P, Naber, G, Tsun, T.S). Elsevier (Academic Press, Amsterdam u.a (2006).

[3]. Quantum Gravity, Standard Encyclopedia of Philosophy, May 27, 2015.

[4]. Value of the Cosmological Constant: Theory versus Experiment https://cds.cern.ch/record/485959/files/0102033.pdf

[5]. http://www.researchgate.net/post/What is the value of the pressure in the universe

[6]. http://www.physicsoftheuniverse.com/number.html