A Possible Universe in Pulsation by Using a Hydro-Dynamical Model for Gravity

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Abstract: *By using a hydro-dynamical model for gravity previously given by the author, a pulsating universe is possible to describe. This is possible because two hydro-dynamical sources are in attraction both when they are emitting and absorbing fluid. In our model, bodies (matter and energy) are interacting via an incompressible fluid made of gravitons (photon-like particles having a wave length of the order of magnitude of the radius of universe).*
One considers the universe uniform at large scale, the effects of general relativity type being local and negligible at global scale. An "elastic sphere" model for the universe is suggested to describe the possible inversion. The expansion of the universe stops when the "elastic energy" overcomes the kinetic one; this takes place near the point of maximal emission speed of the fluid of gravitons. The differential equation for the universe in expansion is adapted to contraction. Analytical solutions are given.

Key Words: *graviton emission/absorption, critical point, elastic sphere model*

1. INTRODUCTION

The possibility of a pulsating universe - an idea attributed to Einstein - was discussed many times [1-5].
The main reason for the universe to stop was a large enough density of the matter in universe. Of course the gravity is playing its role.
In a previous paper [6] we have presented a hydro-dynamical model for gravity at the universe scale by using an analogy with the interaction of sources in an incompressible fluid made of gravitons - photon like particles with a wave length of the order of magnitude of the radius of universe.
Only the case of emitting sources was then considered although an attraction modeling the gravity takes also place in case of absorption.
Some information was taken from [7]. In the following, one considers both situations: emission and absorption.

2. MODEL PRESENTATION

Let Q_1, Q_2 be the volume rates of two sources of fluid located in two points, as seen in Fig 1. The hydro-dynamical force of interaction F_H is oriented along the direction which connects the two sources and has the expression [8]:

$$F_H = \frac{\rho\, Q_1\, Q_2}{4\,\pi\, R_{12}^2}; \rho = const., \tag{1}$$

where ρ is the mass density of the fluid which fills the space and R_{12} the distance between sources.

A source is positive/ negative if it injects/ absorbs fluid (of the same density). The force is attraction for sources of the same sign and rejection in case of different signs. On the other hand, the Newton law of the universal attraction of two bodies is:

$$F_N = f_N \frac{m_1\, m_2}{R_{12}^2}, \tag{2}$$

where m_1, m_2 are the body masses and $f_N = 6.67E-11 m^3/kg/\sec^2$ is the Newton constant of universal attraction.

One introduces as necessary the total energy, *E (Joule)*, using the special relativity formulas [11]:

$$E = m\, c^2;\ m = m_0 / \sqrt{1 - V^2/c^2}, \tag{3}$$

m_0 being the proper mass, *V* the body velocity and *c* the speed of light in vacuum.

As one can speak about vacuum, we consider as reference system the vacuum itself, and the total energy is considered with respect to this system of reference. The origins of space and time are considered in the point and moment of *BIG BANG* (or, better said, *BIG FLASH* [7]). The incompressible fluid is made of gravitons -photon-like particles with wave length of the order of the radius of universe.

The Newton formula then becomes:

$$F_N = f_{NE}(t_u)\, E_1 E_2 / R_{12}^2;\ f_{NE}(t_u) = f_N(t_u)/c^4 \tag{4}$$

$f_{NE}(t_u)$ being the new coefficient of universal attraction in the formulation considering energies instead of masses and depending on the age of universe, t_u.

The proposed model has as one of basic assumptions that at the global (universe) scale the energy repartition is uniform enough distributed for an average density to be used, the existing agglomerations of matter being small as compared to the universe volume.

The analogue of a hydro-dynamical source is any amount of energy (larger then the energy of a graviton) emitting/absorbing gravitons due to the expansion/ contraction of universe.

Further one transforms the formula (1) of the hydro-dynamical force, first by introducing the mass rate and the energy rate, then by considering that any amount of energy (other than gravitons) injects/absorbs a rate of “fluid of gravitons” proportionally with its energy.

One denotes by $\theta_g(t_u)$ the emission/ absorption intensity per second. One introduces ρ_{Egu} the density of energy for free gravitons in universe:

$$\rho_{E\,g\,u}(t_u) = \frac{3E_{g\,u}(t_u)}{4\pi R_u^3(t_u)}. \tag{5}$$

where $E_{g\,u}(t_u)$ is the total energy of the fluid of (free) gravitons filling the universe.
The expression of the “hydro-dynamical” force (2) finally becomes [7]:

$$F_H = \frac{\theta_g^2(t_u)\,E_1\,E_2}{4\,\pi\,\rho_{E\,gu}(t_u)\,c^2 R_{12}^2}. \tag{6}$$

Therefore one obtains attraction both for emission ($\theta_g(t_u) > 0$), and absorption ($\theta_g(t_u) < 0$). In the following we consider both cases.

By equating the Newton force (4) and the “hydro-dynamical” force (6), one obtains the intensity $\theta_g(t_u)$:

$$\theta_g^2(t_u) = 4\pi c^2\,\rho_{E\,gu}(t_u)\,f_{NE}(t_u). \tag{7}$$

3. THE EQUATION FOR THE ENERGY OF EMITTED/ABSORPTED GRAVITONS

One considers an initial moment, t_{u0}, of the universe expansion, from the *BIG FLASH* and another moment from the contraction start. In both cases the speed of the universe frontiers is the speed of light except a time interval for a slow stopping of expansion.

3.1 The Expansion of Universe

The initial moment for expansion is taken from our model of universe [7] and corresponds to the moment when the substance was created from radiation under the form of neutrons. This is also considered as the moment when the Newton law of gravity starts to act in the standard form; for the earlier stage, $t_u \in (0; t_{u0})$, the force of attraction could be different from the Newton form. The main features of this model of an early universe in expansion are given in Table 1.

The radii of universe in light years (*l.ys*) are given for the initial and actual time. The actual background temperature is T_G. E_{U0} = 3.467916 *E70 Joule* is the total energy of universe and E_{ne0} = 1.507437*E-10 Joule* is the energy of neutron at rest.

Table 1 - Radii of universe and background temperature

R_{u0} (*l. ys.*)	R_{uact} (*l. ys.*)	T_G (K)	E_{U0} / E_{ne0}
5.091 E5	18.30 E9	3.4679	2.308 E80

The number of neutrons at t_{u0} = 5.091*E5* years is close to 2.308 *E80* neutrons. One considers that at substance occurrence **an equal number of gravitons were released**. Then the “fluid of gravitons” at t_{u0} has the energy $E_{g\,u\,0}$, given by:

$$E_{g\,u\,0} = 2.308E80hc / R_{u\,0} = 9.52608E33\,Joule. \tag{8}$$

Other information regarding the mass of the universe is useful [9; 10; 11] but does not provide a starting moment and energy of the “fluid of gravitons” for our model.

A differential equation for the increasing average energy of the “fluid of gravitons”, E_{gu}, at the universe scale, can be written under the form:

$$\frac{dE_{gu}}{d\tau} = t_{u0}\theta_g(\tau)\left(E_{U0} - E_{gu}(\tau)\right);\ \tau = t_u / t_{u0}, \tag{9}$$

where the dimensionless time τ was introduced.

Besides the equation (9) one more equation for $\theta_g(\tau)$ can be written [6]. To this aim a connection with the expansion/contraction of the universe which is controlled by gravity was used.

By calculating the time derivative of the universe volume taking into account that the universe frontier is moving, by replacing the density $\rho_{Egu}(\tau)$ from (7) and by denoting v_{front} the universe frontier speed (mainly the speed of light) one obtains:

$$\theta_g(\tau) = \pm\frac{3\chi_0 v_{front}\tau^{\alpha-1}E_{gu}}{E_{U0}R_{u0}} \tag{10}$$

The eq. (9) is written first for expansion at $v_{front} = c$:

$$\frac{dE_{gu}}{d\tau} = \frac{3\chi_0 c\tau^{\alpha-1}}{E_{U0}}\left(E_{U0} - E_{gu}\right)E_{gu} \tag{11}$$

and adapted latter for contraction χ_0, α are two adjusting coefficients presented in the following.

The equation (11) has an analytical solution, for $v_{front} = c$, given bellow:

$$\ln\left(\frac{E_{gu}\left(E_{U0} - E_{gu0}\right)}{E_{gu0}\left(E_{U0} - E_{gu}\right)}\right) = \frac{3\chi_0(\tau^{\alpha} - 1)}{\alpha}, \tag{12}$$

where the condition at the initial time ($\tau = 1; E_{gu} = E_{gu0}$) is satisfied.

The universal coefficient of attraction, $f_{NE}(\tau)$, is:

$$f_{NE}(\tau) = 3\chi_0 E_{gu} R_{u0}\tau^{2\alpha+1} / E_{U0}^2. \tag{13}$$

Because the actual value of the gravity constant, denoted by f_{NEact}, is known one obtains an expression for the exponent α:

$$\alpha = \frac{1}{\ln\left(\tau_{act}\right)}\ln\left(\frac{E_{U0}\sqrt{f_{NEact}}}{\chi_0\sqrt{3R_{u0}\tau_{act}E_{guact}}}\right);\ \tau_{act} = 3.595E4. \tag{14}$$

The actual value of the dimensionless time, τ_{act}, was calculated using the values from Table 1, whereas the energy E_{guact} must satisfy the equation (13) for $\tau = \tau_{act}$:

$$\ln\left(\frac{E_{guact}\left(E_{U0}-E_{gu0}\right)}{E_{gu0}\left(E_{U0}-E_{guact}\right)}\right)=\frac{3\chi_0\,(\tau_{act}^{\alpha}-1)}{\alpha}, \tag{15}$$

If the adjusting constant χ_0 is chosen, then the unknowns α, E_{guact} can be calculated.

3.1.1 The Stop of Graviton Emission. Point of Maximum Emission Speed

One studies now the behavior of the gravitons emission. The second order derivative of E_{gu} vanishes when the increasing velocity has a maximum:

$$\frac{d^2E_{gu}}{d\tau^2}=0;\ \tau=\tau_{\max}=\frac{(1-\alpha)E_{U0}}{3\chi_0}\frac{1}{\left(E_{U0}-2E_{gu}\right)};\ E_{U0}-2E_{gu}>0. \tag{16}$$

The moment of maximum $\tau_{\max}$ is determined from equations (15) and (16). From the following calculations one can see that the energy of graviton fluid at $\tau_{\max}$ is very close to the value $E_{U0}/2$ (Tables 2; 3)

3.1.2 Calculations. Some Results and Interpretation

The main parameters of the model are calculated by using the above relations and presented in Table 2, for $\chi_0=1$, and Table 3, for $\chi_0=2$.

Table 2
($f_{NE\,act}$ = 8.235*E*–45*m /Joule; τ_{act}* = 3.595*E*4*; E_{gu0}* = 9.5261*E*33 *Joule; χ_0 = 1;* α = 0.157436)

τ/τ_{act}	E_{gu}	E_{gu}/E_{U0}	$f_{NE}(\tau)/f_{NE\,act}$	θ_g	$\rho_{Egu}(\tau)$	$10^{-6}t_u(ys)$
0.50	2.4889*E*64	7.1536 *E*-7	1.4174 *E* -5	1.1592*E*-31	9.1617*E*-15	0.915*E*4
1- 1/18.3	2.9785*E*68	0.00856	0.39195	8.1113*E*-28	1.6222*E*-11	1.730E4
1	7.05797*E*68	0.02029	1	1.8332*E*-27	3.2476*E*-11	1.830*E*4
1+1/18.3	1.5853*E*69	0.04556	2.4138	3.9451*E*-27	6.2311*E*-11	1.930*E*4
1.2756 (max)	1.73958E70	0.4999969375	34.03050	1.1041E-17	3.85607E-10	2.3344E4

One can see that the adjusting parameters χ_0,α can be maintained within reasonable limits. During the next billion years the increasing of $f_{NE}(\tau)$ is 2.4138 times of the actual value for $\chi_0=1$ and during the next million years this amplification is 1.00088 times. If the angular momentum of our planet is

Table 3
($f_{NE\,act}$ = 8.235*E*–45*m /Joule; τ_{act}* = 3.595*E*4*; E_{gu0}* = 9.5261*E*33 *Joule; χ_0 = 2;* α = 0.046841)

τ/τ_{act}	E_{gu}	E_{gu}/E_{U0}	$f_{NE}(\tau)/f_{NE\,act}$	θ_g	$\rho_{Egu}(\tau)$	$10^{-6}t_u(ys)$
0.50	2.35776E66	6.7768E-5	6.15151E-4	7.4328E-30	8.6791E-13	0.915E4
1-1/18.3	1.05925E69	0.030446	1/1.80293	1.8196E-27	5.7690E-11	1.730E4
1	1.79593E69	0.05164	1	2.9423E-27	8.2636E-11	1.830E4
1+1/18.3	2.95255E69	0.084086	1.72657	3.9454E-27	1.1475E-10	1.930E4
1.34280 (max)	1.73958E70	0.4999983544	34.02476	2.9952E-18	3.3059E-10	2.4886E4

constant, then its distance to sun is inverse to $f_{NE}(\tau)$, decreasing in the same ratio.

Then if the Sun radiation is not modified, in a time interval of a billion years, for example, the flux of energy from Sun will increase about six times having a dramatic impact on biosphere.

As regards the density of energy, $\rho_{Egu}(\tau)$, increasing, it has a rate of 1.00273 per 10^6 years, for $\chi_0 = 1$ (Table 2); **then the "fluid of gravitons" can be considered incompressible**. Similar conclusions result for $\chi_0 = 2$ (Table 3).

From the two Tables 1 and 2 one can see that the increasing of the ratio $f_{NE}(\tau)/f_{NE\,act}$ ***as well as the increasing of the emission factor*** θ_g ***are very important near the maximum emission. This suggests that a critical moment for the expansion to stop could be near*** τ_{max}.

3.2 The inversion of expansion. Model of the elastic sphere

A possible simple explanation for the stopping of the expansion could be obtained considering the universe an elastic sphere extended against the gravity forces (Fig.1). The elastic potential energy increases in time (see Tables 4 and 5) although not linearly, mainly due to the increasing of the energy E_{gu}. Accumulated in time this can stop and invert the expansion

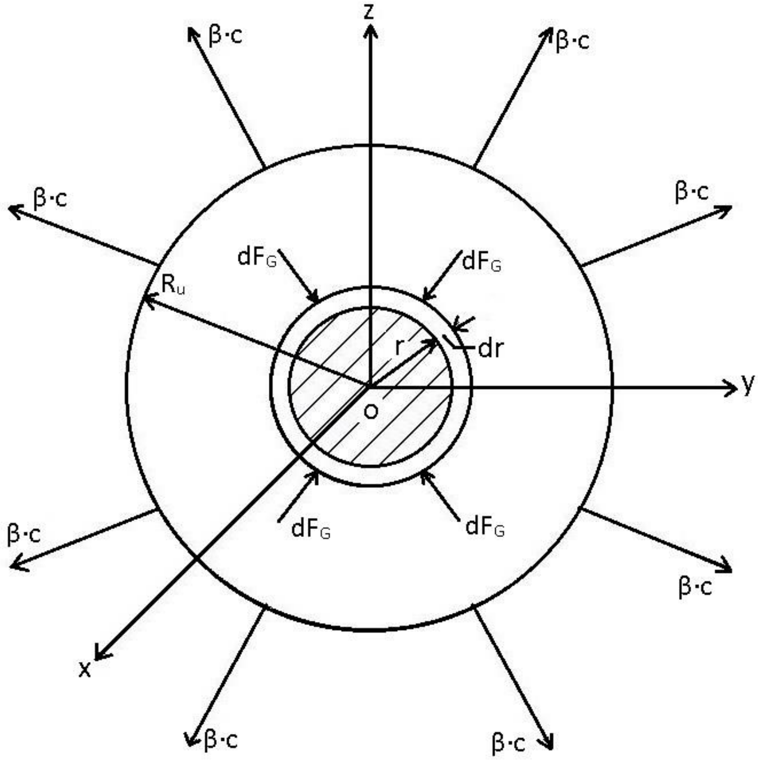

Fig. 1 The elastic sphere model: R_u, radius of universe; c, speed of light; $|\beta| \in [0;1]$; dF_G, the element of gravity force at *r* radius

3.2.1 The sudden inversion

A possible scenario is for inversion ***to take place suddenly (implosion) near*** τ_{max}**,** such that the speed of the universe frontier passes from the speed of light *c* to (- *c*). According to the uncertainty principle this large momentum variation will lead to a very small variation in the universe radius.

One considers for simplicity the universe a sphere and the velocity inside it increasing linearly from the center $(r=0)$ to the frontier $(r=R_u)$. For the energy density distribution a non-linear decreasing is taken, null at frontier which has the speed of light, as follows:

$$\rho_{EU}(r)=K\left(\frac{r}{R_u}\right)^{-\nu}\left(1-\frac{r}{R_u}\right);\quad \nu\le 2. \tag{17}$$

The constant *K* is obtained by considering the whole energy of universe; for $\nu=0$, one obtains a linear density distribution and for $\nu>0$ the density is infinite at $r=0$.

At any direction, say *Oz*, the universe momentum, P_{Uz}, considering two semi-spheres obtained with a plane orthogonal to *Oz* is:

$$P_{Uz}=\frac{E_{U0}}{4c}\left(\frac{3-\nu}{5-\nu}\right), \tag{18}$$

and the uncertainty principle [11] requires a momentum variation ΔP_U and correspondingly a universe radius variation, ΔR_u, as follows:

$$\Delta P_U=2P_{Uz};\ \frac{\Delta R_u}{c}\cong\frac{h}{4\pi}\frac{2}{E_{U0}}\frac{5-\nu}{3-\nu}. \tag{19}$$

h being the Plank constant.

One can see that the maximum time interval $\Delta R_u/c$ for the implosion is larger than the maximum time interval imposed to the initial explosion [6]. The time amplification factor is 10/3 for $\nu=0$. This could be interpreted as ***a larger probability of implosion as compared to BIG FLASH***. Of course, in case of the BIG FLASH the time is just starting to flow; in case of implosion one can expect ***a time inversion.***

If the evolution after implosion is reversible, the previous states are similar, the relation for the time τ_{contr} after contraction being:

$$\tau_{contr}=\tau_{crit}-\tau+1, \tag{20}$$

In this way the formula (15) from expansion is extended to contraction. In order to calculate τ_{crit} one computes the kinetic energy and the mechanical work of gravity forces at a time τ. Considering similar assumptions as for calculation of momentum and the expression (17) for density the kinetic energy of universe E_{KU} is constant in time:

$$E_{KU}=\frac{(3-\nu)}{(5-\nu)}\frac{(4-\nu)}{(6-\nu)}\frac{E_{U0}}{2}, \tag{21}$$

As regards the gravity forces they are distributed being equal on spheres with the center in origin. Their mechanical work, L_G, during expansion is:

$$\frac{(\text{-L}_G)}{3\chi_0 I_\nu} = \int_{\tau_0}^{\tau_{crit}} E_{gu}\left(1-\frac{E_{gu}}{E_{U0}}\right)^2 \tau^{2\alpha-1} d\tau\,;\; I_\nu = \frac{1}{2(3-\nu)^2}\left(\frac{1}{(5-\nu)} - \frac{(3-\nu)}{(4-\nu)(7-\nu)}\right). \quad (22)$$

The quantity (-L_G) is interpreted as an elastic energy. In (22) one has taken in account that gravitons are not in attraction.

One considers the critical time of the sudden inversion, τ_{crit}***, at a moment when the elastic energy of universe is two times the kinetic energy i.e.:***

$$\tau = \tau_{crit}\,, \quad 2E_{KU} = -L_{FN}\,. \quad (23)$$

On the other hand the total energy of the universe, E_{U0}, can be written as follows:

$$E_{U0} = E_{KU} + (-L_{FN}) + E_{REST}\,. \quad (23\text{-a})$$

where the rest energy E_{REST}, is modified to maintain the kinetic one constant according to (21), whereas the elastic energy increases.

Table 4 - The sudden inversion

ν	χ_0	E_{KU}/E_{U0}	$-L_{FN}/E_{KU}$	$\tau_{crit}/\tau_{\max}$	$t_{u\,crit}10^{-9}(lys)$
0	1	0.200	2.0000	0.87698	20.472
0	2	0.200	2.0000	0.9652	23.718
1	1	0.150	2.0000	0.8475	19.784
1	2	0.150	2.0000	0.8852	21.752

The results are given in Table 4. As one can see, τ_{crit} and $\tau_{\max}$ are close. The sudden inversion could take place about two billion of years ($\chi_0 = 1$), or about five billions of years ($\chi_0 = 2$) from now on. A larger density near the universe center leads to an earlier implosion ($\nu = 1$).

3.2.2 The slow inversion

In another scenario, after a time t_{uI} when the elastic energy equates the kinetic one, the expansion of the universe is slowed down to zero at the critical time $t_{u\,crit}$ when the implosion takes place. One considers the energy E_{REST} in (23-a) constant up to $E_{KU\,crit} = 0$. Then by using the conservation law (23-a), the moment of the slow inversion, $t_{u\,crit}$, corresponds to the equality:

$$(-L_{FN})_{crit} = 2E_{KUI}\,. \quad (24)$$

The universe radius, starting with the time t_{uI} is taken to vary as follows:

$$t_u \geq t_{uI}\,,\; \frac{R_u}{R_{u0}} = \tau_I + \frac{\tau_{crit}-\tau_I}{n+1}\left(1-\beta(\tau)^{\frac{n+1}{n}}\right);\; \beta(\tau) = \left(\frac{\tau_{crit}-\tau}{\tau_{crit}-\tau_I}\right)^n;\; \nu_{front} = c\beta(\tau)\,, \quad (25)$$

ν_{front} being the velocity at the universe frontier and n an odd integer so that ν_{front} is anti-symmetric around τ_{crit}. This leads to equal radii for expansion and contraction.
The equation (9) is now integrated along two time intervals: $(t_{u0};t_{u0})$ and $(t_{uI};t_{ucrit})$. For the first time interval the solution (12) is valid. For the second time interval the expression (25) for ν_{front} is used. One maintains the values for χ_0 and α because the known value f_{Nact} belongs to the first interval. The same parameters χ_0 and α from expansions will be maintained for contraction as well.

Table 5 - The slow inversion

ν	χ_0	n	E_{KUI}/E_{U0}	$\tau_I/\tau_{\max}$	$\tau_{crit}/\tau_{\max}$	$t_{ucrit}10^{-9}(lys)$
0	1	1	0.200	0.83516	0.88084	20.5626
0	2	1	0.200	0.85859	0.88066	21.6407
1	1	1	0.150	0.80876	0.8808	20.6176
1	2	1	0.150	0.8077	0.9411	21.6453
0	1	3	0.200	0.83516	0.88479	20.6547
0	2	3	0.200	0.85859	0.88096	21.6481
1	1	3	0.150	0.80876	0.9585	22.3759
1	2	3	0.150	0.8077	0.9242	22.7106

The solution for the time interval $(t_{uI};t_{ucrit})$ is

$$\frac{E_{gu}}{E_{U0}}=\left(1+\frac{(y_I)^{-1}-1}{e^{I(z)}}\right)^{-1};\ y_I=\left(\frac{E_{gu}}{E_{U0}}\right)_I;\ z=\frac{\tau}{\tau_{\max}}, \tag{26}$$

where $I(z)$ represents the integral:

$$I(z)=3\chi_0\int_{z_I}^{z}\beta(z)\frac{(z\,\tau_{\max})^{\alpha}}{R_{u\,rap}}d\,z;\ R_{u\,rap}=\frac{R_u}{R_{u\,0}}=z_I+\frac{z_{crit}-z_I}{n+1}\left(1-[\beta(z)]^{\frac{n+1}{n}}\right). \tag{26-a}$$

Although the integral $I(z)$ is numerically computed the precision is good, the interval $(t_{uI};t_{ucrit})$ being short enough.

The results of calculations for various values of the parameters are given in the Table 5. One can see that the values for the time of slow implosion are not much different from the time of the sudden implosion. The critical moment depends mainly on the parameter χ_0 as well as on the density distribution (the exponent ν) The increasing of the exponent n will postpone the implosion. After τ_{crit}, the stop of expansion, the universe in implosion has the frontier speed as follows:

$$\tau\in[\tau_{crit},2\tau_{crit}-\tau_I],\ \nu_{front}=c\beta(\tau);\ \tau\geq 2\tau_{crit}-\tau_I,\ \nu_{front}=-c\,. \tag{27}$$

Remark 1. By maintaining the parameters χ_0 and α the universe in contraction takes back the states from expansion at the corresponding moments as if the process would be reversible. One question is how long such a reversibility of contraction could last. One expects that at $\tau=1$, when for the transformation of protons in neutrons and of neutrons in photons could be irreversible, a threshold could occur [10-11].

If one assumes the pulsation of the universe as successive pairs of expansion-contractions such that the entropy balance is zero on every pair, then the process of pulsation will go forever. Another scenario could be: the irreversibility (especially at contraction) is compensated from the entropy increase at the first BIG FLASH; then a limited number of expansion-contractions could take place.

Remark 2. One interesting question is if one could speak about a ***time inversion*** and about a ***space diminution*** as well, starting from the implosion. If one admits that the universe in expansion produces increasing time and space one may attribute to contraction inverse effects.

4. CONCLUSIONS

A universe in pulsation (expansion/contraction) seems possible by using the hydro-dynamical model of gravity previously proposed by the author [6]. The property of emission/absorption of gravitons makes it possible, in both cases arising a force of attraction unlike the electrical interaction. An elastic sphere model for universe is given.

The differential equations for the energy of the "fluid of gravitons" is written and solved analytically for expansion and extended to contraction as well.

The model is first applied for expansion starting from an initial time, t_{u0}, selected by using a model of an early universe previously given by author [7]. This time corresponds to the substance formation under the form of neutrons. The contraction starts at a critical time, τ_{crit} when the elastic energy due to the gravity and accumulated by the sphere of universe in expansion exceeds about twice the kinetic energy. This happens near the maximum speed of graviton emission.

The emission of gravitons is connected with the expansion/contraction of the universe via an adjusting term depending on the age of the universe and containing a free parameter χ_0. A larger value of χ_0 postpones the implosion. A larger density near the center of universe leads to an earlier sudden implosion and to a later slow implosion.

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