An Extension of Newton Gravity Formula Considering the Universe Expansion Effects

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Abstract: *The Universe expansion and gravity are perhaps the main factors that determine the Universe evolution at global scale. The expansion of the Universe seen as a sphere whose frontier is moving at the speed of light in vacuum (c_V) increases the distances among bodies similarly to a dilatation process. If one studies the expansion effects on bodies in interaction, an interesting question is whether the configuration of these bodies is maintained such that the distances among them are proportionally modified. For example, it is known that the Solar planetary system has the same configuration for billion of years. Then, by applying the mechanical conservation laws, one may obtain important conclusions. Here we show that one of such important consequences is the dependence of the terms in Newton expression of the gravity force (including the universal coefficient of gravity) on the age of the Universe. An expression for the Hubble coefficient as a function of the age of Universe and a suggestion for the value of the actual age of Universe are also given.*

Key Words: *age of Universe; coefficient of universal attraction; mass dependence; Hubble coefficient*

1. INTRODUCTION

Newton formula of universal attraction is well-known. Although corrections of this formula are introduced by the theory of relativity, its precision when used for astronomical purposes is still satisfactory.

For example, the correction factor γ of the special theory of relativity [1]

$$\gamma = \sqrt{1 - \left(\frac{v}{c_V}\right)^2} \tag{1}$$

applies, where c_V is the speed of light in vacuum and *v* the relative speed of two reference systems.

If v = 30 m/s is the orbital speed of Earth around the Sun, one obtains $\gamma \cong 1-0.5\cdot 10^{-14} \cong 1$. To refer to the Universe as a whole, a coordinate system is used with the center C_U at BIG BANG (better said BIG FLASH as the sound does not propagate through vacuum) where the age of Universe denoted by t_U is null.

The radius of Universe whose frontier (made of photons) propagates with the speed c_V is denoted by R_U.

A linear velocity distribution along the radius in the interval (0; c_V) due to the Universe expansion is considered.

It is assumed that, on average, this simple model represents the Universe in a satisfactory way. In fact, the simple structures of the Universe are workable [2]. In Fig. 1 the consequences of this model are highlighted.

It follows that the motions of three arbitrary points A_1, B_1, C_1 at age t_{U1} on different radii, given by the unit vectors $\vec{e}_A, \vec{e}_B, \vec{e}_C$ to the positions A_2, B_2, C_2 at age t_{U2} satisfy the relations (similar triangles):

$$\frac{A_2B_2}{A_1B_1}=\frac{B_2C_2}{B_1C_1}=\frac{C_2A_2}{C_1A_{11}}=\frac{R_{U2}}{R_{U1}}=\frac{t_{U2}}{t_{U1}}=\frac{r_2}{r_1} \tag{2}$$

r_1, r_2 being the radii of the circumscribed circles of triangles $A_1B_1C_1$, $A_2B_2C_2$.

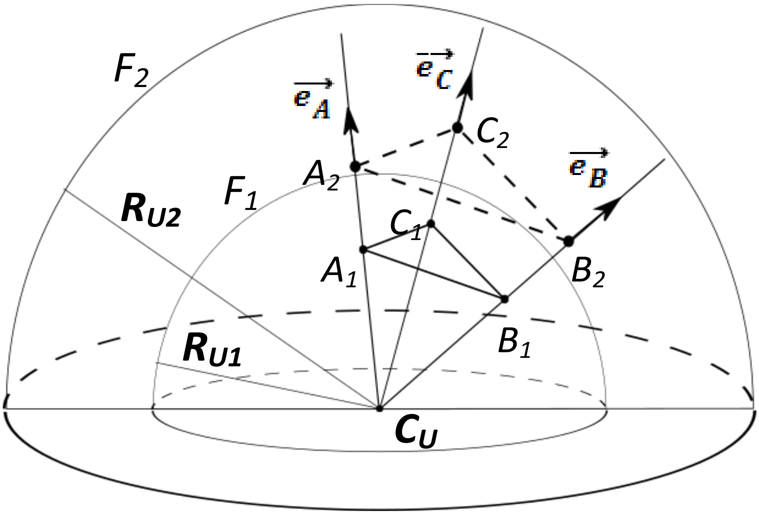

Fig. 1 - Sphere of the Universe
$F_1; F_2$ = frontiers of the Universe at times $t_{U1}; t_{U2}$; C_U = center of the Universe at Big Bang (Big Flash)

The dependence of the Hubble coefficient H_B on the age of Universe t_U is a first consequence of the Universe expansion (dilatation). One obtains:

$$H_B = 9.78\cdot 10^{11}/t_U \text{ [km/s/Mpc]};\ t_U = \text{no. of years since Big Flash} \tag{3}$$

For t_U = 1.38·10^{10} ys one obtains H_B = 70.87 km/s/Mpc, a value which lies in the range admitted today [2].

2. THE EFFECTS OF THE UNIVERSE EXPANSION ON THE NEWTON GRAVITY FORMULA

If M_A, M_B are two masses located at points A and B (mass centers), we shall write the Newton gravity formula as follows:

$$\vec{F}_{BA}(t_U) = -f_N(t_U)\frac{M_A(t_U)\,M_B(t_U)}{\left(\overline{AB(t_U)}\right)^2}\vec{e}_{AB} \tag{4}$$

where a dependence of the age t_U was introduced for the universal coefficient of attraction f_N as well as for masses, together with $\overline{AB(t_U)}$ the distance between the mass centers. The above notations show that the gravity force $\vec{F}_{BA}$ is exerted on mass *B* by mass *A* and is directed along *AB* as a force of attraction.

In order to establish the admitted dependence on the age t_U, one applies the conservation laws of momentum and mechanical energy to a **system with stable configuration** [3]: the system Sun - (Earth-Moon), the orbit being on average very close to a circle.

Let mass M_A with the center in A rotate around mass M_B with the center in B on a circle with the velocity V_A constant in magnitude, in a reference system with the origin in point B.

Between the times t_{U1}, t_{U2} the system (M_A, M_B) is dilated due to the Universe expansion according to relations (2).

Remark: We call attention to the fact that such effects like tides (often used to explain recession effects) cannot modify the momentums on orbits, in particular the angular momentum. Indeed, tides produce **inner oscillatory forces** and can mainly influence the body energy of rotation around the proper axis, by dissipating mechanical energy.

One applies:

a) the momentum conservation for mass M_A in the *AB* direction at age t_{U1}, representing the equality between the gravity force and the centrifugal force:

$$f_N(t_{U1})\frac{M_A(t_{U1})M_B(t_{U1})}{\overline{A_1B_1}^2} = \frac{M_A(t_{U1})\,V_{A1}^2}{\overline{A_1B_1}} \tag{5-a}$$

V_{A1} representing the speed of mass M_A at age t_{U1}:

b) similarly, the momentum conservation for mass M_A in the *AB* direction at age t_{U2} and speed V_{A2} gives:

$$f_N(t_{U2})\frac{M_A(t_{U2})\,M_B(t_{U2})}{\overline{A_2B_2}^2} = \frac{M_A(t_{U2})\,V_{A2}^2}{\overline{A_2B_2}} \tag{5-b}$$

From relations (5-a) and (5-b) one obtains:

$$V_{A1}^2 = f_N(t_{U1})\frac{M_B(t_{U1})}{\overline{A_1B_1}};\ \ V_{A2}^2 = f_N(t_{U2})\frac{M_B(t_{U2})}{\overline{A_2B_2}} \tag{6}$$

c) the angular momentum conservation between times t_{U1}, t_{U2}:

$$\overline{A_1B_1} \cdot V_{A1} M_A(t_{U1}) = \overline{A_2B_2} \cdot V_{A2} M_A(t_{U2}) \tag{7}$$

Putting:

$$M_{A,B}(t_{U2}) = M_{A,B}(t_{U1})(1+\varepsilon_{12});\ f_N(t_U) = f_{N\,ref}\left(\frac{t_U}{t_{U\,ref}}\right)^{\nu};\ f_N(t_{U2}) = f_N(t_{U1})\left(\frac{t_{U2}}{t_{U1}}\right)^{\nu_{12}} \tag{8}$$

where ε_{12} is a mass fraction and ν an exponent to be determined, one obtains:

$$\left(\frac{t_{U2}}{t_{U1}}\right)^{1+\nu_{12}} = (1+\varepsilon_{12})^{-3};\ \nu_{12} = -1,\ for\ \varepsilon_{12} = 0 \tag{9}$$

d) The mechanical energy conservation between times t_{U1}, t_{U2} yields:

$$\begin{aligned} &E_{KA}(t_{U1}) + E_{PA}(t_{U1}) + \left(M_A(t_{U1}) + M_B(t_{U1})\right)c_V^2 = \\ &\qquad E_{KA}(t_{U2}) + E_{PA}(t_{U2}) + \left(M_A(t_{U2}) + M_B(t_{U2})\right)c_V^2 \end{aligned} \tag{10}$$

where E_{KA}, E_{PA} stand for the kinetic and potential energies, respectively. As for the terms of form $\left(M_{A,B}(t_{U2}) - M_{A,B}(t_{U1})\right)c_V^2$ they are considered to be mechanical energies because they are connected to gravity.

To calculate them one uses our **hydro-dynamical analogy between the Newton gravity formula and the force of attraction of two sources in incompressible fluid** [4].

3. THE HYDRODYNAMICAL ANALOGY BETWEEN GRAVITY AND SOURCES ATTRACTION

In order to determine the mass fraction ε_{12} and the exponent ν, we adapt our hydro-dynamical analogy given in ref. [4], taking into account the definition of the HD-graviton (see bellow). One notes that in an incompressible fluid two sources ***are in attraction both when they are emitting and absorbing fluid.*** To make a connection with gravity one assumes that any amount of energy can emit or absorb particles ***called HD-gravitons***. A HD-graviton is a photon-like particle having the wave length equal to the radius of the Universe; it is the weakest possible particle in Universe being very hard (if not impossible) to detect. The flux of HD-gravitons *E'* emitted /absorbed by any amount of energy *E* (other then HD-graviton) is:

$$E' = \theta_g(t_U)E \tag{11}$$

where $\theta_{gU}(t_U)$ is the intensity of emission/absorption $\left(\sec^{-1}\right)$ which is obtained by equating the Newton and gravity forces. One adapts $\theta_{gU}(t_U)$ [4] in the form:

$$\theta_g(t_U) = \pm t_{UHD}\sqrt{\frac{3 f_{N\,ref}\, t_{U\,ref}\, E_{gU}}{c_V^5}}\,(t_U)^{\frac{\nu-5}{2}} \tag{12}$$

Here E_{gU} is the total energy of HD-gravitons in Universe and E_{U0} the total energy of the Universe; t_{UHD} is the time since the hydro-dynamical analogy can be applied. One considers the coefficient $f_{N\,act} = 6.67 \cdot 10^{-11}$ N.m^2 / kg^2 and the actual age of the Universe $t_{U\,act} = 1.38 \cdot 10^{10}$ yrs to have these values unless otherwise specified.

For the total energy of HD-gravitons in Universe E_{gU}, the following equation of balance can be written:

$$\frac{d\,E_{gU}}{d\,t_U} = \theta_g(t_U)\left(E_{U0} - E_{gU}\right) \tag{13}$$

Taking for the exponent ν in (12) the value $\nu = -1$ extrapolated for ages where one does not know stable configurations, we obtain for the intensity $\theta_g(t_U)$ the expression:

$$\theta_g(t_U) = \pm\frac{2A(t_{UHD})}{t_U^3}\sqrt{\frac{E_{gU}}{E_{U0}}}; \quad A(t_{UHD}) = \frac{t_{UHD}}{2}\sqrt{\frac{3 f_{N\,act} t_{U\,act} E_{U0}}{c_V^5}};\ t_U \geq t_{UHD} \tag{14}$$

With (14), the differential equation (13) has an analytical solution given below:

$$\ln\left(\frac{1+X}{1-X}\frac{1-X_{ref}}{1+X_{ref}}\right) = \pm\frac{t_{UHD}}{2}\left(1-\left(\frac{t_{U\,ref}}{t_U}\right)^2\right);\ X = \sqrt{\frac{E_{gU}}{E_{U0}}};\ t_U \geq t_{UHD} \tag{15}$$

$t_{U\,ref}$ being a reference (initial) time. For t_{UHD} two values were selected after the radiation started to be transformed in substance [7] (neutrons at various speeds): $t_{UHD1} = 10^6\ ys., t_{UHD2} = 10^7\ ys.$

There are arguments that from a pretty early age the state of the Universe corresponds to absorption of HD-gravitons.

These arguments are related to the existence of so-called “black energy” existing now in Universe [5] and to “black holes” [6]; we associate it with the fluid of HD-gravitons. Therefore in equations (8), (9), one has $\varepsilon_{12} \geq 0$.

Now we calculate for any mass M its contribution ε_{12} to the creation of gravity in Universe in a time interval $\left(t_{U1}; t_{U2}\right)$:

$$M(t_{U2}) = M(t_{U1})\left(1+\varepsilon_{12}\right);\ \varepsilon_{12} = \int_{t_{U1}}^{t_{U2}}\left[\left(-\theta_g(t_U)\right)\right]dt_U = -\theta_{gAV}\left(t_{U2} - t_{U1}\right) \tag{16}$$

The subscript *“AV”* stands for *“AVERAGE”*.

Only a fraction of the quantity ε_{12} denoted by β is associated with the mechanical energy conservation of the system $\left(M_A; M_B\right)$. As the gravity propagates at finite speed (c_V), one has $\beta_A \neq \beta_B$ for the two bodies.

Because the mass M_B is distant from M_A we shall take $\beta_B = 0$. In general, one should have $\beta_{A,B} \in \left(0;1\right)$.

The exponent value in the interval $(t_{U1};t_{U2})$ is:

$$\nu_{12}=-1+3\theta_{gAV}\left(t_{U2}-t_{U1}\right)/\ln\left(t_{U2}/t_{U1}\right) \tag{17}$$

As one can see, the universal coefficient of attraction f_N depends on the age of Universe even for constant masses ($\varepsilon_{12}=0$).

In fact, the percentage ε_{12} is very small (see Table 1). Thus, a power law with ν_{12} very close to -1 for f_N is confirmed. The mechanical energy conservation (10) is finally written as follows:

$$\left(E_{KA2}-E_{KA1}\right)+\left(E_{PA2}-E_{PA1}\right)+\left(\beta_A M_{A1}+\beta_B M_{B1}\right)\varepsilon_{12}c_V^2=0; \tag{18}$$

$$E_{KA2}-E_{KA1}=-\frac{M_{A1}V_{A1}^2}{2}\left[1-\frac{1}{1+\varepsilon_{12}}\left(\frac{t_{U1}}{t_{U2}}\right)^2\right] \tag{19-a}$$

$$E_{PA2}-E_{PA1}=-f_{N1}M_{A1}M_{B1}\left(\left(1-\frac{t_{U1}}{t_{U2}}\left(1+\varepsilon_{12}\right)^2\right)\frac{1}{R_{B1}}-\left(\frac{t_{U2}}{t_{U1}}-\frac{t_{U1}}{t_{U2}}\left(1+\varepsilon_{12}\right)^2\right)\frac{1}{A_2B_2}\right) \tag{19-b}$$

R_{B1} is the radius of the sphere representing the mass M_{B1}.The rotation energies of bodies around their proper axes were neglected, being comparatively small.

Both terms (19-a) and (19-b) are negative. Therefore, the mechanical energy conservation cannot be satisfied in the absence of the HD-gravitons absorption (i.e. for $\varepsilon_{12}=0$***).***

Table 1 gives the fractions ε_{12} and β_A ($\beta_B=0$) for Earth-Moon (mass M_A) rotating around the Sun (mass M_B) for an interval of time of 10^8 years. The actual energy of the HD-gravitons E_{gU} was taken $0.95E_U$ according to the total black energy (including black matter energy) [2].

Table 1. The Energy of HD-gravitons and the mass variations in 10^8 years ($\varepsilon_{12}=\varepsilon_{AV};\beta_B=0$)

t_U [years]	f_N $[\mathrm{N.m^2/kg^2}]$	$\frac{E_{gU\,ref}}{E_U}$	E_{gU}/E_U	$-\theta_g$ [s^{-1}]	$-\theta_{gAV}$ [s^{-1}]	ε_{AV}	$10^8\beta_A$
$13.8\cdot10^9$	$6.670\cdot10^{-11}$	0.95	0.95	$2.7381\cdot10^{-22}$	$2.709\cdot10^{-22}$	$0.855\cdot10^{-6}$	5.3865
$13.9\cdot10^9$	$6.622\cdot10^{-11}$	0.95	$0.95-0.427\cdot10^{-7}$	$2.7695\cdot10^{-22}$			

Table 2 gives the mean values of the mass fraction ε_{12} and of the exponent ν for the system Earth-Moon (mass M_A) rotating around the Sun (mass M_B) for a large interval of time: $\left(t_{U\,act}-4\cdot10^9\text{ yrs};\, t_{U\,act}+4\cdot10^9\text{ yrs}\right)$ The values of the gravity coefficient f_N for the interval ends are also given.

Table 2. The variation of main parameters for $8{\cdot}10^9$ years interval of time

$t_U.10^{-9}$ [years] / f_N $[\mathrm{N.m^2/kg^2}]$	$E_{gU}\ /\ E_U$	$-\theta_g \cdot 10^{22}\,[\mathrm{s^{-1}}]$	$-\theta_{gAV} \cdot 10^{22}\,[\mathrm{s^{-1}}]$	$\varepsilon_{AV} \cdot 10^5$	ν_{AV}
9.8	$0.95{+}0.484{\cdot}10^{-6}$	7.6457	5.3731	6.7825	$-1-\ 5.944{\cdot}10^{-4}$
$9.3924{\cdot}10^{-11}$					
13.8	0.95	2.7381	2.1884	2.7625	$-1-\ 3.256{\cdot}10^{-4}$
17.8	$0{,}95{-}1.189{\cdot}10^{-6}$	1.2759			
$5.1711{\cdot}10^{-11}$					

As one can see the exponent ν is very close the value -1 $(\nu_{AV} \cong -1)$, the universal coefficient of gravity varying in an inverse ratio with the age of Universe.

4. CONCLUSIONS

The expansion of the Universe which amplifies the distances between bodies is shown to influence all the terms existing in Newton's gravity law including the masses as well as the universal coefficient of gravity.

To prove this fact, one applies the mechanical conservation laws of momentum and energy to systems of bodies in a configuration maintained during large intervals of time. In the first step one can observe that the momentum and angular momentum conservation imply the dependence of the universal coefficient of gravity on the age of Universe.

The mass increasing in a process of absorption of particles that we have called HD-gravitons is necessary to satisfy the mechanical energy conservation giving a part of mechanical energy related to the gravity.

This process of HD-gravitons absorption is responsible for creating gravity at the Universe scale.

At the local scale only a fraction β_A, given in Table 1 for the system Earth-Moon rotating around Sun is implied.

As one can see the fraction β_A is very small. As regards the universal coefficient of gravity f_N, it depends on the age of Universe, the exponent being very close to (-1) for very large intervals of time (8 billion of years, see Table 2).

The time variation of f_N is very small at the actual age of Universe as one can see from Table 1; its effect on the day length is then difficult to be evidenced [8]. However the influence of this variation for a new basis for Cosmology [9] is evident.

As a general remark the obtained values for several parameters within reasonable limits supports the proposed models.

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