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A cosmological view on Milgrom's acceleration constant

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Summary
In this article a two-parameter model is developed for the universe. The two parameters are the age of the universe and Milgrom's acceleration constant. It is shown that these are sufficient to calculate the amounts of matter and dark energy in the universe, as well as the contributions of dark matter and baryonic matter in the matter part. All this, not only for present time, but also as a function of cosmological time. The developed theory gives an adequate explanation for the phenomena of the accelerated scaling of the universe and the anomaly of the stellar rotation curves in galaxies. The numerical results are in agreement with those of the Lamda-CDM model.

Keywords: Cosmological Constant; MOND; dark matter; dark energy; Lamda-CDM model

1. Introduction

This article is meant as an extension to a previous study [1]. It is my aim to give some view on the cosmological space, in which I will apply the concepts that I have developed to give an explanation for the negative pressure executed by the spatial fluid that must be present in vacuum to justify a positive value of the Cosmological Constant Λ in Einstein's Field Equation. Such a value is required to remove the anomaly of particular cosmological phenomena, like the rotation curves of stars in galaxies and the accelerated expansion of the universe. In my previous article, it has straightforwardly been derived that in a gravitational system with a central mass M in vacuum, the Cosmological Constant, while independent of space-time coordinates, amounts to

$$\Lambda = a_0 / 5MG \,, \qquad (1)$$

where a_0 ($\approx 10^{-10}$ m/s^2) is Milgrom's acceleration constant [2,3,4] and G the gravitational constant. It is my aim to show that this relationship between Milgrom's acceleration constant and the Cosmological Constant not only applies to galaxies, but holds for the universe as a whole as well, in spite of the obvious difficulty to identify a central mass. The study is prompted by the wish to find a means to assess the numerical value of Milgrom's acceleration constant by theory, for which no clue could be found within the scope of galaxies. Doing so, it is useful to emphasize that, unlike Newton's gravitational constant G, Einstein's Cosmological Constant is not an invariable, but depends on the amount of baryonic mass M in the system under consideration. This suggests that Milgrom's acceleration constant is an invariable constant of nature, next to G. If so, it should be true at cosmological scale as well.

Satisfying Einstein's Field equation in vacuum under absence of a massive source under the condition of a positive Cosmological Constant Λ requires the presence of a background energy [5]. Under inclusion of the massive source, the background energy will of course still be there and shows up as polarized dipoles [1,6], which explains the $1/M$ dependency of the Cosmological Constant. It may seem that a gravitational dipole concept, in the sense of a bond between a positive mass and a negative mass, violates physics, because a negative mass is not a viable concept. A close inspection reveals (see appendix in [1]) that these dipoles are the result of a modulation of the background energy density, due to a disturbance caused by the insertion of a central mass M. This allows to conceive the disturbance as gravitational dipoles on the pedestal of the background energy density. What may seem as a negative mass in the gravitational dipole is a dip in the background energy. The dipoles constitute grains in the fluidal vacuum with a negative pressure that neutralizes the gravitational force between the poles. This makes the gravitational dipole a valid concept.

The vacuum fluid is an ideal one. This implies that its stress-energy tensor contains diagonal elements only and that in space-time ((ict, x, y, z) with (+,+,+,+) metric they all have the same value. The pressure p_v is due to the background energy of the fluidal space, expressed by,

$$p_v = -\rho c^2 = -\frac{c^4}{8\pi G}\Lambda, \tag{2}$$

where c is the light velocity in vacuum and where ρ is the fluidal mass density. It must be present for giving a solution of Einstein's Field Equation with $\Lambda \neq 0$ for the vacuum without any baryonic sources. Assuming the correctness of (1), the fluidal pressure would rise to infinity under the absence of baryonic source. Baryonic sources "eat" from the fluid, thereby gaining mass and reducing the energy level of the fluid. This model is applicable to cosmological objects with a massive kernel, like galaxies. Interestingly, though, it can be evolved to a model that fits to the cosmos where matter is distributed. We shall denote the quantity ρc^2 as gravitational matter density. This gravitational matter density is composed by various components. Baryonic mass density is one of these. Paragraph 2 deals with the relationship between gravitational matter and baryonic matter. Paragraph 3 is a summary of present standard model for cosmology, known as the Lamda-CDM model (CDM = Cold Dark Matter), where the gravitational matter density shows up as a composition of a (true) matter density and a virtual matter density, known as dark energy. As discussed in paragraph 4, the baryonic matter density is just one component of the (true) matter density. The other component of it is the dark matter density. Dark matter is associated with baryonic matter, because it is the displacement matter that occurs as a result of the polarization of fluidal space under influence of baryonic sources [1]. All together we have,

gravitational matter density = (true) matter density + dark energy matter density
(true) matter density = baryonic matter density + dark matter density.

Normalizing all densities on the gravitational matter density gives,

$$1 = \Omega_m + \Omega_\Lambda = (\Omega_B + \Omega_D) + \Omega_\Lambda ,$$

where $\Omega_m, \Omega_\Lambda, \Omega_B, \Omega_D$, respectively are the relative matter density, the relative dark energy matter density, the relative baryonic matter density and the relative dark matter density. These symbols are the ones used in the Lamda-CDM model (CDM = Cold Dark Matter). It will be shown in this article that the interpretation of the Cosmology Constant concept as expressed by (1), developed from a straight evolution from Einstein's Field Equation [1], nicely fits to the Lamda-CDM model that evolves from the Friedmann-Lemairtre-Robertson-Walker (FLRW) metric. One of the results is the assessment of a numerical value of Milgrom's acceleration constant by theory. Other benefits are a better understanding of the nature of dark matter and dark energy and a simple rudimentary two-parameter model for cosmology.

2. Cosmological model

Let us model the universe as a sphere in the cosmos with radius L and distributed gravitational energy. This distributed energy is a gradually developed mixture of the energy from fluidal matter as meant by (2) and the energy from baryonic matter M_B as meant by (1). Hence, from (1) and (2),

$$M_G c^2 = \int_0^L \frac{a_0}{5M_B G} \frac{c^4}{8\pi G} 4\pi r^2 dr . \tag{3}$$

Let ΔM_G the difference between the gravitational matter in a sphere $L + \Delta L$ and the gravitational matter in a sphere L. It follows readily that

$$c^2 \Delta M_G = \frac{a_0}{10 M_B G^2} c^4 L^2 \Delta L . \tag{4}$$

After writing the baryonic matter as a dimensionless fraction β of the gravitational matter as,

$$M_B = \beta M_G , \tag{5}$$

eq. (4) can be integrated as

$$\frac{1}{2} M_G^2 c^2 = \frac{a_0}{10 \beta G^2} c^4 \frac{L^3}{3} . \tag{6}$$

The gravitational energy $M_G c^2$ therefore, is

$$M_G c^2 = \sqrt{\frac{a_0}{5 \beta G^2} c^6 \frac{L^3}{3}} . \tag{7}$$

Hence, the gravitational energy density $\rho_G c^2$ in the sphere with radius L is given by

$$\rho_G c^2 = \sqrt{\frac{a_0}{5\beta G^2} c^6 \frac{L^3}{3}} \cdot \frac{3}{4\pi L^3} = \frac{3}{4\pi}\sqrt{\frac{a_0}{15\beta G^2}\frac{c^6}{L^3}}\,. \tag{8}$$

This unification of baryonic energy and gravitational energy allows us to compare the gravitational energy with the one as obtained in the present cosmological model, known as the Lamda-CDM model (CDM≡Cold Dark Mass, Lamda≡ Einstein's Cosmological Constant), [7]. The CDM-Lamda model has been evolved from the Einstein-de Sitter model that has been the preferred one for the universe up to the 1980s. It has been refined to the present one to cope with certain cosmological phenomena, like for instance the discovery of the accelerating universe in 1998, [8,9].

3. The Lamda-CDM model

The model evolves from the solution of Einstein's Field Equation under the constraint of a particular metric.

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu} \quad \text{with} \quad G_{\mu\nu} = R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu}\,, \tag{9}$$

where $T_{\mu\nu}$ is the stress-energy tensor, which describes the energy and the momenta of the source(s) and where $R_{\mu\nu}$ and R are respectively the so-called Ricci tensor and the Ricci scalar, which can be calculated if the metric tensor components $g_{\mu\nu}$ are known [10,11,12]. The adopted metric, known as the FLRW metric [13], is

$$\mathrm{d}s^2 = \mathrm{d}q_0^2 + a^2(t)\left(\frac{\mathrm{d}r^2}{1-kr^2} + r^2 \sin^2\vartheta \mathrm{d}\varphi^2 + r^2 \mathrm{d}\vartheta^2\right), \tag{10}$$

where $q_0 = \mathrm{i}ct$ is the normalized time coordinate ($\mathrm{i} = \sqrt{-1}$), and where k is a measure for the curving of space-time. The scale factor $a(t)$ expresses the time-dependence of the size of the universe. The ratio

$$\frac{\dot{a}}{a} = H(t)\,, \tag{11}$$

is known as the Hubble factor. It is the main observable of the universe, because its numerical value can be established from red shift observations on cosmological objects ($\dot{a} \equiv \mathrm{d}a/\mathrm{d}t$).

By moving the term $\Lambda g_{\mu\nu}$ to the right side of (9), it can be conceived as an additional contribution to the energy density,

$$\rho(t) \to \rho(t) + \rho_\Lambda; \quad \rho_\Lambda = \frac{\Lambda}{\kappa}; \quad \kappa = \frac{8\pi G}{c^2}. \tag{12a}$$

$$p(t) \to p(t) - \rho_\Lambda c^2. \tag{12b}$$

The solution of (9) under constraint of the metric (10) are the two Friedmann equations [14],

$$(\frac{\dot{a}}{a})^2 + \frac{kc^2}{a^2} = \frac{8\pi G}{3}\rho \tag{13a}$$

$$2\frac{\ddot{a}}{a} + (\frac{\dot{a}}{a})^2 + \frac{kc^2}{a^2} = -\frac{8\pi G}{c^2}p. \tag{13b}$$

Under the constraint $k =$ 0 (flat universe), and taking into consideration (12a,b), the first Friedmann equation evolves as,

$$(\frac{\dot{a}}{a})^2 = \frac{8\pi G}{3}(\rho + \rho_\Lambda) \to (\frac{\dot{a}}{a})^2 = \frac{8\pi G}{3}\rho_c; \qquad \rho_t = \rho + \rho_\Lambda. \tag{14a}$$

The second Friedmann equation reads as,

$$\frac{\ddot{a}}{a} = \frac{4}{3}\pi G(2\rho_\Lambda - \rho) \to \frac{\ddot{a}}{a} = \frac{4}{3}\pi G(2\rho_\Lambda + 2\rho - 3\rho) = \frac{8}{3}\pi G\rho_t(1 - \frac{3}{2}\alpha); \alpha = \frac{\rho}{\rho_t}. \tag{14b}$$

Differentiating the mass density ρ_t in (14a) gives,

$$\begin{aligned}
&\dot{\rho}_t = \frac{3}{8\pi G}\frac{\mathrm{d}}{\mathrm{d}t}(\frac{\dot{a}}{a})^2 = \frac{3}{8\pi G}[2\frac{\dot{a}}{a}\{\frac{\ddot{a}}{a} - (\frac{\dot{a}}{a})^2\}] = \\
&2\frac{3}{8\pi G}\frac{\dot{a}}{a}\{\frac{8}{3}\pi G(1 - \frac{3}{2}\alpha) - \frac{8\pi G}{3}\}\rho_t = 2\frac{\dot{a}}{a}\{(1 - \frac{3}{2}\alpha) - 1\}\rho_t = -3\alpha\frac{\dot{a}}{a}\rho_t \to \\
&\dot{\rho}_t = -3\alpha\frac{\dot{a}}{a}\rho_t \to \frac{1}{\rho_t}\frac{\mathrm{d}\rho_t}{\mathrm{d}t} = -3\frac{\rho}{\rho_t}\frac{1}{a}\frac{\mathrm{d}a}{\mathrm{d}t} \to \frac{\mathrm{d}\rho_t}{\mathrm{d}t} = -3\rho\frac{1}{a}\frac{\mathrm{d}a}{\mathrm{d}t} \to \\
&\frac{\mathrm{d}\rho}{\mathrm{d}t} + \frac{\mathrm{d}\rho_\Lambda}{\mathrm{d}t} = -3\rho\frac{1}{a}\frac{\mathrm{d}a}{\mathrm{d}t}.
\end{aligned} \tag{15}$$

Because the background massive density ρ_Λ is time-independent (Λ is independent of space-time coordinates), (15) is satisfied if,

$$\frac{\mathrm{d}\rho}{\mathrm{d}t} = -3\rho\frac{1}{a}\frac{\mathrm{d}a}{\mathrm{d}t} \to \rho = \Omega_m H_0 a^{-3} \quad \text{and} \quad \rho_\Lambda = H_0\Omega_\Lambda, \tag{16a,b}$$

where Ω_m, Ω_Λ and H_0 are constants. The quantity H_0 is the Hubble parameter $\dot{a}/a$ at $a(t) = 1$. It is tempting to believe that Ω_m and Ω_Λ are, respectively, the relative amount of baryonic mass ρ/ρ_t and the relative amount of background mass ρ_Λ/ρ_t at $a(t)=1$. This, however, is not necessarily be true, because (without further constraints) the differential equation (14) is satisfied for any distribution between Ω_m and Ω_Λ as long as $\Omega_m+\Omega_\Lambda=1$.

Applying (16a,b) on the first Friedmann equation (14a), results into,

$$H(a)=\frac{\dot a}{a}=H_0\sqrt{\Omega_m a^{-3}+\Omega_\Lambda}\,. \tag{17}$$

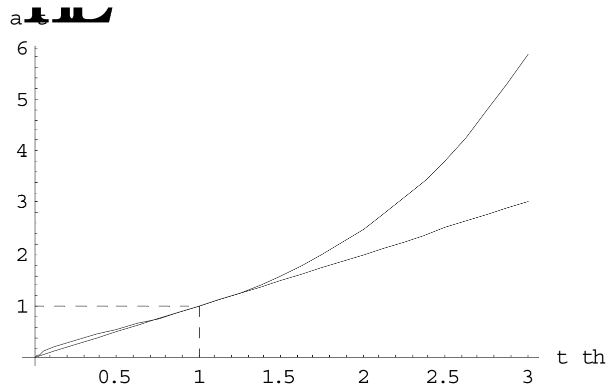

Fig.1: The scaling factor $a(t)$ as a function of cosmological time. The lower curve represents Hubble's law. The upper curve shows the curve of accelerated scaling due to Einstein's Cosmological Constant.

This equation represents the Lamda-CDM model in its most simple format (actually, more terms are heuristically added under the square root operator to model empirical evidence from certain cosmological phenomena). Eq. (17) can be analytically solved as [15],

$$a(t)=\left(\frac{\Omega_m}{\Omega_\Lambda}\right)^{1/3}\sinh^{2/3}(3\sqrt{\Omega_\Lambda}\,t/2t_H);t_H=H_0^{-1}. \tag{18}$$

At present time $t=t_P$, the scale factor equals unity ($a=1$) and the Hubble parameter is the observable H_0. Equating present time t_P with Hubble time t_H is justified if $a(t)$ would have shown a linear increase over time up to now, under a constant rate of say c_0, because in that case $a(t)=c_0 t$ and $\dot a(t)=c_0$. This is Hubble's empirical law. Equating $t_P=t_H$ in (18) as an axiomatic assumption, indeed results in a behavior of the scale curve that, up to present time $t\le t_H$, is pretty close to Hubble's empirical law. Hence, from (17),

$$a(t_H)=1;\;\; H(a)|t_H=H_0\rightarrow\Omega_m+\Omega_\Lambda=1. \tag{19}$$

Hence, from (19) and (18),

$$\left(\frac{1-\Omega_\Lambda}{\Omega_\Lambda}\right)^{1/3}\sinh^{2/3}(3\sqrt{\Omega_\Lambda}/2)=1\rightarrow\Omega_\Lambda=0.737;\;\Omega_m=0.263. \tag{20}$$

These values are only slightly different from those in the six-parameter Lamda-CDM model (where Ω_m = 0.259)The difference is due to the simplicity of the format (17). Figure 1 demonstrates the viability of the axiomatic assumption to equate present time with Hubble time.

4. Harmonizing the view on the universe with the view on the cosmos

Let us proceed by trying to harmonize the view on the cosmos as discussed in the second paragraph with the view on the universe as discussed in the third paragraph. This will be done by comparing the amount of massive energy in the universe that is presently observable with the massive energy that would be observable on the basis of the cosmological model. Note that we wish only taking care of observability, thereby ignoring possible massive energy in non-observable ranges.

The present gravitational mass $\rho_t(a=1)$, known as critical mass ρ_c in the Lamda-CDM model observed within the Hubble horizon $L_H = ct_H$, can be established from (13a) as,

$$\rho_c = \frac{3H_0^2}{8\pi G}. \tag{21}$$

Its massive energy is equivalent with the gravitational energy as defined by (7). Hence,

$$\frac{3H_0^2}{8\pi G}c^2 = \frac{3}{4\pi}\sqrt{\frac{a_0}{15\beta G^2}\frac{c^6}{L_H^3}}. \tag{22}$$

Let us eliminate H_0 and L_H from (22) by introducing a quantity a_L with the dimensionality of acceleration (m/s²),

$$a_L = \frac{c^2}{L_H}, \tag{23}$$

Hence, from $L_H = ct_H$ and (19),

$$H_0 = \frac{a_L}{c}. \tag{24}$$

Expression (22) evolves as,

$$\begin{gathered}\frac{3H_0^2}{8\pi G}c^2 = \frac{3}{4\pi}\sqrt{\frac{a_0}{15\beta G^2}\frac{c^6}{L_H^3}} \to \frac{3a_L^2}{8G} = \frac{3}{4}\sqrt{\frac{a_0}{15\beta G^2}a_L^3} \to \\ (\frac{3a_L^2}{8})^2 = \{\frac{3}{4}\}^2\frac{a_0}{15\beta}a_L^3 \to a_0 = \frac{15}{4}\beta a_L.\end{gathered} \tag{25}$$

For proper interpretation of this relation it has to be realized that the total gravitational energy is built-up as a sum of three components, such that

$$M_G c^2 = M_B c^2 + M_D c^2 + M_\Lambda c^2, \tag{26}$$

where the dark matter M_D is the displacement matter as a consequence of the polarization of the fluid [1] and where the dark energy matter M_Λ is the residual fluidal matter. Dividing (26) by $M_G c^2$, we have

$$1 = \frac{M_B c^2}{M_G c^2} + \frac{M_D c^2}{M_G c^2} + \frac{M_\Lambda c^2}{M_G c^2} = \Omega_B + \Omega_D + \Omega_\Lambda. \tag{27}$$

From (5) and (16),

$$\beta = \Omega_B \text{ and } \Omega_m = \Omega_B + \Omega_D. \tag{28}$$

These quantities are well established values in the Lamda-CDM model. From t_H = 13.8 Gyear, we have $a_L = c^2/(ct_H) = 6.9 \times 10^{-10}$ m/s². Furthermore

$$\Omega_B = \Omega_m \frac{\Omega_B}{\Omega_m} = 0.259\text{x}0.185 = 0.0486. \tag{29}$$

Inserting these values in (25) gives $a_0 = 1.256 \times 10^{-10}$ m/s². The correspondence of the calculated value for Milgrom's acceleration parameter in present time with evidence of observations gives a strong support for the viability of the theory developed in this article. It strengthens the expectation that Milgrom's acceleration constant is an invariable constant of nature next to G. If so, the relative baryonic matter content β scales with $a_L^{-1} (= t_H / c)$. However, other scenarios are possible as well, under constraint that a_0 / β scales with $a_L = c / t_H$. Anyhow, the present time value of Milgrom's acceleration is now established by theory as $a_0 = 1.256 \times 10^{-10}$ m/s².

5. Dark matter and dark energy

While under expansion of the universe the matter density decreases proportionally with the size of the universe, thereby keeping the mass of the matter constant, the density of the dark energy, remains invariant under expansion, possibly after an initial loss of matter. Let us try gaining more insight on the scaling behaviour of the universe. To do so, let us first consider the Cosmological Constant. It is tempting to establish its numerical value by inserting into (2) the value of the critical mass density. The latter is given by (21). Doing so, we find

$$\Lambda = 3\frac{H_0^2}{c^2}, \tag{30}$$

and also, because of (18) and (24),

$$\Lambda = 3(ct_H)^{-2} \text{ , equivalent with } \Lambda = 3\frac{a_L^2}{c^4}. \tag{31}$$

This means that observers in different cosmological times adhere different numerical values to Λ. This is contra-intuitive, because this seems to violate the independence of Λ from time-space coordinates. The paradox is solved from the consideration that at any moment t_H of cosmological time, the Friedmann model prescribes a resetting of the set of coordinates for Einstein' Field Equation, valid for $a=1$. In fact, (30) does not show a coordinate-dependence for Λ, but a mass-dependence, because at different values of cosmological time t_H, the matter content might be different. This is consistent with the behaviour of Λ in galaxies, where the coordinate-independence is preserved as long as Λ scales with the mass M [1]. Galaxies with different central mass M have different values for Λ. The same is true for the universe. At different moments in cosmological time, the value of the matter content is different, and therefore Λ is different. It will be clear from (31) that, knowing the life time of the universe, the Cosmological Constant will not add any new information.

The actual new information is the developed relationship (25),

$$\beta\big|_{t_H} = \frac{4}{15}\frac{a_0}{a_L} = \frac{4}{15}a_0\frac{t_H}{c}. \tag{32}$$

The choice for primary parameters is arbitrary. Only two are needed. The age t_H is an obvious one, because it can be straightforwardly derived from the observable Hubble parameter H_0. The choice for the second parameter is either the known value of $\beta = 0.0468$ at present time $t = t_H$, as can be read from the parameters in the Lamda-CDM model, or Milgrom's acceleration constant derived from it.

Equation (32) shows an intimate relationship between the ratio $\beta = \Omega_B$ of baryonic matter/gravitational matter at one side and the age of universe at the other side. Observers in earlier times as well as observers in future times would notice the same relative amount of matter density Ω_m and the relative amount of dark energy density Ω_Λ as an observer in present time. The scaling of a_L with t_H (as $a_L = c^2/ct_H$) raises the question about the scaling of a_0 in relation with the scaling of Ω_B over Ω_D. From a physical point of view, the likely scenario would be that Ω_B raises over Ω_D, because under expansion of the universe, an initial bubble of baryonic matter in the fluidal cosmos sea will gradually diffuse under increase of entropy. This will gradually reduce the polarization degree of the fluid, thereby reducing the amount of displaced matter. It would seem as if baryonic matter "eats" from dark matter. If this is the case indeed, Milgrom's constant eventually drops to zero, because $\beta \le \Omega_m$. Most likely, while β is striving for its maximum value Ω_m for t_H at infinity.

6. Conclusion

Putting everything together, we arrive at a very simple model for the universe, which nevertheless explains phenomena as dark matter, dark energy, the anomaly of the stellar rotation curves in the galaxies and the accelerated expansion of the universe. It gives an explanation as well for the empirical laws of Hubble and Milgrom. Next to Newton's gravitational constant G, only two other parameters are needed. These are the age of the universe t_H and the present value of Milgrom's acceleration constant. Everything else follows from Einstein's Field Equation in conjunction with the FRLW-metric. Let me summarize the basic equations and their implications.

The time behaviour of the scaling factor of the universe is a solution of Einstein's Field Equation under the FRLW-metric,

$$a(t) = (\frac{\Omega_m}{\Omega_\Lambda})^{1/3} \sinh^{2/3}(3\sqrt{\Omega_\Lambda}\, t/2t_H); t_H = H_0^{-1}. \tag{33}$$

As a consequence of $a(t_H)=1$, the relative values for matter density and dark energy are established as,

$$\Omega_m = 0.263 \text{ and } \Omega_\Lambda = 0.737. \tag{34}$$

The relationship between Milgrom's acceleration parameter and the ratio β of baryonic matter over gravitational matter is established as,

$$a_0 = \frac{15}{4}\beta a_L. \tag{35}$$

Accepting the life time of the universe t_H = 13.8 Gyear and a_0 = 1.256 x 10^{-10} m/s^2 as primary independent quantities, we get $\beta = \Omega_B$ = 0.0486.

All this has been derived straightforwardly by this two-parameter theory. The calculated quantities correspond nicely with those of the six-parameter Lamda-CDM model, which is largely empirical. The benefit of including more parameters is the modelling of cosmological effects beyond the scope of the simple model. The benefit of the simple model is its strength to show the relationship between dark energy and dark matter as well as the relationship between Milgrom's empirical MOND theory [2] and the Lamda-CDM model. Moreover, the two parameter theory strengthens the prediction made before that at large cosmological distance gravity turns on and-off into antigravity with some spatial periodicity [1].

7. Discussion

The previous paragraph contains the conclusions of this work. Harder than formulae is not possible. And a better proof than the match with known empirical evidence cannot be given. This leaves the problem of interpretation. This will be open for discussion and opinions might diverge. In the picture of the author, which he wants to give free for a better one, the universe seems appearing as a bubble in the cosmos. The cosmos is a sea of fluidal energy.

Otherwise Einstein's Cosmological Constant would be zero (an empty universe does not allow a viable solution of Einstein's Field equation for $\Lambda \neq 0$). The universe is created from the subtraction of a matter bubble from this sea. The ratio of the fluidal energy and the matter energy is found from Einstein's Field Equation and the axiom that the universe is a flat one. The matter subtraction is the event that marks the birth of the universe. The matter bubble might be a "quid pro quo" for spontaneously created ubiquitus ones.

As shown in the previous study [1], in which the relationship between Milgrom's acceleration constant and the Cosmological Constant has been derived, the sea of fluidal energy contains grains with a gravitational dipole. The negative pole is a dip in the sea of energy. That means that the grains are ripples in the sea and that the gravitational dipole has a pedestal. In a galaxy, the grains influence the gravitational force, because the field from the central baryonic mass polarizes their gravitational dipole moment, thereby creating the gravitational equivalent of a displacement charge that adds to the baryonic one. Effectively, it means that matter from outside is pushed in within the matter bubble. This "displaced" matter is the dark matter.

This dark matter model is less clear for the universe, where baryonic matter has a uniform distribution, thereby causing an overall random distribution of the gravitational dipole moments of the grains. Nevertheless, the universe is an assembly of galaxies as well, which all show the mechanism of attracting mass from beyond their cosmological horizons. Considering the universe as an expanding matter bubble allows to apply the same model. The gravitational matter bubble of the universe consists of a combination of true matter and virtual matter (dark energy). The true matter part consists of baryonic matter and dark matter. The ratio is subject to scaling: baryonic mass "eats" from the dark matter part, while the total matter part conserves its energy.

The developed theory predicts the decay of dark matter into baryonic matter. However, in spite of an adequate description of the process, as a consequence of Einstein's Cosmological Constant, it does not reveal the very physical structure of the decay. Both components are gravitational and the decay gradually occurs in cosmological time. In that respect it is quite different from the timescale associated with the escape of photons in the initial phase of the universe, such as imprinted in the cosmological microwave background (CMB). This imposes the problem how to find empirical evidence for the decay. Accepting the viability of gravitational dipoles, the mechanism can be qualitatively understood. The higher the degree of polarization the more dark matter. The early universe shows a high degree of polarization. Under expansion of the universe the polarization is randomized. Stated in other words, it is fair to say that the entropy of the dipoles increases, thereby increasing the amount of baryonic matter under a simultaneous decrease of dark matter. The entropic view relates this work with Verlinde's entropic gravity theory [17,18].

It has to be emphasized one more that the theory developed in this article and its predecessor [1] is a straight analysis based on Einstein's Field Equation in conjunction with the FRLW-metric. Radiation is not part of it. Therefore the viability of the theory is restricted to the matter phase of the universe. It is inadequate to describe the initial phase. The viability of the developed theory is most clear from the calculation of the value of Milgrom's acceleration from the present amount of baryonic matter in the universe.

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