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ETG Galaxies (<400 [My]) from JWST Already Predicted in 2019 from This Cosmological Model AΛΩ (Slow Bang Model, SB)

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Abstract

A model of the universe (preprint 2019), based on a quantum approach to the evolution of space-time as well as on an equation of state that retains all the infinitesimal terms, has made it possible to estimate a large number of parameters relating to the universe and in particular the estimation of a colossal phantom energy E_Λ represented by the existence of a hidden photon $\hat{\gamma}$ present everywhere. This energy undergoes dilution in H^4 due to expansion of the universe. In order to introduce the effects of this energy on the curvature of space-time, we chose to express it by the cosmological constant Λ in the equation of the GR via the element tensor T^{00}. This positive energy E_Λ which acts as additional effect to gravity and we have expressed this energy in the form of an equation which expresses a so-called cosmological force F_Λ. We estimated that this photon or hidden particle of spin 1 has an energy ~1 [meV] at our cosmic position t_0 which makes it an ultra-light axion ULA. Subsequently, with the action of this augmented force, especially in the first 400 [My] we were able to explain, in part, the rapid development of galaxy formation as seen by JWST as well as several observed dynamic behaviors of the barionic mass of some galaxies as MW, M33, UGC12591, NGC3198, UGC2885 and NGC253 whose observations raise questions and require additional explanations that led to the likely existence of unobserved matter called DM. However, it appears that this cosmological force makes it possible to explain several observations without the use of this DM. A first conclusion was drawn, namely the much earlier formation of galaxies by the action of this cosmological force coupled with gravity (GLASS z12). In addition, the model made it possible to explain the need or not to use the concept of DM for ETGs and LTGs by the more or less early and long period of the beginning of galaxy formation over a period ranging from ~170 to 1200 [My]. Thus, the model makes it possible to explain to a large extent the observations of the

dynamics of the galaxies studied. However, several questions remain.

Keywords

Model of Universe, ETG, LTG, UDG, Cosmological Constant, Hidden Photon, Hidden Boson, GLASS z12

1. Introduction to This Model and Update since First Publication in 2019 and JWST

It was in 2018 that the development of the model began and the first preprint publication appeared in [1]. Subsequently, in 2021, 3 publications appeared in this journal [2] [3] [4]. We refer the reader to these articles which contain more details. Since these publications, there has been little interest about this model. The reasons could be many but mainly due to the fact that the model predicts a form of progressive creation of the energy of the universe by the creation of photons originally, called alpha photon (alphaton). We will see that this almost undetectable photon could be identified as a hidden photon $\hat{\gamma}$ or hidden boson. The age of the universe is estimated at 76 [Gy] if based on the assumption that energy of Casimir effect is the energy of these first alphaton acting at our universe observed at cosmic time t_0 13.8 [Gy]. In fact, this model does not follow the ΛDCM standard model. It should be noted that the age of the universe estimated at 76 [Gy] is a parameter that can be changed without changing the predictions of the model but rather the numerical values obtained. Moreover, the age of the universe is estimated from an integration of estimated set of values of Ω_{i0} and H_0 at our position in this equation whatever the model assumptions used (FLRW metric).

$$t_u = \frac{1}{H_0}\int_0^a \frac{1}{\sqrt{\frac{\Omega_{r0}}{a^2}+\frac{\Omega_{m0}}{a}+\frac{\Omega_{k0}}{1}+\frac{a^2\Omega_{\Lambda 0}}{1}}}\mathrm{d}a$$

with (r, m, k, Λ: radiation, mass, curvature and cosmologic)

$$1=\Omega_{r0}+\Omega_{m0}+\Omega_{k0}+\Omega_{\Lambda 0}$$

Since JWST, several observations have shown the very likely existence of very large structures similar to mature galaxies (or BH?) already present as early as a few hundred My after the SB (Finkelstein *et al.* [5], Cowley *et al.* [6], Naidu *et al.* [7], Labbé *et al.* [8]). In the current state of calibration of the standard model ΛCDM, the existence of such structures cannot be explained so easily (fig 4, Haslbauer *et al.* [9]). Recently, various publications have provided plausible explanations for the early observation of already well-formed galaxies such as the *Renaissance* simulation using the ΛCDM model parameters and finer spatial resolution of the mesh (19 pc), McCaffrey *et al.*, [10]. However, other simulations of the same type will be needed in order to definitively decide on the ability of the Standard Model to predict the formation of massive galaxies so early.

The objective of this article is to recall that already in 2019, the present model predicted that galaxies are formed very soon after the beginning and the formation time of these is much shorter. It must be admitted that this prediction had also surprised the author. We will see in the following sections how this is possible.

2. Key Elements of This Model (Slow Bang, SB)

At the beginning, at time 0, a first Planck volume and first photon $\hat{\gamma}$ is present and this is predicted by an equation (see below). Here is a possibility of a mechanism for generating the energy and space of the universe considering the quantum nature of the process. According to the model and the quantization of energy and space, alphatons are generated, at each Planck time, during ~10^{-9} [s] according to a progression close to $(n+1)^3$, n being the Planck time number. Time and space evolve quantically in this model. The energy source causing alphaton generation is contained at the outer edge of the universe or from an unidentified internal source often referred to as vacuum energy. The number reached is about $6.4\times10^{89}\hat{\gamma}$. Thus, we see that the model considers an origin of the "Bang" type but the "Big" is rather a relatively slow quantum evolution of energy creation is the expression Slow Bang, SB. The model evolves according to cosmic time and all the variables of the universe (more than 25) are dynamic and evolve according to cosmic time. This model does not need the inflation phenomena since energy generation is slow and in phase (causal) with the space generation (see [2]).

Here is a summary of the main elements of this model, for a full description see [2] [3] [4].

The following are the key premises of the model:

- Time and space evolve quantically (Planck step t_p, l_p).
- During the energy creation (~10^{-9} [s]), the quantum nature of photon creation is applied.
- The macroscopic laws of physics applied after this energy creation period.
- All infinitesimal variations of dT, dP, dV and similar variables are to be considered and maintained in the elaboration of differentials equations given the large and small quantities involved in the equation terms (e.g. t_p ~10^{-43} [s], T_p ~10^{32} [K]).
- The law of conservation of energy applies to universe-size scales.
- The cosmological principle is not necessarily adhered to.
- The Hubble constant of the Hubble-Lemaître law is used to solve the Friedmann equations and find specific expression for $\Lambda(t)$ and $k(t)$.

At the beginning, at $t = 0$, the photon gas equation applied when photons are created, that is written as:

$$PV = \frac{\zeta(4)}{\zeta(3)} k_b NT = f(t)$$

Observations show that the universe is expanding with time $\dot{r}(t) > 0$. Expansion of the universe is isotropic on average ($\dot{r}$ isotropic) and in accordance with the Hubble-Lemaître law. The volume V of space (photon propagation) thus generated is isotropic (large-scale isotropic, $\dot{V}$). The mechanism behind the evolution pattern for V is unknown but it is represented by the evolution of energy associated with curvature k (see later). It starts with the initial Planck time t_p, and time evolves freely as $t + nt_p$. At every step, t, V, T and P evolve, but the triggering mechanism for this evolution is unknown. V, T and P evolve in some sort of sequence, which is probably as follows: $t + t_p$, $V + dV$, $N + dN$, $T - dT$, $P - dP$, $E - dE$. The expanding volume (space-time) is a sphere whose radius evolves in line with cosmic time.

Let us write the equation of state for photon gas in the form of the variation, freely choosing the negative form of the variations (observation is for a $\dot{T} < 0$):

$$\frac{PV}{T} = \frac{(P - dP)(V - dV)}{T - dT} = f(t)$$

Developing the right-hand side yields:

$$\frac{dT}{T} = \frac{dV}{V} + \frac{dP}{P} - \frac{dPdV}{PV}$$

The final term on the right is retained and it is critical because of large and small quantities involved of P and V.

Also, it contains the potential existence of a singularity at the beginning of the evolution of the universe. Possibility that is not used in the model.

Let us develop V (spherical), dV, P and dP:

$$V = \frac{4\pi}{3} r^3 = \frac{4\pi}{3} (ct)^3$$

$$\frac{dV}{V} = 3Hdt$$

$$P = \frac{4\sigma}{3c} T^4$$

$$\frac{dPdV}{PV} = 12Hdt \frac{dT}{T}$$

Finally, we derive the following specific equation for the evolution of photon gas temperature in a context of expansion of the universe ($N \gg 1$):

$$\frac{dT}{T} = \frac{Hdt}{-1 + 4H\widetilde{dt}}$$

The equation for temperature variations in line with the Hubble constant yields different scenarios of evolution for $T(t)$. First, integration creates a problem since infinitesimal dt appears in both the numerator and denominator. The presence of $\widetilde{dt}$ in the denominator is caused by the term $dVdP/VP$. Let us assume that this term remains constant for the main integration of dt, therefore:

$$T(t) = \frac{C}{-t + 4\widetilde{dt}}$$

where $H = 1/t$, or $\ddot{r}/r = H^2 + \dot{H} = 0$, or still $q = 0$ (for the boundary of the universe).

Note that the acceleration factor q of the boundary of the universe is zero, but it is not zero for the mass of the universe (see [3]). If we take $T(0) = T_p$, ([11] Lima *et al.*), which denotes the maximum energy in the universe at positive temperature, we get:

$$T(0) = T_p = \frac{C}{-4\widetilde{dt}}$$

And then

$$C = -4\widetilde{dt}T_p$$

Let us define the age of the universe as t_Ω, and CMB temperature as T_Ω or T_{CMB}. Therefore:

$$T(t_\Omega) = T_\Omega = T_{CMB} = \frac{-4dtT_p}{-t_\Omega + 4\widetilde{dt}}$$

The value of $\widetilde{dt}$ for this condition is:

$$\widetilde{dt} = \frac{T_p t_\Omega}{4(T_\Omega + T_p)}$$

To develop an equation for T, we find:

$$T(t) = \frac{\dfrac{T_\Omega T_p t_\Omega}{T_\Omega - T_p}}{-t + \dfrac{T_\Omega t_\Omega}{T_\Omega - T_p}}$$

Finally, we can assume $(T_\Omega - T_p) \sim -T_p$, then the final expression for T is:

$$T(t) = \frac{-t_\Omega T_\Omega}{-t - \dfrac{t_\Omega T_\Omega}{T_p}} = \frac{-t_\Omega T_\Omega}{-t + \tau}$$

The most important point to note about this timespan or delay, expressed as $\tau = -t_\Omega T_\Omega T_P^{-1}$, is the fact that it allows to slow the decrease in temperature down to a characteristic value of $\sim 10^{-14}$ [s]. We will see that during that delay, the number of photons increases at a quasi-constant temperature and pressure (this makes it possible to find causality and solve the problem of the event horizon, see [3]).

Photon gas pressure is expressed as ($N \gg 1$):

$$P = \frac{4\sigma}{3c} T_\Omega^4 \left[\frac{t_\Omega}{-t - \dfrac{t_\Omega T_\Omega}{T_p}} \right]^4$$

Volume is expressed as:

$$V = \frac{\dfrac{\zeta(4)}{\zeta(3)} k_b N T}{P}$$

At the beginning, the volume is:

$$V(0)=\frac{4}{3}\pi l_p^3$$

For the number of photons in line with temperature (photon gas):

$$N=Vn=V\frac{2\zeta(3)}{\pi^2}\left(\frac{2\pi k_b T}{hc}\right)^3=\frac{4\pi}{3}(ct)^3\frac{2\zeta(3)}{\pi^2}\left(\frac{2\pi k_b T}{hc}\right)^3$$

If the expressions l_p and T_p at $t = 0$ are used, the number of photons at the beginning of the universe, ($t = 0$), is:

$$N(0)=\frac{4\pi}{3}l_p^3\frac{2\zeta(3)}{\pi^2}\left(\frac{2\pi k_b T_p}{hc}\right)^3$$

$$=\frac{4\pi}{3}\frac{2\zeta(3)}{\pi^2}\left(\frac{hG}{2\pi c^3}\right)^{3/2}\left(\frac{2\pi k_b\left(\frac{hc^5}{2\pi G k_b^2}\right)^{1/2}}{hc}\right)^3$$

$$=\frac{64\zeta(3)}{24\pi}=\frac{8\zeta(3)}{3\pi}=1.02!$$

We see that at the beginning, only one photon is present in the original Planck volume (a hidden photon $\hat{\gamma}$ in a box of l_p size!). The expression of expansion of the number of photons making up the most part of the energy of universe relative to the age of the universe is, t_Ω. Expression of the number of photons in relation to cosmic time is:

$$N(t)=\frac{8\zeta(3)}{3\pi}\left(\frac{2\pi k_b T_\Omega}{hc}\right)^3\left[\frac{\left(-cT_p t_\Omega\right)t-l_p T_p t_\Omega}{\left(-T_p\right)t-t_\Omega T_\Omega}\right]^3$$

The cosmic time expression can be used as a progression of n Planck time units, which then yields the following expression of the expansion of the number of photons in relation to the number of Planck time units:

$$N(nt_p)=\frac{8\zeta(3)}{3\pi}\left(\frac{2\pi k_b T_\Omega}{hc}\right)^3\left[\frac{\left(-cT_p t_\Omega\right)nt_p-l_p T_p t_\Omega}{\left(-T_p\right)nt_p-t_\Omega T_\Omega}\right]^3$$

The above expression of the number of photons relative to time is unusual. Indeed, we find that the number of photons increases according to a geometrical progression of $\sim(n+1)^3$ over a characteristic time of $\sim10^{-9}$ [s] for an age of 76.1 [Gy], up to a maximum where it remains constant. This gradual expansion of the energy of the universe is called the Slow Bang (SB). However, the energy necessary to expand the number of photons is not known. This energy of expanding the number of photons could be identified as the one often mentioned vacuum energy but this energy could come from outside of the known universe. An important point to emphasize, the model is based on the idea of an original big bang but to the difference that the total energy of the universe is created during this characteristic time of 10^{-9} [s], a Slow Bang. In summary, the creation of the universe begins with 1 photon originally at $t = 0$ and subsequently the following photons are created during this period. One can call this period, the inflation of photons and the original photons the alphaton.

The expression trends towards a constant number of photons, ~10^{-9} [s] ($dN/dt = 0$). For t_Ω = 76.1 [Gy] (2.39 × 10^{18} [s]), we get a constant number of photons:

$$N(\infty) = \frac{64\zeta(3)\pi^2}{3}\left(\frac{k_b T_\Omega t_\Omega}{h}\right)^3 \sim 6.42\times10^{89}\,(\text{constant})$$

The time period when the number of photons increases geometrically is called the photon epoch (see Figure 1). The process leading to photon inflation is unknown but at every time increment (quantum), the number of photons increases. However, the increase in energy is caused by photon inflation because photon energy remains slightly below Planck energy, E_p, (1.76 × 10^9 [J]) until time ~10^{-9} [s].

Energy at the beginning of the universe is expressed as the energy of a single photon, the value of which is slightly lower than Planck energy, E_p. For $N = 1$:

$$U(0) = 0.9Nk_bT_p = 0.9k_bT_p = 0.9E_p = 0.9c^2\sqrt{\frac{ch}{2\pi G}} = 1.76\times10^9\,[\text{J}]$$

Photon gas energy in relation to time can be expressed in several equivalent ways for $N \gg 1$:

$$U(t) = 3PV = \frac{4\sigma}{c}T^4V = 3\frac{\zeta(4)}{\zeta(3)}Nk_bT \sim 2.7Nk_bT$$

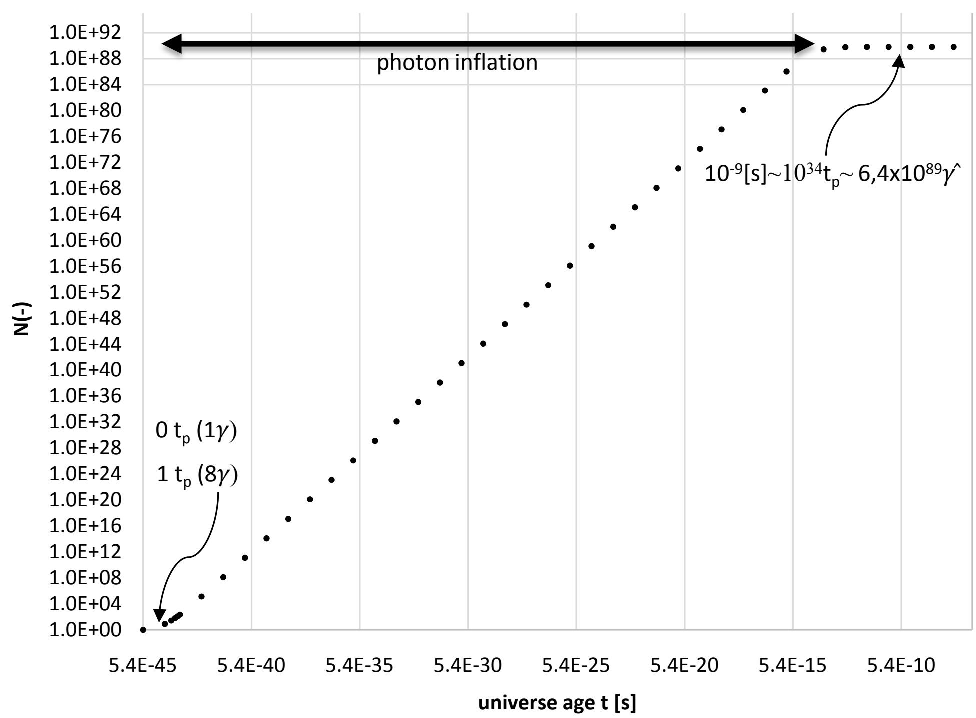

Figure 1. Inflation of photons number from 0 t_p to 1 × 10^{-6} [s].

with the expression for $N(t)$ obtained earlier:

$$U(t) = 2.7Nk_bT = 64\pi^2\zeta(4)\left(\frac{ct+l_P}{hc}\right)^3 (k_bT)^4$$

It can be written as:

$$U(t) = \left(\frac{64\zeta(4)\pi^2k_b^4}{h^3c^3}\right)\left(\frac{(ct+l_p)^3}{(-t+\tau)^4}\right)(t_\Omega T_\Omega)^4 = U_0\left(\frac{(ct+l_p)^3}{(-t+\tau)^4}\right)(t_\Omega T_\Omega)^4$$

Or still as:

$$U(n) = \left(\frac{64\zeta(4)\pi^2}{h^3t_p}\right)\left(\frac{(n+1)^3}{(n+k')^4}\right)(k_bt_\Omega T_\Omega)^4$$

where n is the whole number of Planck time units, t_p.

For $t = t_\Omega$, ($N \gg 1$) we get:

$$U(t_\Omega) = \left(\frac{64\zeta(4)\pi^2k_b^4t_p^4k'^4}{h^3}\right)\frac{T_p^4}{t_\Omega} = \left(\frac{64\zeta(4)\pi^2k_b^4T_\Omega^4}{h^3}\right)t_\Omega^3$$

Maximum energy is reached for $\dot{U}(t_{\max}) = 0$.

And for ($t_\Omega = 76.1$ [Gy]):

$$U_{\max}(t_{\max}) = 3.57\times10^{98}\,[\mathrm{J}]$$

Mass has not yet been created at this time because the temperature is in the order of 3.5×10^{31} [K]. To get an idea of the sheer magnitude of energy, assuming that the entire mass created is in the order of 10^{52} [kg], with relativistic energy-mass equivalence (β~0.9), this corresponds to 2×10^{69} [J]; still an infinitesimal fraction of the energy in the universe.

The energy gain, by a factor of 10^{89}, can be explained by the increase in the number of photons, also by a factor of 10^{89}, during time period named photon inflation period, or 10^{-9} [s].

Early baryogenesis (protons, neutrons) and leptons (electrons, neutrinos)

In this model, the appearance of matter takes place much later (t_{pr} ~10^3 [s]). Although the generation of particles even more fundamental than baryons (quarks, gluons) probably took place before, we begin the generation of matter with the hadrons. During early baryogenesis, at very high temperature ($mc^2 \ll kT$), the Maxwell-Juttner MJ (relativist) statistical law is used to predict particle properties (fermions and letpons). Moreover, the presence of antiparticles must be considered, along with the creation-annihilation process.

As example, the stopping temperature of creation of baryons is 2.08×10^{14} [K] (see [2]). We can estimate the value of β_{pr} with the hypothesis of creation of a baryon p and $10^{-9}\,\overline{p}$ with the energy of an alphaton at $\upsilon_{\hat{\gamma}}$ and participation of another particle (momentum conservation), at the same cosmic time *i.e.* the equation:

$$\beta_{pr} = \sqrt{1-\left(\frac{(m_p+10^{-9}m_{\overline{p}})c^2}{h\upsilon_{\hat{\gamma}}}\right)^2} \sim 0.9987$$

$$h\upsilon_{\hat{\gamma}}\left(t_{pr}\right)=2.96\times10^{-9}\left[\mathrm{J}\right]$$

Either (possible Feynman) (**Figure 2**).

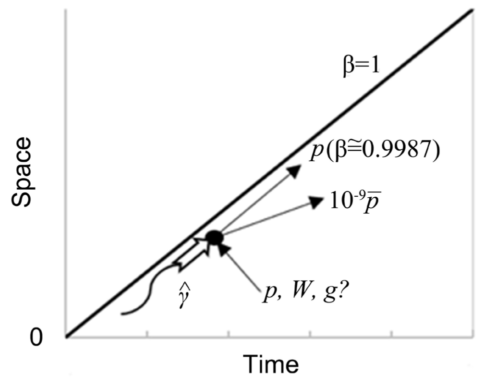

Figure 2. Possible Feynman diagram of proton creation.

We find the same value of β_n,β_e for neutrons and electrons with t_n and t_e.

In this model, we estimated the total barionic mass produced at the end of baryogenesis (see [1]).

$$M_p\sim10^{-9}\left(n_pm_p+0.8n_nm_n\right)\sim6.53\times10^{50}\left[\mathrm{kg}\right]$$

$$M_n\sim0.2\times10^{-9}n_nm_n\sim7.25\times10^{49}\left[\mathrm{kg}\right]$$

However, with the exponential disintegration of neutrons, ~95% of them will still be available for capture (formation of deuterium at β) after 43 [s] before the creation of protons.

Also, an equation can be found for the baryon-photon ratio, η_B. We get the following equation and a maximum value for the ratio:

$$\eta_B=\frac{n_b\left(t_{pr}\right)}{n_\gamma\left(t_{pr}\right)}\sim\frac{2n_p\left(t_{pr}\right)}{N\left(t_{pr}\right)}=10^{-9}\frac{\dfrac{2V4\pi cm_p^2k_bT_{pr}K_2\left(\mu\right)}{eh^3}}{64\dfrac{\zeta\left(3\right)\pi^2}{3}\left(\dfrac{k_bT_{pr}t_{pr}}{h}\right)^3}$$

$$=10^{-9}\frac{\left(1-\beta^2\right)K_2\left(\mu\right)}{2e\zeta\left(3\right)}=10^{-9}\frac{\left(1-\beta^2\right)K_2\left(\mu\right)}{6.53}\sim2.48\times10^{-10}$$

The electron creation potential (without $e\overline{e}$ annihilation) at the electron stop time is:

$$n_e=\frac{V4\pi cm_e^2k_bT_eK_2\left(\mu\right)}{eh^3}=\frac{16\pi^2c^4t_{el}^3m_e^2k_bT_eK_2\left(\mu\right)}{3eh^3}=2.1700\times10^{86}$$

To estimate the final number of electrons, the respective antiparticle creation and annihilation must be considered. To do so, let us assume that lepton asymmetry prevails according to a proportion of one stable electron created for every 10^9 $e\overline{e}$ annihilation.

For $t_\Omega = 76.1$ [Gy]:

$$M_e=10^{-9}\left(n_em_e+0.8n_nm_e\right)\sim3.55\times10^{47}\left[\mathrm{kg}\right]$$

Finally, the following total mass for the creation of electrons, protons and neutrons is achieved:

$$M_t = M_p + M_n + M_e = 7.26 \times 10^{50} [\text{kg}]$$

Let us revisit the total predicted mass of ~7 × 10^{50}, which is relatively lower (17 to 350 times) than the oft-mentioned total mass of the universe (1.25 × 10^{52} to 2.5 × 10^{53}). However, total mass is relative to the age of the universe. Hence, baryon mass could be increased by increasing the age of the universe or by reducing the particle-antiparticle annihilation factor. With the energy-mass equivalence, when the ratio of total created mass-energy to total universe energy at the time of electron production (around the end of the main leptogenesis) is obtained, we get $\beta = 0.001$, or a low non-relativistic speed of the baryonic mass, but still within the range of velocity for the MW:

$$\frac{E_{mass}}{E_{total}} = \frac{\frac{M_t c^2}{\sqrt{1-\beta^2}}}{U(t_{el})} = \frac{6.43 \times 10^{67}}{2.72 \times 10^{78}} = 2.3 \times 10^{-11}$$

This energy ratio confirms that the universe, during early leptogenesis, or at the end of the creation of the particles that make up most of the mass, was vastly influenced by radiation (radiation universe and dS_n) and that the effects associated with mass, such as gravity, were negligible compared to the electromagnetic impact of photon gas.

Total energy predicted of the universe at 13.8 [Gy] after the beginning is:

$$U_{total} \sim 2.05 \times 10^{69} [\text{J}]$$

That energy, when converted to energy-mass equivalence, yields the following mass ($\beta = 0.001$):

$$M_{equi\text{-}energy} = \frac{2.0 \times 10^{69} \sqrt{1-\beta^2}}{c^2} = 2.23 \times 10^{52} [\text{kg}]$$

The model proposed herein sheds light on the importance of the cosmological constant, Λ, which acts as a dominant gravitational force in the early universe. **Einstein's proposed cosmological constant is used in this model to predict the total energy of the universe rather than as a gravitational balance effect**. This colossal energy is worth ~10^{98} [J]. By comparison, the total energy associated with the baryonic mass (~10^{52} [kg]) is worth ~10^{69} [J], a tiny portion of the total energy. The development of the state equation highlights the importance of not neglecting any of the differential terms given the existence of large and small values mixed in equation during the Planck era.

3. Cosmological Constant Λ Estimated Values and Energy E_Λ of the Universe

The Friedmann equation (FLRW metric) for an isotropic universe made up of matter in the presence of energy associated with the cosmological constant can be written in relation with the terms that contribute to the expansion or contraction of the universe, H, with gravity, G, the existence of energy other than baryonic through Λ and the space curvature, k, or:

$$H^2 = \left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi G\rho}{3} + \frac{\Lambda c^2}{3} - \frac{kc^2}{a^2}$$

where the scale factor is a [−], k is the space curvature, [m^{-2}] and ρ, the density of conventional mass [$\mathrm{kg \cdot m^{-3}}$]. Indeed, assuming the existence of mass-energy equivalence (non-baryonic), represented by constant Λ, along with zero acceleration ($H = 0$) of that mass-energy equivalence, that equation, which represents the non-baryonic residual volumetric mass-energy equivalence of the universe, is written as:

$$\frac{E_{conventional} - E_{mass\text{-}energy}}{V} = \frac{E_\Lambda}{V} = \frac{m_\Lambda c^2}{V} = \rho_{e\Lambda} c^2 = \left| \frac{3kc^4}{a^2} - \frac{c^4 \Lambda}{8\pi G} \right|$$

with space curvature k (closed if $k > 0$, flat if $k = 0$ and open if $k < 0$):

$$k = \left[\frac{a^2 8\pi G\rho}{3c^2} + \frac{a^2\Lambda}{3}\right] - \left[\frac{a^2 H^2}{c^2}\right]$$

The effects of each term of the equation are clearly seen. The first term is the closing effect caused by gravity, G, via mass density, ρ; the second is the closing effect caused by the residual mass-energy equivalence (non-baryonic) via cosmological constant Λ; and the last term is the opening effect, caused by an unknown element, but represented by the Hubble constant. The value of k today, time t_0, is very close to zero, but slightly negative (open).

$$k(t_0) \sim -5.6 \times 10^{-53} \left[\mathrm{m}^{-2}\right]$$

The transition between a closed and open universe occurs ~ 3 [Gy] (see [2] Figure 6).

An oft-mentioned expression for the cosmological constant is found in the following equation (with space curvature, k, considered to be zero), which represents the existence of a non-baryonic volumetric energy density in the universe:

$$\rho_{\Lambda e} = \rho_\Lambda c^2 \sim \frac{c^4 \Lambda}{8\pi G}$$

The model estimates this residual conventional energy density from the mass created at time t, with the equation below. Indeed, all the variables in this equation are conventional type (positive pressure and positive volume). There are no new-type variables which could translate the existence of a form of energy other than conventional (negative pressure, negative energy, negative mass):

$$\rho_{\Lambda e} c^2 = \frac{E_{conventional} - E_{equivalence\ m-E}}{V} = \frac{3PV - \frac{M_T c^2}{\sqrt{1-\beta^2}}}{V} = \left[\frac{4\sigma T^4}{c}\right] - \left[\frac{4\sigma \frac{M_T c^2}{\sqrt{1-\beta^2}}}{3c^4 \psi k_b t^3}\right]$$

where $\psi = \frac{64}{3}\pi^2 \zeta(3)\left(\frac{k_b}{hc}\right)^3 \sim 8.497 \times 10^7 \left[\mathrm{m^{-3} \cdot K^{-3}}\right]$.

With the equation below, two dominant terms at different times are found for the expression of the cosmological constant, by virtue of the dominator, which reduces in t^4 for the first term, and t^3 for the second. Hence, the first dominant term for the beginning of expansion can be written as Λ_{rad}, and the second, Λ_{mass}, for the time period that comes later with the creation of the baryonic mass until today, at time t_0. Moreover, the second term, which contains the mass generated over time, shows that the constant can undergo relatively quick variations:

$$\Lambda(t) = \Lambda_{rad} - \Lambda_{mass} \sim \left[\frac{8\pi G}{c^4}\right]\left[\frac{4\sigma T^4}{c}\right] - \left[\frac{8\pi G}{c^4}\right]\left[\frac{4\sigma \frac{M_T c^2}{\sqrt{1-\beta^2}}}{3c^4 \psi k_b t^3}\right]$$

$$= \left[\frac{32\pi G\sigma T^4}{c^5}\right] - \left[\frac{32\pi G\sigma \frac{M_T c^2}{\sqrt{1-\beta^2}}}{3c^8 \psi k_b t^3}\right]$$

Finally, after some development, we get an approximative expression for the cosmological constant, taking only the proton mass into consideration:

$$\Lambda(H) \sim 2.88\times10^{17} H^4 - 8.24\times10^{-2} H^3 \left[\mathrm{m}^{-2}\right]$$

In brief, those expressions for space curvature and energy density (non-baryonic) can be obtained by substituting the cosmological constant equation:

$$k(H) = a^2\left[\frac{k_\Lambda}{3(-1+bH)^4}H^4 + GM_t\frac{\left(2-\frac{\pi^4}{4\zeta(3)}\right)}{c^5}H^3 - \frac{1}{c^2}H^2\right]$$

$$k(H) \sim a^2\left[9.61\times10^{16} H^4 + 3.04\times10^{-3} H^3 - 1.11\times10^{-17} H^2\right]\left[\mathrm{m}^{-2}\right]$$

The space curvature equation yields $k = 0$ for $t = 2.95$ [Gy], or the transition from closed to open universe. This closely corresponds with the value found for deceleration transition, q, around 2 [Gy] (see fig 3 [3]). That these two values are relatively close is promising in terms of model constancy.

As concerns energy density, we find two distinct contributions: one associated with radiation and the other, with mass (valid for $t > 10^{-13}$ [s]):

$$\rho_{\Lambda e}(H) = \rho_{\Lambda e}^{rad} + \rho_{\Lambda e}^{mass} = \frac{c^4 k_\Lambda}{8\pi G(-1+bH)^4}H^4 - \frac{\pi^3 M_t}{120\zeta(3)c}H^3$$

$$\sim 1.38\times10^{60} H^4 - 3.98\times10^{41} H^3$$

To determine the type of energy behind the expansion of the universe, the Friedmann equation can be expressed in terms of energy. Indeed, if all the terms of the equation are multiplied by $c^5 G^{-1} H^{-3}$, we get:

$$\left(\frac{c^5}{GH^3}\right)H^2 = \left(\frac{c^5}{GH^3}\right)\frac{8\pi G\rho_m}{3} + \left(\frac{c^5}{GH^3}\right)\frac{\Lambda c^2}{3} - \left(\frac{c^5}{GH^3}\right)\frac{kc^2}{a^2}$$

$$\frac{c^5}{GH} = \frac{c^5}{H^3}\frac{8\pi\rho_m}{3} + \frac{c^7}{GH^3}\frac{\Lambda}{3} - \frac{c^7}{GH^3}\frac{k}{a^2}$$

Let us express density with total mass and radius using the Hubble-Lemaitre law for the boundary ($c = Hr$), as:

$$\rho_m = \frac{M}{V} = \frac{M}{\frac{4\pi}{3}r^3} = \frac{3M}{4\pi r^3} = \frac{3MH^3}{4\pi c^3}$$

Finally, we get an expression of the Friedmann equation in the form of energy:

$$\frac{c^5}{GH} = 2Mc^2 + \frac{c^7}{GH^3}\frac{\Lambda}{3} - \frac{c^7}{GH^3}\frac{k}{a^2}$$

$$E_{Planck} = E_{mass} + E_{radiation} + E_{curvature}$$

Let us express the energy associated with curvature as:

$$E_{curvature} = E_{Planck} - E_{mass} - E_{radiation}$$

$$E_{curvature} \sim \frac{F_{Planck}c}{H} - 2Mc^2 - \frac{c^7}{G}\frac{k_\Lambda H}{3}$$

where: $k_\Lambda = 2.88\times10^{17}\left[\mathrm{s}^4\cdot\mathrm{m}^{-2}\right]$, $M \sim 7.53\times10^{50}\left[\mathrm{kg}\right]$, $P_{Planck} = 3.629\times10^{59}\left[\mathrm{W}\right]$.

A positive energy result represents an open universe, while a negative result means a closed universe. In the above equation, note that both positive and negative results are possible according to the values of the terms. The first term, open, is Planck power multiplied by cosmic time. The second term, closed, is a constant of total energy associated with mass (50% energy, 50% kinetic, $\overline{\beta} = \sqrt{3/4}$), and the third term, closed, is the energy associated with radiation (via Λ), which decreases with the increase in cosmic time. The transition from a closed universe to an open one is for $E_{curvature} = 0$. We get the following positive root:

$$H = 1.054\times10^{-17}\left[\mathrm{s}^{-1}\right]$$

$$t = \frac{1}{H} = 3.00\left[\mathrm{Gy}\right] \quad (z \sim 3.6)$$

In short, with the Friedmann equation and the assumptions of this model, we find that energy of unknown origin is acting on the expansion of the universe through an enormous power that is equal to Planck power P_P multiplied by cosmic time. That expansion energy E_{curv} is not directly expressed in a model variable. Moreover, it is positive via Planck power, which represents conventional energy acting in opposition to gravity F_G (or E_{mass}) and cosmological gravity force F_Λ ($E_{radiation}$ or E_Λ). The expansion power is not associated to mass (baryonic) or radiation (photonic via Λ). This unknown energy of expansion is possibly contained in a potential form available in the volume and at the frontier of the universe that acts by an expansion effect of space in the manner of a stretching of space. This Planck power P_P can be expressed by the Planck force F_P multiplied by c. In this model, we consider that the frontier of the universe moves at speed c. It is seen that the idea of an internal and external force (multiverse) of the magnitude of Planck force acts at the boundary to stretch the space at speed c.

4. Cosmological Gravity Force, F_Λ from Mass-Energy Equivalence and GR

For the time period when radiation was dominant, a central force associated with Λ_{rad} can be determined using mass-energy equivalence. Indeed, we know the value for Λ_{rad} via the evolution of energy in the universe. Let us assume an element with mass m in rotation according to a Kepler model in a central gravity field of mass M. Another attractive force is a work around mass m, this time associated with the non-baryonic energy density, which acts through mass-energy equivalence of the interior sphere whose boundary is determined by the rotation radius, r, of mass m.

In this model, we consider that the force is attractive simply through mass-energy equivalence, which can also be achieved with the GR (see below), meaning that a positive energy mass is associated with a positive energy, such as the energy of photons associated with constant Λ, and that energy exerts a spacetime deformation on surrounding masses the same way the inertial mass (baryonic) does.

We can see that the mass-energy associated with the cosmological constant (hidden photon gas $\hat{\gamma}$) depends on a zone demarcated by the assumed radius, r. This can partially explain the issues with the cosmological constant, Λ. In fact, that gravity force can be put into action in the GR equation through the existence of the cosmological constant, as put forth by Einstein but for a different reason than the static universe he proposed. Indeed, the cosmological constant was later added by Einstein as an opposing force to gravity. Therefore, when the term $\Lambda g_{\mu\nu}$ is moved to the right-hand side, the side of the energy-momentum tensor, we get a repulsive effect associated with Λ:

$$R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

with the signature of the metric tensor (+, −, −, −), the energy-momentum tensor can be expressed as:

$$T_{\mu\nu}^{total} = T_{\mu\nu}^{baryonic} - \rho_{\Lambda e} g_{\mu\nu}$$

In this case, the resulting force is repulsive, as Einstein wanted. **However, it is also possible to make the effects of that energy appear directly in the energy-momentum tensor as a source of additional mass-energy through the mass-energy principle**, as:

$$T_{\mu\nu}^{total} = T_{\mu\nu}^{baryonic} + T_{\mu\nu}^{mass\text{-}energy}$$

$$T_{\mu\nu}^{total} = T_{\mu\nu}^{baryonic} + \frac{E_\Lambda}{V} g_{\mu\nu}$$

$$T_{\mu\nu}^{total} = T_{\mu\nu}^{baryonic} + \rho_{\Lambda e} g_{\mu\nu} = \rho_m c^2 + \frac{c^4 \Lambda}{8\pi G} g_{\mu\nu}$$

Hence, the energy density component of the tensor, T^{00}, is entirely positive:

$$T^{00} = \rho_m c^2 + \frac{c^4 \Lambda}{8\pi G} = \rho_{m+\Lambda} c^2$$

The solution for the spherical geometry is found in the Newton equation for low velocities:

$$\nabla^2\Phi = 4\pi G\rho_{m+\Lambda} = 4\pi G\left(\rho_m + \frac{c^2\Lambda}{8\pi G}\right) = 4\pi G\rho_m + \frac{c^2\Lambda}{2}$$

The potential being:

$$\Phi = -\frac{Gm}{r} + \frac{c^2\Lambda r^2}{12}$$

A potential in r^2 is said harmonic and the equation of the trajectory of a mass m' in harmonic potential is a closed curve like that Newtonian in r^{-1} (Bertrand's problem). The acceleration of a mass m' in this field is expressed as the gradient of potential Φ:

$$\boldsymbol{a} = -\nabla\Phi\boldsymbol{e}_r = -\frac{\partial\Phi}{\partial r}\boldsymbol{e}_r = -\frac{\partial\left(-\frac{Gm}{r} + \frac{c^2\Lambda r^2}{12}\right)}{\partial r}\boldsymbol{e}_r$$

$$\boldsymbol{a} = -\frac{Gm}{r^2}\boldsymbol{e}_r - \frac{\Lambda}{6}c^2 r\boldsymbol{e}_r$$

We can see that, at this time, solving the equation predicts an attractive force associated with constant Λ and of the same type as the baryonic mass. The r term can be related to the Hooke ellipse.

$$\Phi(m,r,H) = -\frac{Gm}{r} + \frac{c^2 k_\Lambda}{12}H^4 r^2$$

Then, solving the equation for low velocities (Newton) includes one mass contributors (baryonic) and one energy (k_Λ, cosmological). The geometric variable r of the structure and the time factor of formation of the structure H. At this time, we can see that expansion of the universe is not caused by hidden energy associated with Λ, but by another effect seen earlier, the energy associated with curvature, k.

Finally, based on this approach, we can see that the cosmological constant must be included in Einstein's equation because it represents non-baryonic energy in the universe, but the sign for the term $\rho_{\Lambda e}g_{\mu\nu}$ on the right-hand side of the equation must be positive, which provides a possible explanation for the additional attractive gravity effects associated with the positive energy of constant Λ. At this time, expansion of the universe can be attributed to energy associated with curvature, k, as stated earlier.

Therefore, assuming this notion of mass-energy, and according to Newton's law of attraction for that mass, m_Λ, the central attractive force associated with the mass-energy equivalence can be written as:

$$|F_\Lambda| = \frac{Gm_\Lambda m}{r^2} = \frac{G(\rho_\Lambda V)m}{r^2} = \frac{G(\rho_\Lambda 4\pi r^3)m}{3r^2}$$
$$= \frac{4\pi G(\rho_\Lambda)rm}{3} = \frac{4\pi G}{3}\left(\frac{c^2\Lambda}{8\pi G}\right)rm = \frac{\Lambda}{6}c^2 mr$$

The force can be expressed in relation to the age of the universe and the mass/size of the structure:

$$F_\Lambda(m,r,H)=\frac{\Lambda}{6}c^2rm=G\left(\frac{16\pi\sigma T_\Omega^4 t_\Omega^4}{3c^3}\right)\frac{rm}{t^4}=G\left(\frac{16\pi\sigma T_\Omega^4 t_\Omega^4}{3c^3}\right)mrH^4$$

For T_{CMB} = 2.7 [K], t_Ω = 76.1 [Gy], and $t = t_0$ = 13.8 [Gy], we get;

$$F_\Lambda(m,r)=4.82\times10^{-36}mr$$

This attractive force can be attributed to the cosmological constant, which translates conventional energy density that is not in the form of conventional baryonic mass. Moreover, the force of gravity, which varies in r, is active everywhere on the same basis as baryonic mass gravity. Note that such a force has never been detected around us because the cosmological constant is extremely small today (~10^{-54}). However, at the time of primitive galaxy formation, the cosmological constant was much greater (Λ ~10^{-48} at t ~0.5 [Gy]). Also, when we include the great galaxy or cluster radii, we will see that the cosmological gravity played a large part in galaxy rotation. For comparison purposes, let us calculate the ratio between the cosmological gravity and Newton's gravity for the solar system:

$$\frac{F_\Lambda}{F_G}=\frac{\dfrac{\Lambda c^2mr}{6}}{\dfrac{GMm}{r^2}}=\frac{\Lambda c^2r^3}{6GM}=\frac{\left(6.73\times10^{-54}\right)\left(2.99\times10^{8}\right)^2\left(149.6\times10^{9}\right)^3}{6\left(6.67\times10^{-11}\right)\left(1.98\times10^{30}\right)}=2.53\times10^{-24}$$

Note that the attractive effect of cosmological gravity is huge and greatly surpasses that of gravity alone during the formation of great structures like galaxies. At 500 [My], the ratio was ~34. Note that the cosmological gravity makes it possible for the great structures like galaxies to form much faster than simply under gravity. This notion of additional force to gravity could provide a possible explanation for the production of primitive black holes PMB or early type galaxy ETG. Indeed, the ratio F_Λ/F_G is ~54 around 400 [My], which may accelerate the accumulation of mass beyond the Eddington limit. In the next section, we will discuss the effects of this additional cosmologic force on the primitive formation of large structures as observed since JWST.

This cosmological gravity force may have an impact on the different concepts used in cosmology as the Eddington limit, the Jeans radius. For the first ~3 [Gy], the values obtained from the concepts can be adapted using the adapted Newton gravitation constant G^Λ to take into consideration this cosmological force of a structure mass M and radius r by substituting G with the adapted one.

$$G^\Lambda(H)=\left(1+\frac{\Gamma H^4r^3}{M}\right)G$$

with: $\Gamma=\dfrac{c^2k_\Lambda}{6G}\sim6.47\times10^{43}\left[\mathrm{kg\cdot s^4\cdot m^{-3}}\right]$.

The model proposes a very small modification of the G value which depends mainly on the r^3 size of the structure in question. This small change in G could be a part of the search for a new metric $f(R)$ gravity theory models. In a near future, the observations and measurements of gravitational waves GW with the development of more sensitive sensors will determine whether or not the GR theory will be a definitive, or not, theory of gravity as it has been formulated in 1916 (Corda, 2009 [12]).

According to the author, while that force F_Λ is negligible today on our scale, it was central to the formation of our universe and the great structures within it.

5. Alphaton (Hidden Photon $\hat{\gamma}$, Hidden Boson?)

We have seen that the energy of the universe is essentially electromagnetic in nature (hidden photonic or bosonic).

$$U_{tot} = E_\Lambda \sim 3.57\times 10^{98}\left[\mathrm{J}\right]$$

This energy is everywhere and it is expanding (diluted). Of course, it is not possible to determine the exact nature of this energy by modeling alone but by experimentation and observation. However, we made the hypothesis of photon gas originally. We will see later that this radiative (electromagnetic) energy helps explain the non-Keplerian rotations of the mass of the observed galaxies. This missing mass will actually be this unobservable energy E_Λ, estimated by the model with the alphaton $\hat{\gamma}$. We can associate it by analogy with photons that are difficult to detect either the existence of a hidden light particle called a hidden photon or a boson-type DM particle. The existence of this hidden photon or undetectable particle was first proposed by (Ackerman *et al.*, [13]) and its detection is still being investigated (Cervanates *et al.*, 2022 [14], Essig *et al.*, 2013 [15], Adrian *et al.*, 2018 [16], Akash *et al.*, 2021 [17], Graham *et al.*, 2016 [18], Battaglieri *et al.*, 2017 [19]). We refer to Battaglieri *et al.*, 2017 [20] for a complete review. According to this review, the estimated alphaton mass at t_o, $m_{\hat{\gamma}} \sim 1\left[\mathrm{meV}\right]$ is located in an area called ultra light DM and more specifically post inflationary axion (see **Figure 3**). In addition, according to this review, the mass attributed to this phantom particle can vary by 36 orders of magnitude! (10^{-21} eV to 10^{15} eV) according to many theories brought to explain its existence. Recently, an estimate of the excess of the cosmic optical background COB made from analyses using archival images of the New Horizons Long Range Recognition Imager (LORRI) estimated that a fossil radiation of the order of 8 to 20 [eV] exists and would correspond to a decay from an axion to a photon, Bernal *et al.*, 2022 [21]. First, according to this model, this particle is not the sterile neutrino, in fact, we estimated that the mass of sterile neutrinos (υ_μ~48 [keV]) corresponds approximately to 4% of the baryonic mass which is too low to explain this energy (see [2]). We can estimate the average energy of the unobservable photon from 400 [ky]. We find this curve in **Figure 3**. We also see different estimated values and large variations. The modelled value is in the order of magnitude of a few reported measurements.

In summary, according to this model, a colossal amount of electromagnetic type energy (~10^{98} [J]) was generated during the first 10^{-9} [s]. This energy, contained by $\sim 10^{89}\hat{\gamma}$, is active on structures dynamic by mass-energy equivalence in the T^{00} of GR but is not directly observed (hidden nature). It is similar to a hidden photon or a hidden boson (spin 1).

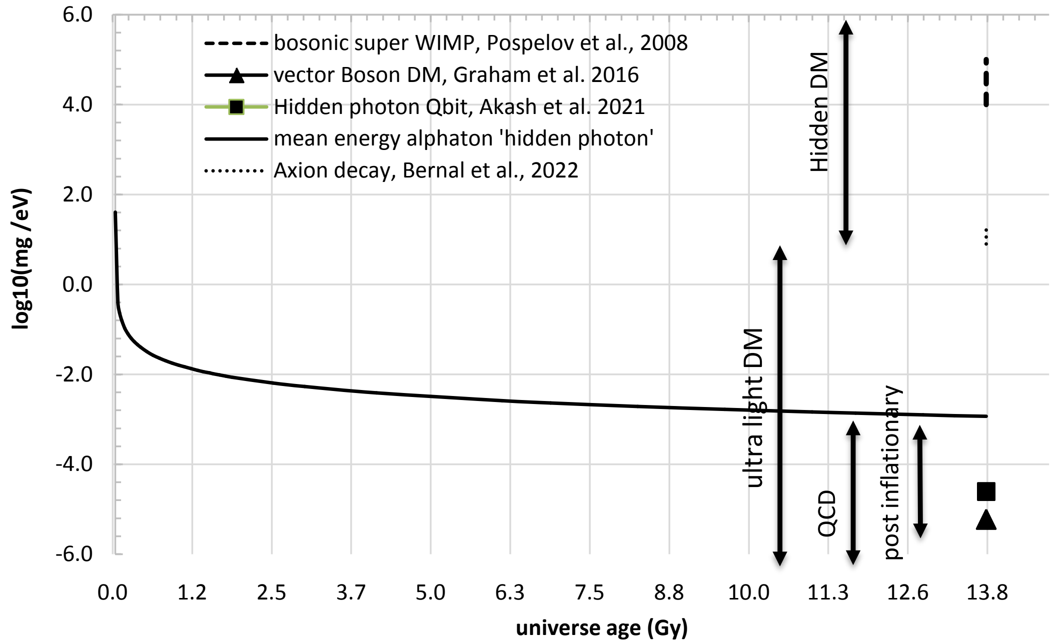

Figure 3. Estimated energy of hidden photon $\hat{\gamma}$ in time from 400 [ky] to 13.8 [Gy].

6. Some Galaxies Rotation with Baryon and Alphaton

We have seen that a colossal energy, represented by the cosmological constant, Λ which acts everywhere on the deformation of space-time in the same way as baryonic matter via the energy-impulsion tensor T of the GR. If we develop the approximation at small velocities (Newton) of the solution for central fields, we find an equation which expresses the rotation of the structures taking into consideration this energy (see below).

The formation and evolution of galaxies is a very complex field of study, and the associated mechanisms have not yet been fully interpreted. Indeed, the number of phenomena in play during galactogenesis, such as supplemental forces to gravity, the birth of stars and internal structures, energy dissipation effects, and the quantity and type of neighborhood matter being absorbed are only some of the factors involved in galaxy formation, North, 2011 [22]. We do know the values of the cosmological constant, Λ, at the time of primitive galaxy formation (200 [My] to 1 [Gy]). We can calculate that attractive force and see its effects on the rotation of some galaxies. Put simply, for a given circular rotation orbit, the tangential rotation speed of a mass is expressed through the balance of the main forces considered in the model: Newtonian gravity and cosmological gravity via mass-energy equivalence:

$$F_c = F_G + F_\Lambda$$

$$m\omega^2 r = Gm\left(\frac{M}{r^2} + \frac{\Lambda c^2 r}{6G}\right)$$

$$v_t^2 = G\frac{M}{r} + \frac{\Lambda c^2 r^2}{6}$$

Note that cosmological attractive force associated with Λ is supplemental to conventional gravity (baryonic). Moreover, that force cannot be attributed to negative masses. In fact, the denominator of the second term is not the inverse of the radius, which confirms that the force is not due to the effects of mass as such, but to a mass-energy equivalence associated with Λ. Finally, a very important point, because that force is relative to Λ, which is relative to the age of the universe, the rotation profile of masses like galaxies is in turn relative to time from the standpoint of forces in play. In other words, the rotation profile should take into consideration the evolution of Λ as the galaxy absorbs matter over time and energy (alphaton $\hat{\gamma}$).

To do so, the galaxy formation process can be simplified by assuming that mass accumulates according to a simple function of time, and that Λ(t) also evolves according to time (bottom-up model). The simplified equation of galaxy rotation has three terms, the effects associated with the bulb, or denser central area, and with the disc around the central area, and the effects of Λ(t) at formation time t and radius r(t). We will see that for some galaxies, such as M33, the observable mass (luminous) is not sufficient to explain the observed rotations, meaning that we have to assume the likely existence of some baryonic hidden masses (non-luminous).

The time at which a galaxy started to form is important because it influences the effective value of Λ. Then, the formation time of the galaxy is just as important (acceleration rate of the mass), since this yields the total variation of Λ on the rotation process. To initially demonstrate the effects of force F_Λ on galaxy rotation, let us find an expression of rotation speed relative to time: the time at which the galaxy started to form, t_i, the total formation time of the galaxy, t_t, with variable force, F_Λ, acting during that formation time, $t_t - t_i$. For the masses of the bulb and disc, we get a simplified expression:

$$M_T(r,t) = M_b(r,t) + M_d(r,t)$$

$$M_T(r,t) = \frac{V_b(r,t)}{V_{b_T}} M_b + \frac{V_d(r,t)}{V_{d_T}} M_d = \frac{r(t)^3}{r_b^3} M_b + \frac{r(t)^2 - r_b^2}{r_T^2 - r_b^2} M_d$$

where:

$0 \le r(t) \le r_b$, for the bulb

$r_b \le r(t) \le r_T$, for the disc

r_b: bulb radius determined at the end of galaxy formation

r_T: disc and bulb radii determined at the end of galaxy formation

M_b: bulb mass determined at the end of galaxy formation

M_d: disc mass determined at the end of galaxy formation

A simple law can be used to calculate mass accumulation at a constant rate:

$$r(t) = \alpha t = \frac{t}{t_T - t_i} r_T$$

where

$t_i \le t \le t_t$, formation time of the galaxy

α: galaxy radius growth rate (accumulation)

For the mass, we get:

$$M_T(r,t) = \frac{\alpha^3 t^3}{r_b^3} M_b + \frac{\alpha^2 t^2 - r_b^2}{r_T^2 - r_b^2} M_d$$

For rotation speed, we get:

$$v_t^2 = G\frac{M}{r} + \frac{\Lambda c^2 r^2}{6} = \frac{G}{r}\left[\frac{\alpha^3 t^3}{r_b^3} M_b + \frac{\alpha^2 t^2 - r_b^2}{\left(r_T^2 - r_b^2\right)} M_d\right] + \frac{k_\Lambda c^2 \alpha^2 t^2}{6\left(t+t_i\right)^4}$$

$$v_t^2 = G\left[\frac{\alpha^2 t^2}{r_b^3} M_b + \frac{\alpha^2 t^2 - r_b^2}{\alpha t\left(r_T^2 - r_b^2\right)} M_d\right] + \frac{k_\Lambda c^2 \alpha^2 t^2}{6\left(t+t_i\right)^4}$$

where

$t_i \le t \le t_t$, formation time of the galaxy

$t_i \le t_b \le t_B$: formation time of the galaxy bulb

$t_B \le t_d \le t_t$: formation time of the galaxy disc

t_i : age of the universe at the time of galaxy formation to calculate

$\Lambda(t) = \frac{k_\Lambda}{\left(t_i + t\right)^4} = k_\Lambda H^4$, with:

$$k_\Lambda = \left[\frac{32\pi G\sigma C_1^4}{c^5}\right] = \left[\frac{32\pi G\sigma T_\Omega^4 t_\Omega^4}{c^5}\right] = 2.88\times 10^{17}\left[\mathrm{s^4 m^{-2}}\right]$$

In the above equation for v_t, the first term is for the attraction of the bulb on the rotating mass, the second, for the attraction of the disc, and the third, for the attraction of force F_Λ due to the cosmological constant through the residual mass-energy equivalence of $\hat{\gamma}$ at the beginning of formation, t_i, of the galaxy acting throughout formation time, $t_t - t_i$. This equation contains the essential elements for predicting the rotation curve of the luminous mass of galaxies. In [4] we have already used this rotation equation for some galaxies. Here are the curves obtained for some galaxies. What we find is special. Indeed, according to the model, most galaxies are formed much earlier than the predictions of conventional models for predicting galaxy formation. As an example, the MW to start the formation of the bulb 180 to 200 [My] after the beginning! In addition, the evolution time is much faster than is normally envisaged. Here are the times since the beginning of the formation and the evolution time of the main formation of galaxies studied. Of course, nothing prevents the internal reorganization of galaxies by collisions and other phenomena throughout the history of galaxies.

MW, begin 180 - 200 [My], formation time 320 [My], main structure ~ 520 [My] (**Figure 4** and **Figure 5**, measured values, Blitz *et al.*, 1980 [23]).

UGC12591, begin 170 - 180 [My], formation time 280 [My], main structure ~ 460 [My] (**Figure 6**, measured values, Giovanelli *et al.*, 1985 [24]).

NGC3198, begin 180 - 185 [My], formation time 880 [My], main structure done ~1.1 [Gy] (**Figure 7**, measured values, Gentille *et al.*, 2013 [25]).

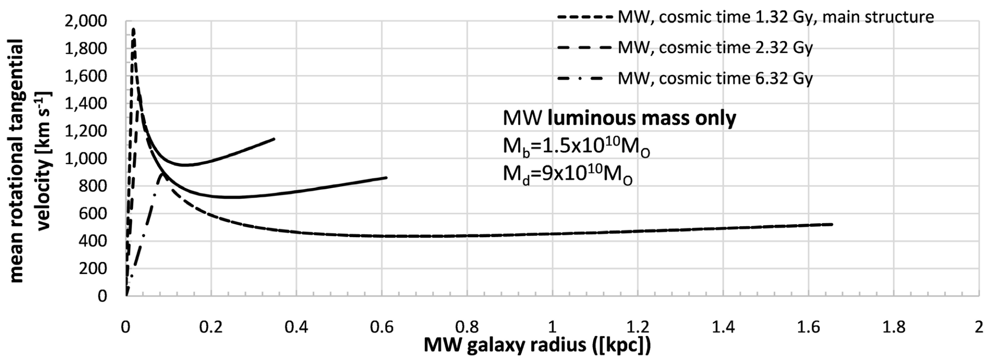

Figure 4. MW rotational and size evolution since formation to 6 [Gy].

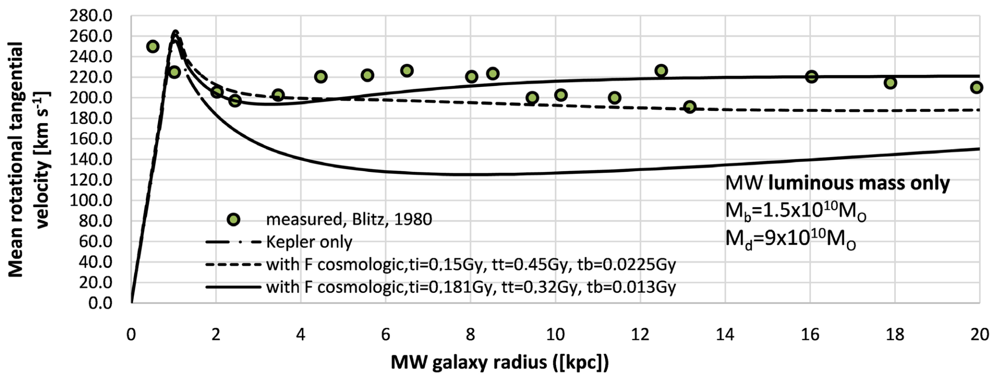

Figure 5. MW rotational velocities.

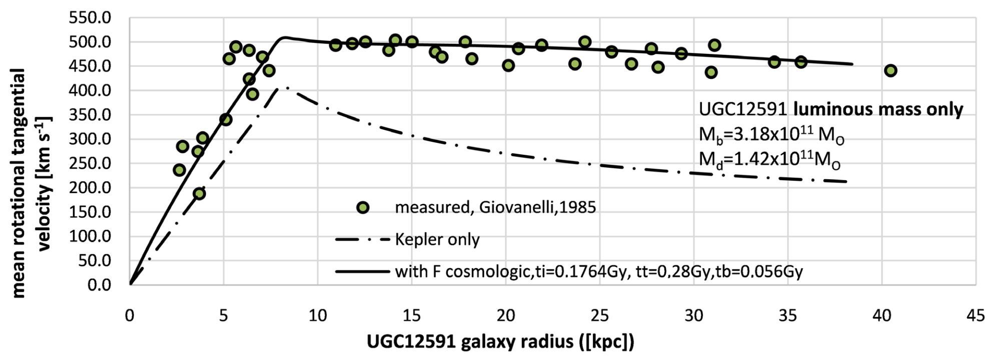

Figure 6. UGC12591 rotational velocities.

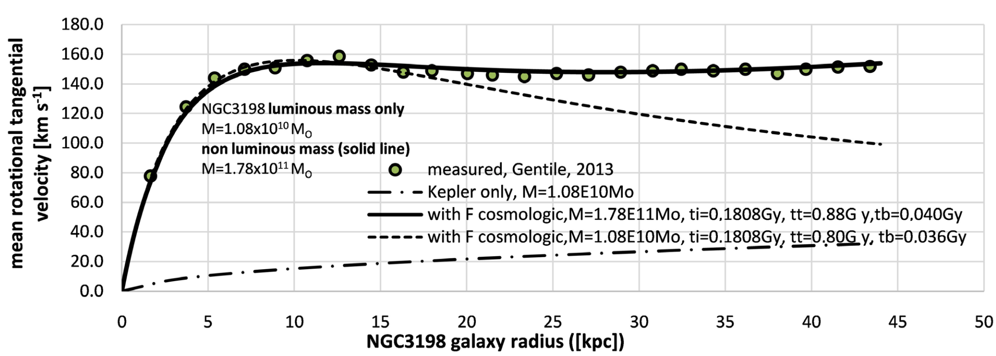

Figure 7. NGC3198 rotational velocities.

UGC2885, begin 175 - 180 [My], formation time 1.2 [Gy], main structure done ~1.4 [Gy] (**Figure 8**, measured values, Gentille *et al.*, 2013 [25]).

NGC253, begin 175 - 180 [My], formation time 320 [My], main structure done ~500 [My] (**Figure 9**, measured values, Pence *et al.*, 1981 [26]).

We see that an intense period of galaxy formation around 170 - 185 [My] after the beginning seems to exist, at least for galaxies near MW. We will see in the next section the mechanisms of galaxy formation putting into action this mass-energy equivalence of E_Λ alphaton $\hat{\gamma}$ acting in the space-time of galaxies represented by the cosmological constant.

7. Generic Type of Galaxies Rotation Function of Time of Formation and Duration t_i, t_t

The cosmologic force F_Λ decreases over time accordingly to the age of the universe, but one must consider that the prevailing conditions of galaxy formation are still present in the space-time continuum of that galaxy. In other words, we will see that, in simulations of the rotation of some galaxies, the time at which mass started to accumulate is crucial for the development of the type of rotation

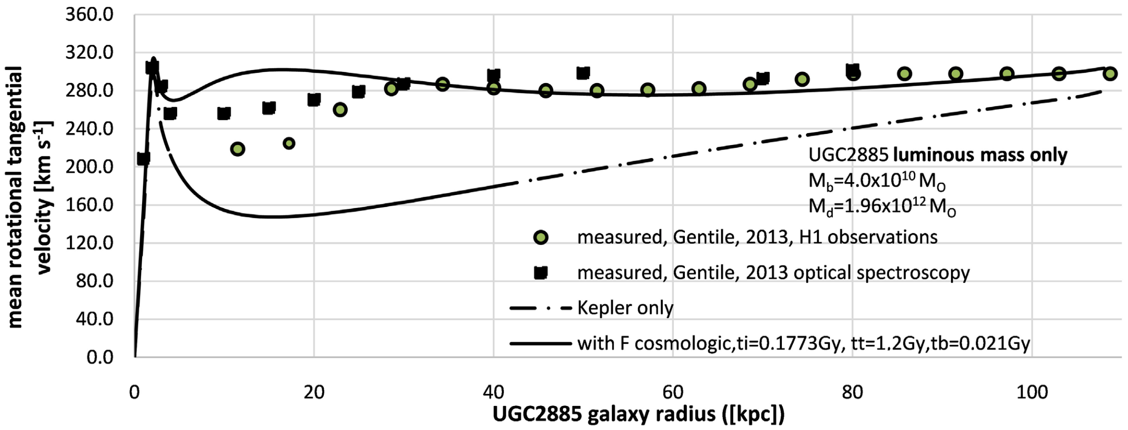

Figure 8. UGC2885 rotational velocities.

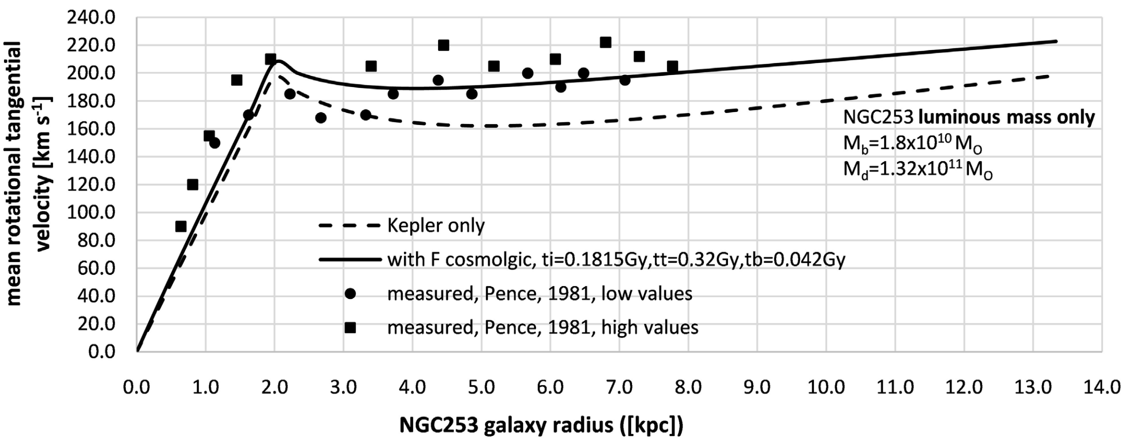

Figure 9. NGC253 rotational velocities.

because cosmological gravity varies like $1/t^4$, or inversely with the fourth power of the universe age during the formation of that galaxy. This means that the type of rotation curve more (concave ⌢ or convex ⌣) lets us know, in part, whether the galaxy was formed in the first 100 - 400 [My] of the universe, or later (concave = ETG; convex = LTG). So, a weaker cosmological gravity should lead to Keplerian rotation, or a convex curve. Finally, we have assumed a very simple galaxy radius growth rate that is linear over time. Other, more realistic models can be introduced in the equation to better illustrate the generic growth of an isolated galaxy. Of course, the impacts of galactic collisions and agglomerations are not considered here.

In order to illustrate the effects of time (beginning and time of formation) on the rotation curve of baryonic matter, we used the parameters of the galaxy M33. The following Figure 10 shows the calibration obtained for this galaxy. The total mass reported for M33 is 6×10^{10} [M_O], Corbelli 2002 [27] of which 85% is said to be unobserved (non-luminous). The luminous mass is about 9×10^9 [M_O]. We observe that the luminous mass alone cannot correctly reproduce the measured velocity profile, we must add a hidden mass (dust or non-stellar mass?) or put into action the effects of the cosmological force. If we add an appreciable amount of non-luminous mass (~4× the luminous mass) as well as the cosmological force, we can find an acceptable rotational profile as shown in the following figure.

We observe that the M33 has developed for a time ~700 [My]. Moreover, if we do not consider the cosmological force, it is not possible to reproduce the velocity profile well even if we increase the non-luminous mass up to 7×10^{10} [M_O]. Indeed, the profile is not as regular compared to that of the figure with this cosmological force.

In order to show the combined effects of the cosmological force which is variable in time, the following figures present the effects of the time of the beginning of the formation t_i of M33 and the effects of the total time of its formation t_t. We considered a constant mass in all cases.

In order to see directly the effects of time on the formation of a galaxy, the following Figure 11 and Figure 12 present the effects of the beginning time as t_i as well as the total time of formation t_t for the galaxy M33. We see the effects of

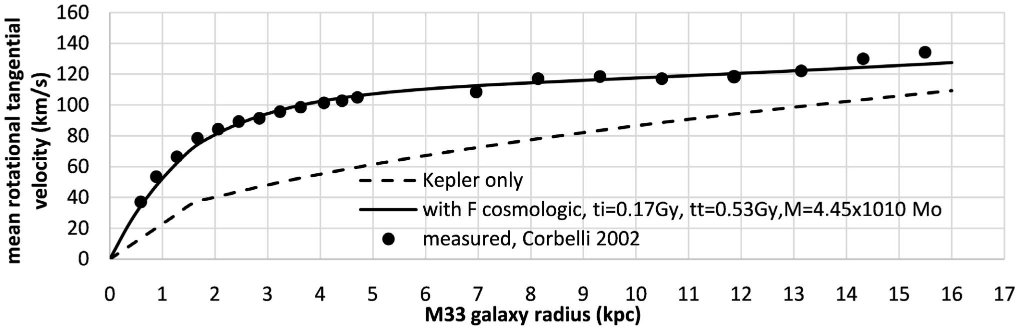

Figure 10. M33 rotational velocities.

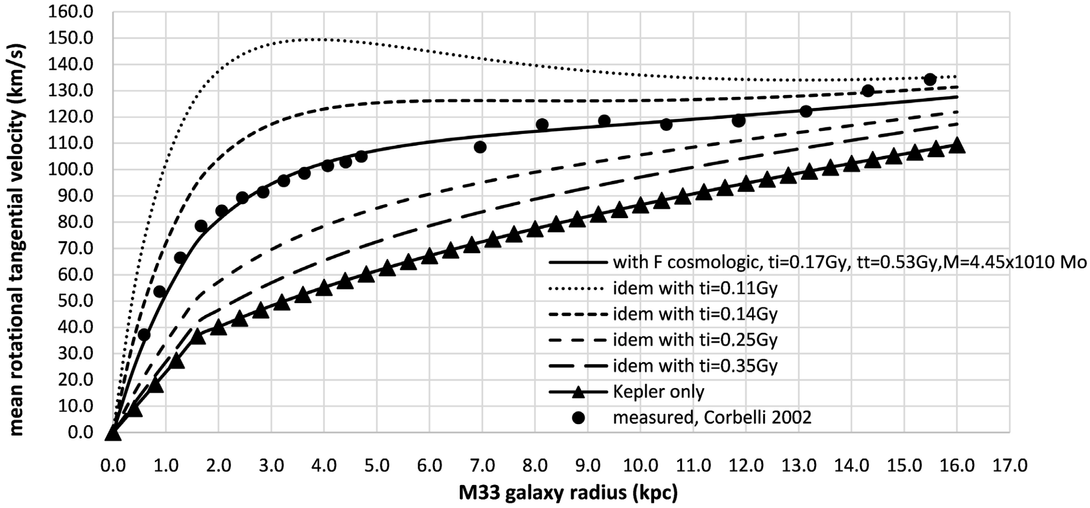

Figure 11. Effect of beginning time t_i on M33 rotational tangential velocity.

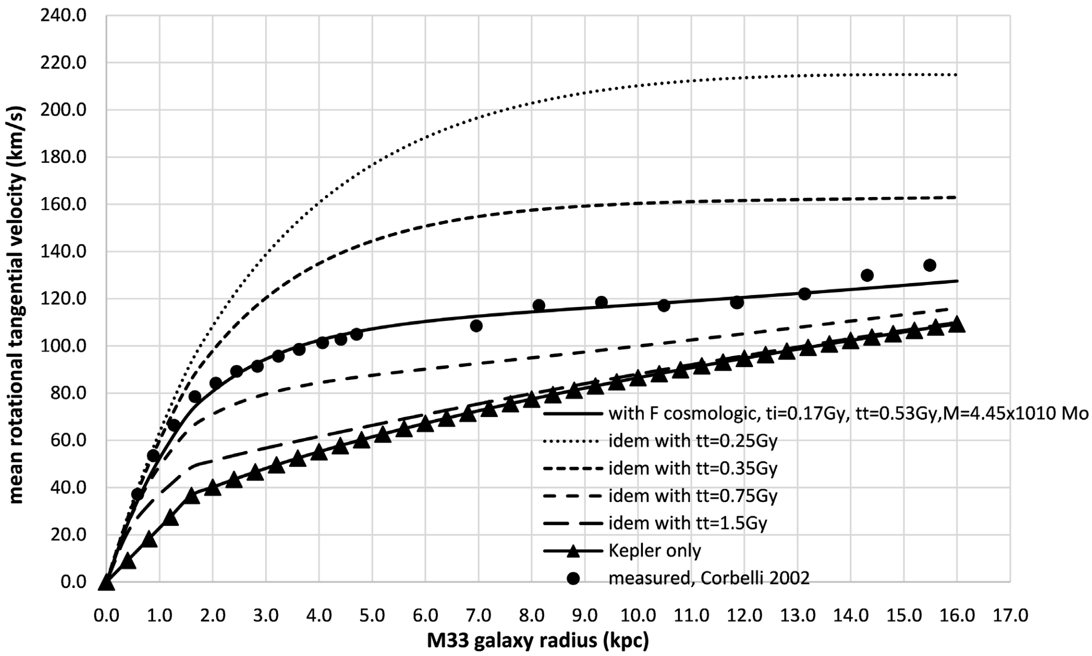

Figure 12. Effect of total formation time t_t on M33 rotational tangential velocity.

the starting time ranging from 110 to 350 [My] after the beginning. It is clear that the longer the start of the formation is delayed, the more we observe a profile of the velocities that is close to Kepler or the effects of the baryonic mass only since the cosmological force acting less and less. Now, for the effects of the total formation time, we observe that the effects are rather pronounced towards the high values of the radius because it is towards the end of the time of formation that the value of the cosmological force decreases. In summary, we observe that it is possible to adjust a particular curve of the tangential velocities of a particular galaxy by adjusting the values of t_i and t_t using the value of the observed luminous mass without first using any so-called dark matter (halo DM). Subsequently, if the adjustments do not seem to match, we can adjust the luminous mass if necessary by assuming that a more or less appreciable amount of unobserved baryonic mass is present within the galaxy.

Models of evolution of the MW

In this section, we will compare one conventional model of MW evolution (bottom-up with exponential time delayed) to that of this paper (additional cosmological force F_Λ). We have seen that this model estimates a much faster temporal evolution of MW compared to current models.

MW is certainly the most studied galaxy. A large number of studies have been produced on the evolution of MW which has led to a better understanding of the evolution of stars and to produce a model for estimating the temporal evolution of MW and other galaxies through the study of the evolution of stars. One of the most recent models, Xiang *et al.*, 2022 [28] using the Gaia satellite and the study of ~250 k subgiant stars to propose a precise evolution of the development phases of the MW (temporal). Essentially, it appears that the evolution of MW has undergone mainly 2 phases, an older one covering a period of 5 [Gy] starting with the beginning of MW estimated at 0.8 [Gy] after the beginning. The second phase, more recent, covering a period of 8 [Gy] until today. In this study, the beginning of MW is estimated at 0.8 [Gy], an earlier period of 1 to 2 [Gy] compared to the typical accepted value. Several models are available to describe SFR in galaxies (Carnal *et al.*, 2019 [29]). At first glance, one can calibrate a model of the SFR (time delayed Kroopa *et al.*, 2020 [30], see eq. Below) builds on the luminous mass of the MW as well as on the measured rate of the SFR Ψ (Mor *et al.*, 2019 [31]) *i.e.*:

$$\Psi(t) = \frac{A}{\tau^2}(t - t_0)\mathrm{e}^{-\left(\frac{t-t_0}{\tau}\right)}$$

$$\frac{M_*}{M_o}(r) = \int_{t_0}^{t} \Psi(t)\,\mathrm{d}t$$

$$\frac{M_*}{M_o}(t) = A\left[1 - \frac{(t - t_0 + \tau)\mathrm{e}^{-\left(\frac{t-t_0}{\tau}\right)}}{\tau}\right]$$

On can find an approximate form of the radius of MW by considering a mass accretion rate according to a law in r^2 (disk areal) or r (disk radius).

$$r_{MW}(t) = \sqrt{\frac{M_*(t)}{M_{*tot}}} r_{MW\ tot} \quad \text{or} \quad r_{MW}(t) = \frac{M_*(t)}{M_{*tot}} r_{MW\ tot}$$

The adjusted values for the MW can be:

$$t_0 = 0.8[\mathrm{Gy}]$$

$$\tau = 2.6[\mathrm{Gy}]$$

$$\frac{A}{\tau^2} = M_{MW} = 1.05 \times 10^{11}[\mathrm{kg}]$$

We find these forms for $\log_{10}(M_*/M_o)$, $\Psi(t)$ and $r_{MW}(t)$ in **Figures 13-15**.

In **Figure 13**, we see that the models do not agree about the formation time of the MW. Indeed, the model with the cosmological force predicts an extremely fast formation of the MW or a total time of 500 [My] while the exponential time delayed model, validated with the SFR of Mor *et al.*, 2019 [31], predicts a continuous

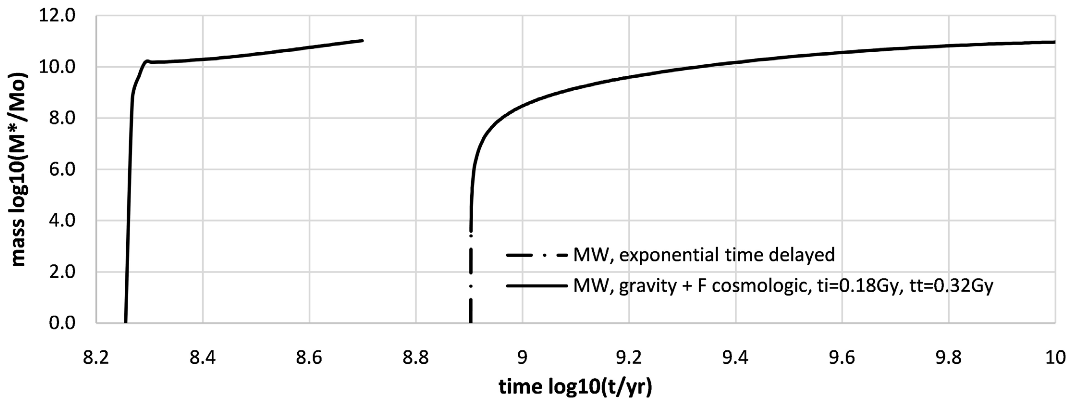

Figure 13. Models of MW mass accretion in time.

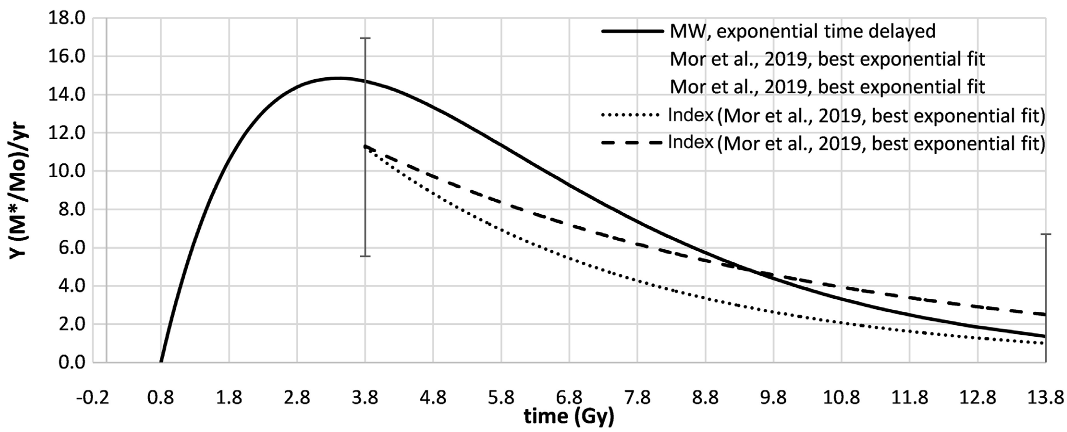

Figure 14. MW SFR measurements and model.

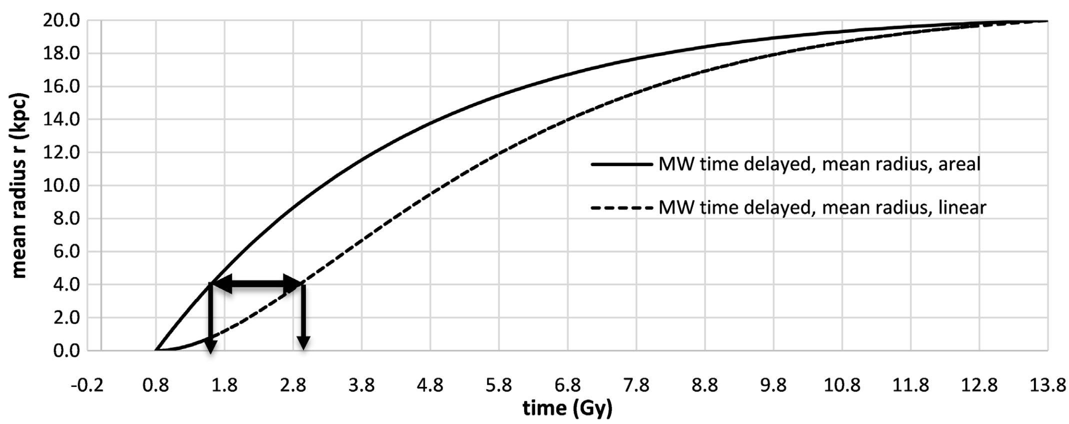

Figure 15. MW mean radius, areal and linear growth model.

formation for 10.2 [Gy] (0.8 [Gy] to 11 [Gy]) (90% of the mass). What explanations can be envisaged? The main one is based on the action of this additional cosmological force which F_Λ acted strongly during the first 400 [My] but which undergoes a decline in H^4. However, this calls into question the temporal aspect of star formation as we know it. Indeed, if we accept a very short time of the formation of ETGs, we must revisit our temporal understanding of star formation while keeping the mechanisms likely intact. Moreover, in the study by Xiang *et al.* [28], the majority of subgiant stars are located in an area around 7.2 to 10.4 [kpc] (90%). However, subgiants can be found as early as 4 [kpc] (figure 1 of [28]). As early as 4 [kpc] implies a time as early as 2.9 [Gy]. This may appear relatively short for the appearance of a subgiant star (HR band). If we go back to the star HD140283 (Methuselah) very close to the sun (0.06 [kpc]) whose estimated age is 12.2 to 13.7 [Gy] (Tang *et al.*, 2021 [32]), which could support that the formation of the MW began earlier than the assumed 800 [My]. Indeed, at our position (~8 [kpc]) of the center, according to the exponential time delayed model, this corresponds to a maximum age of 11 [Gy] (more rapid areal growth mass) which is lower than the minimum value of 12.2 [Gy] age of HD140283. In conclusion with respect to the formation of MW, to say the least, this model raises more questions than it answers.

8. Observed ETG with JWST and Some Explanation with This Model

We can study the temporal evolution of some ETGs as observed with JWST:

GLASS-z12 ($z_{phot} \sim 13.1$, $\log_{10}(M_*/M_o) \sim 9.0$), Halsbauer *et al.* [9].

CEERS-1749 (Schrodinger) ($z_{phot} \sim 17$, $\log_{10}(M_*/M_o) \sim 9.69$) Naidu *et al.* 2022 [7].

ID1514 ($z_{phot} \sim 9.85$, $\log_{10}(M_*/M_o) \sim 9.8$) Halsbauer *et al.* [9].

GLASS-z11 ($z_{phot} \sim 10.9$, $\log_{10}(M_*/M_o) \sim 9.4$) Halsbauer *et al.* [9].

The star formation history model SFH adopted is a delayed τ model, Kroupa *et al.*, 2020 [30] (τ = 0.24 [Gy]). The approximate velocity profile of the galaxy GLASS-z12 was estimated by Bakx *et al.*, 2022 [33] ($z_{phot} \sim 12.1$, $\log_{10}(M_*/M_o) \sim 9.0$) (see Figure 4 of [33]). The profile seems to have a certain structure depending on the radius but a large dispersion of velocities is reported. The velocity profile ranged from ~−25 m/s to 25 m/s (opposite diameter). The following **Figure 16** and **Figure 17** show the velocity profile obtained with this model as well as the exponential time delayed model obtained.

We get a good consistency between models. In this case, the cosmologic force F_Λ acts very little because the radial dimension r is small and this force increases in proportion to the radial dimension (see equation F_Λ).

9. Rotation of Some UDG (How Do We Explain That They Contain a Lot or Very Little DM?)

We have seen that the period of formation of a galaxy either ETG or LTG determines the more or less present effects of the energy E_Λ of hidden photons $\hat{\gamma}$

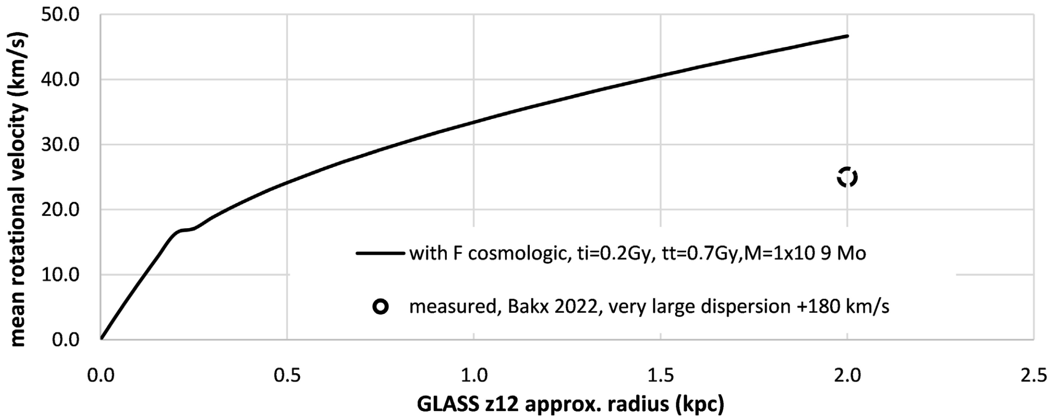

Figure 16. Mean rotational tangential velocity.

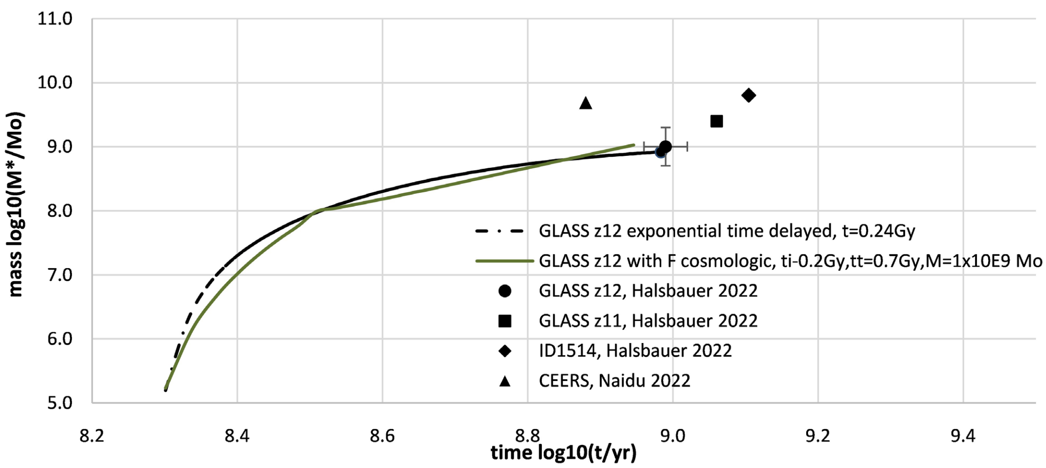

Figure 17. Model of GLASS z12 mass accretion in time.

in the form of the cosmological force F_Λ which acts by the mass-energy equivalence in T^{00} of GR and decreases in H^4. In this section, we will show that UDG ultra-diffuse galaxies could be ETG type galaxies (beginning of galaxy formation time t_i and total formation time t_t **earlier** than ~400 [My]) where the cosmological force acts strongly with a weak content of baryons (case called strong content of DM), or LTG type (beginning of galaxy formation time t_i and total formation time t_t **later** than ~400 [My]) with a weak presence of this cosmological force or a typical behavior called Keplerian (case called very little content of DM).

For a few years now, (Van Dokkum *et al.*, 2015 [34], Van Dokkum *et al.*, 2016 [35], Van Dokkum *et al.*, 2018 [36], Van Dokkum *et al.*, 2019 [37], Mancera Piña *et al.*, 2021 [38]) several studies on ultra-diffuse galaxies UDG, known for a long time (Sandage *et al.*, 1984 [39]), have shown that it seems to contain only DM (up to 98%) and little baryon matter or conversely only baryonic matter (nearly 100%) and very little DM. Indeed, optical, spectroscopic, photometric, interferometric analyses, combined with kinematic and dynamic analyses, indicate that for some of them, the baryonic mass is sufficient to explain the dynamic movements of rotating bodies in these galaxies (LTG type). However, this raises a fundamental question.

How is it that some galaxies and in particular those composed of very few stars and faint (less than 1% of the stars of a typical spiral galaxy), contain no or very little DM, knowing that the ΛCDM theory predicts an almost universal association or proportion of baryon/hidden matter?

We know the answer, it is the beginning period of formation t_i of the galaxy that determines its behavior ETG or LTG either named only or very little DM galaxies.

Today in our space-time of MW, this residual energy is very low but this was not always the case in the first Gy during the formation of the majority of galaxies. However, some of them were formed much later, which explains a diminished effect of this residual energy E_Λ diluted by the expansion of the universe and no need to resort to effects other than baryons to explain the observed dynamics of these LTG. Conversely, galaxies ETG have a larger proportion of this residual energy, hence the need to use DM mass to explain the kinematics observed.

We will study the case of 2 galaxies, one of which is known to contain almost only DM, UDG44 or Dragonfly 44 and AGC 114905 which is known not to contain DM.

UDG44 or Dragonfly 44

UDG44, is a diffuse galaxy in the Coma cluster, studied by Van Dokkum *et al.*, 2016, 2019 [35] [37], who concluded that DM makes up 98% of the galaxy's total mass ~0.7×10^{10} [$M_\odot$] based on rotational dynamic using an estimated halo mass (DM halo mass), with an observable (luminous) mass of ~3×10^8 [$M_\odot$], (r ~5.1 [kpc]). This galaxy is highly diffuse, although very massive, and does not behave like the MW, being considered a "failed MW". authors report that the galaxy's velocity profile is not structured or rotational, and that the mean speed is around 9 [$\text{km}\cdot\text{s}^{-1}$] with large dispersion (unstructured), or σ ~26 to 41 [$\text{km}\cdot\text{s}^{-1}$]. It is obvious that a Kepler rotation model would not apply easily here. However, to perceive the effects of cosmological gravity force F_Λ, the model can be used to see its effects during formation, which lasted ~390 [My], total time t_t approximately the same than MW, with a beginning time t_i around 0.18 [Gy], similar to the MW. **Figure 18** shows the rotation velocity relative to radius and considering a spherical formation in r^3 (globular) and the action of this cosmological force, we can find speeds as high as 40 [$\text{km}\cdot\text{s}^{-1}$] in the line of observation of the galaxy (line of sight). If the start of formation time is delayed and the duration of it (t_i and t_t↑) we are moving closer and closer in proportion to the Keplerian profile.

AGC 114905 (UDG)

This UDG was studied by Mancera Piña *et al.* 2022 [38]. The study showed that the measured rotational speeds can be explained by the presence of barionic matter alone. The reported barionic mass is ~1.4×10^9 [$M_\odot$] (stars and dust). To explain the measured velocities as seen in **Figure 19**, we see that the beginning of the formation t_i is delayed to 500 [My] a period where the cosmological force

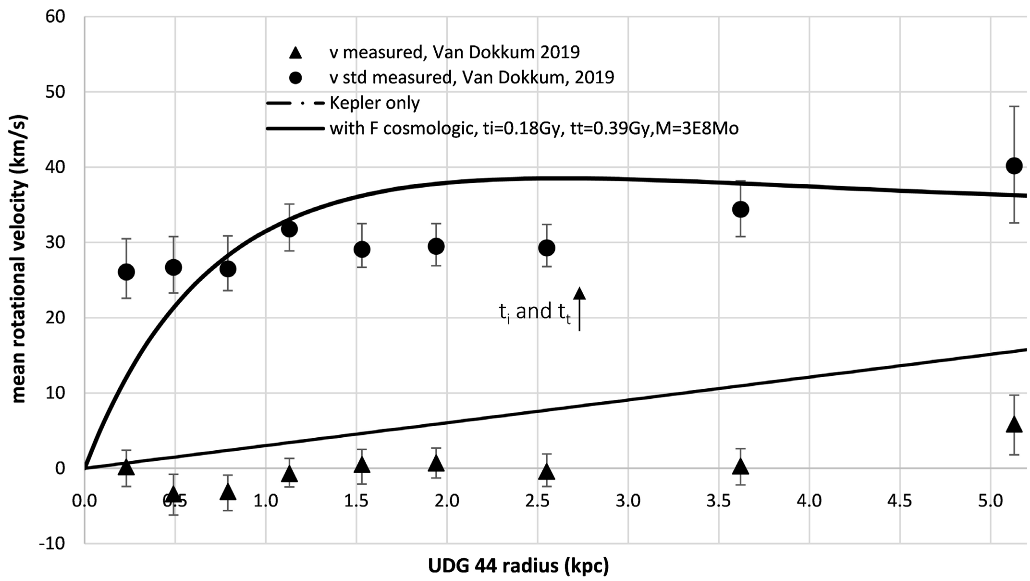

Figure 18. UDG44 rotational velocities.

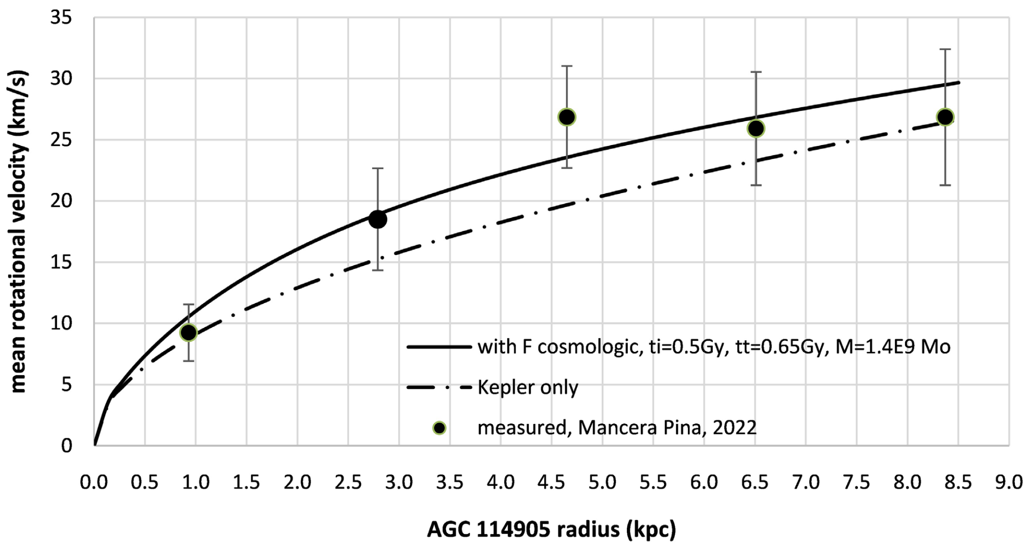

Figure 19. AGC 114905 rotational velocities.

acts weakly. The duration of the formation t_t is estimated around 650 [My] It is the late formation of this galaxy that explains why barionic matter alone can explain Keplerian dynamic behavior LTG. This is the reason why this galaxy is mentioned as having no DM. In addition, Mancera Piña *et al.* mention that the absence of DM imposes a certain difficulty for the ΛCDM model which considers established proportions between DM and barionic matter. Finally, it is also mentioned that the MOND theory cannot well explain the observed rotational speeds. We have shown in [4] that MOND theory is a different way to put this energy E_Λ into action by adjusting the gravitational constant G via a constant named a_0. We have shown that G must be a constant and MOND theory adjusts G for the purposes of explaining the observed rotations of large structures in the universe. We found this expression for a_0.

$$a_0 = \frac{GM}{r^2} + \frac{\Lambda c^2 r}{3} + \frac{\Lambda^2 c^4 r^4}{36GM}$$

We see that constant a_0 is not independent of time. Indeed, it varies with the age of the universe with the cosmological constant $\Lambda(t)$, radius $r(t)$ and mass $M(t)$ of a structure. Hence, when the value for a_0 is adjusted as $a_0 \sim 1.2\times 10^{-10}\left[\mathrm{m}\cdot\mathrm{s}^{-2}\right]$), this consists of making a choice for a given galaxy. This is why this value is often changed to best fit a particular galaxy. The constant a_0 is not a constant of physics.

10. Conclusions

We have seen in this article that a model of the universe, based on a quantum approach to the evolution of space-time as well as on an equation of state that retains all the infinitesimal terms, has made it possible to estimate a large number of parameters relating to the universe and in particular the estimation of a colossal phantom energy E_Λ represented by the existence of a hidden photon present everywhere. This energy undergoes dilution in H^4 due to expansion of the universe. In order to introduce the effects of this energy on the curvature of space-time, we chose to express it by the cosmological constant Λ in the equation of the GR via the element tensor T^{00}. Thus, the expansion energy of the universe (represented by curvature k) is no longer the expression of the cosmological constant. Moreover, we also estimated this expansion energy noted E_{curv}. Let us return to this positive E_Λ energy which acts as additional effect to gravity and we have expressed this energy in the form of an equation which expresses a so-called cosmological force F_Λ. We estimated that this photon or hidden particle of spin 1 has an energy ~1 [meV] at our cosmic position t_0 which makes it an ultra-light axion ULA.

Subsequently, with the action of this augmented force, especially in the first 400 [My] we were able to explain, in part, several observed dynamic behaviors of the barionic mass of some galaxies whose observations raise questions and require additional explanations that led to the likely existence of unobserved matter called DM. However, it appears that this cosmological force makes it possible to explain several observations without the use of this DM. A first conclusion was drawn, namely the much earlier formation of galaxies by the action of this cosmological force coupled with gravity. In addition, the model made it possible to explain the need or not to use the concept of DM for ETGs and LTGs by the more or less early and long period of the beginning of galaxy formation over a period ranging from ~170 to 1200 [My]. Thus, the model makes it possible to explain to a large extent the observations of the dynamics of the galaxies studied. However, several questions remain:

- How can such a short period of galaxy formation time be reconciled (<1 [Gy]) with the evolution model of stars?
- According to the developed model, we have to look for a particle that is simi-

lar to an electromagnetic boson around ~1 [meV]?

- What is the nature of this hidden boson and why is it so difficult to detect it?

In the near future, we hope, we will have made progress in this area and the questions will, in part, be satisfactorily answered.

Finally, we believe the model developed seems interesting and we hope that it will arouse future interest.

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Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this paper.

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