An alternative cosmological model compatible with the ΛCDM model today.

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Abstract

The theory of quantum mechanics and the theory of general relativity always discuss the initial conditions of the universe and its evolution. We will try to add some simple considerations to this question throught a simple cosmological alternative model based on the the Hubble time, Planck mass flow rate and a variable coefficient α_H*. We estimate the parameters obtained by the Planck 2018 results with the Planck mass rate and Hubble time.*

Keywords : cosmology, origin of universe, dark energy, Hubble constant, Planck mass flow rate, evolution of universe, quantum mechanics, general relativity.

Introduction

The ΛCDM model based on Einstein's theory of general relativity and on observations is today the most satisfactory theoretical proposal to describe the universe. On the other hand, no quantum description of the universe is now in consensus. We can note that the Planck mass flux is both a relativistic quantity (c^3/G) and a quantum quantity (mPl/tPl). We will use this quantity associated to the Hubble time to propose a quasi complete alternative theoretical framework, relativistic and quantum, of the universe. This alternative theoretical framework, which follows from the ΛCDM model finds values consistent with the results of the Planck 2018 measurements, tries to explain what dark energy is. Moreover it allows to recover the cosmological diffuse background temperature determined by the WMAP satellite with the Planck 2018 results in a simple and easily affordable cosmological model.

A) A toy cosmological model compatible with the ΛCDM model after the decoupling.

It seems possible to obtain the total mass of the universe from the ΛCDM model otherwise. This could eventually lead to the development of a simple toy cosmological model unknown to the author, built around the Hubble constant , the Hubble time, $t_H = 1 / H$, the Planck mass flow and a variable coefficient α_H.

α_H = **radius of the observable universe** (from calculation of the ΛCDM model for example) **divided by** the **Hubble radius** at time t_H for a flat universe ,:

$$\alpha_H = \frac{c}{H_0}\int_{a=0}^{a=1}\frac{da}{a^2\sqrt{\Omega_r a^{-4}+\Omega_m a^{-3}+\Omega_k a^{-2}+\Omega_\Lambda}}/\frac{c}{H_0} \qquad \text{(Equation 1)}$$

where a is the scale factor, c is the speed of light, $H_0 = 67,4 \pm 0,5$ km s^{-1} Mpc^{-1}, is the Hubble parameter measured today[1], the Ω_i are the density parameters of the standard cosmological model, i.e. the ΛCDM model, measured today[1].

$$\alpha_H = \int_{a=0}^{a=1} \frac{da}{a^2\sqrt{\Omega_r a^{-4} + \Omega_m a^{-3} + \Omega_k a^{-2} + \Omega_\Lambda}} \quad \text{(Equation 2)}$$

$\delta = \frac{c^3}{G} = \frac{m_{Pl}}{t_{Pl}}$ is the Planck mass flow rate.

$t_{H_0} = \frac{1}{H_0}$ is the Hubble time ($\approx$ 4,578 10^{17} s = 14,51 billion light years today)

R_{H_0} is the Hubble radius.

$$R_{H_0} = \frac{c}{H_0} = ct_{H_0} \quad \text{(Equation 3)}$$

The increase of the "total mass", M_{H_0}, of the universe at Hubble radius in the sense of the ΛCDM model is determined for a flat universe by the relation :

$$M_{H_0} = \frac{3}{8\pi G\, t_{H_0}^2}\ \frac{4\pi}{3}(c\ t_{H_0})^3 \quad \text{(Equation 4)}$$

$$M_{H_0} = \frac{1}{2}\ \frac{c^3}{G}\ t_{H_0} \quad \text{(Equation 5)}$$

$$M_{H_0} = \frac{1}{2}\ \frac{m_{Pl}}{t_{Pl}}\ t_{H_0} \quad \text{(Equation 6)}$$

$$M_{H_0} = \frac{1}{2}\ \delta\ t_{H_0} \quad \text{(Equation 7)}$$

The mass of the observable universe in the sense of the ΛCDM model is :

$$M_{H_0}\alpha_{H_0}^3 = \frac{1}{2}\ \delta\ t_{H_0}\alpha_{H_0}^3 \quad \text{(Equation 8)}$$

$\alpha_{H_0} \approx$ 4.399 10^{26} m / 1.372 10^{26} m $\approx$ 3.175 today if H0 = 67,4km s^{-1} Mpc^{-1}, Ωm=0,315 and ΩΛ=0,685[1].

$$M_{H_0}\alpha_{H_0}^3 \approx 2,959\ 10^{54} kg \quad \text{(Equation 9)}$$

in other words, the "total mass" of the observable universe ΛCDM mesured today. ($e=mc^2$)

B) Value of α_H before the decoupling in the cosmological toy model and consequences.

The author hypothesises that, before the decoupling, the radius of the observable universe was equal to the Hubble radius. The ratio α_{H_0} was then equal to 1.

B.1) Thus, the mass of the universe at t_{H0} = Planck time is determined by :

$$M_{H_{t_{Pl}}=\frac{1}{2}\ \frac{m_{Pl}}{t_{Pl}}\ t_{Pl}} \qquad \text{(Equation 10)}$$

$$M_{H_{t_{Pl}}=\frac{1}{2} m_{Pl}} \qquad \text{(Equation 11)}$$

This can be verified with the thermal energy :

$$E_{Th} = \frac{1}{2}\ m_{Pl}\ c^2 = \frac{1}{2}\ k_B\ T_{Pl} \qquad \text{(Equation 12)}$$

where k_B is the Boltzmann constant, with one degree of freedom assumed for the singularity and T_{Pl} the Planck temperature.

B.2) Mass of the universe at Hubble radius in this alternative cosmological model.

Starting from a "Planck time grain mass", the singularity of the Big Bang model, at the beginning of the time of the universe, . Then by making the assumption that for each unit of Planck time that passes, a corresponding mass "Planck time grain mass" is added to the mass of the universe. In our toy cosmological model, the "total mass" (energy) of the universe at the Hubble radius, before and after the decoupling, at time t_{H_0}, grows simply by following the summation :

$$M_{H_0} = \sum_{i=0}^{t_H/t_p} i \frac{m_{Pl}}{2} \qquad \text{(Equation 13)}$$

i.e.

$$M_{H_0} = \frac{1}{2}\ \frac{m_{Pl}}{t_{Pl}}\ t_{H_0} \qquad \text{(Equation 14)}$$

$$M_{H_0} = \frac{1}{2}\ \frac{c^3}{G}\ t_{H_0} \qquad \text{(Equation 15)}$$

t_{H_0} is the Hubble time. $H_0 \approx$ 67,4 km/s/Mpc[1], $t_{H_0} \approx$ 4,578 10^{17} seconds today, so $M_{H_0} \approx$ 9,241 10^{52} kg
Note : … and with datas of §2 we have Eq.9 ,$M_{H_0}\alpha_{H_0}^3 \approx 2,95910^{54} kg$

with t_H = 1/H, so the Hubble radius in this toy universe is the same as the Hubble radius in the ΛCDM model.

This is valid, without recourse to cosmic inflation, from Planck time to the Hubble radius of the universe at the time of decoupling in the standard model (377 700 years) but also beyond. This is made possible by writing the "total mass" and the Hubble radius as sigma summations. This also has the consequence of limiting quantum phenomena in the universe to dimensions of the order of Planck units between t_H and $t_H + t_{Pl}$.

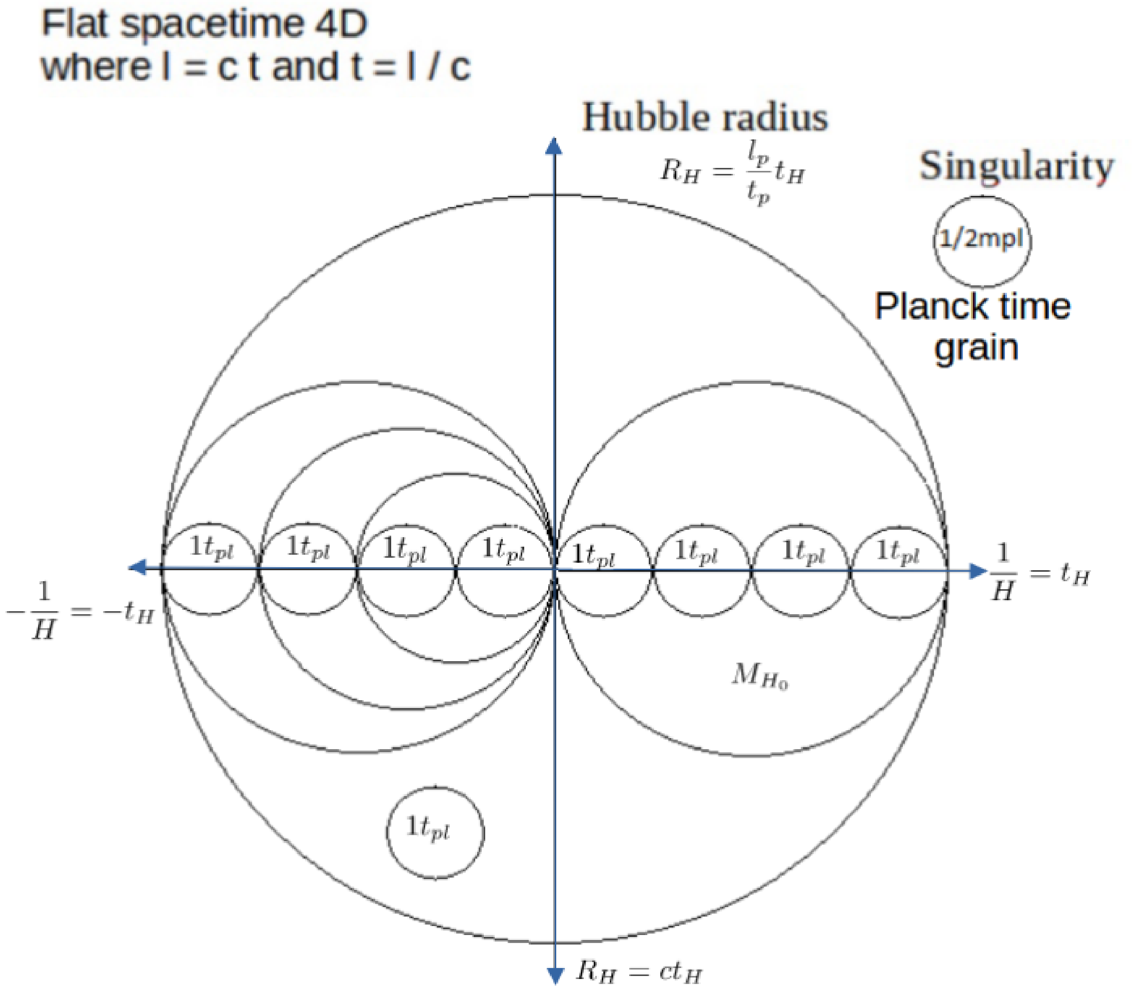

Figure 1: Hubble sphère

C) Proposal of determination of the cosmological constant in this toy cosmological model.

C.1) The Hubble sphere seen as a black hole.

Figure 1 shows that the observation of the Hubble sphere is always done in a given direction whether along the axes t_H or along the axes R_H. When we look in the opposite direction to the Earth, we observe a universe with the same characteristics, namely a Hubble universe whose mass increases as a function of t_H. This toy model is therefore by construction isotropic, i.e. identical whatever the direction of observation. It is also homogeneous on a large scale by construction, i.e. for any considered time interval t_{Pl}, it contains a Planck half-mass. For a large number of Planck half-masses, the latter agglomerate to form stars first under the effect of dark matter and then under the gravitational effect of the Planck half-masses agglomerated under the effect of dark matter.

In other words, there is always an observational bias that makes a part of the Hubble Universe not available to our observation, but it is there. We thus have a Hubble universe of mass $\rho_c V_{H0}$ composed of two mini Hubble spheres whose diameter is R_{H0} and mass $M_{H0} = \frac{1}{2}\frac{c^3}{G}t_{H0}$. These two mini Hubble spheres "touch" each other at the observer's original location and time. The observer sees only one of these mini-spheres at any given time

The invariant gravitational force that attracts these masses of the two mini Hubble spheres is therefore $FM^{\pm}_{H_0}$:

$$FM^{\pm}_{H_0} = \frac{GM^{+}_{H_0}M^{-}_{H_0}}{R^2_{H_0}}$$ (Equation 16)

$$FM^{\pm}_{H_0} = \frac{c^4}{4G}$$ (Equation 17)

$$FM^{\pm}_{H_0} = \frac{F_{Pl}}{4}$$ (Equation 18)

where F_{Pl} is Planck's force où N est le Newton.

$$FM^{\pm}_{H_0} = 3,02564\ 10^{43}\ N$$ (Equation 19)

The Planck force characterizes a property of space-time according to Barrow and Gibbons[2]. In general relativity, the limiting value it represents does not correspond to the Planck unit, but to the reduced Planck unit, where G is replaced by $4G$. The resulting reduced Planck force is four times weaker and is equal to Eq.16 to Eq.19 . This is a maximum limit in general relativity, attainable only at the horizon of a black hole. As the radius of a Schwarzschild black hole R_s is also its horizon R_h where $R_s = R_h = R_{H_0}$ it is permissible to assimilate the Hubble universe to a Schwarzschild black hole. Its barycenter is the center of the Hubble sphere.

$$R_h = \frac{2GM_{H_0}}{c^2}$$ (Equation 20)

Considering the Hubble sphere as a Schwarzschild black hole will be essential in a following paragraph to theorize the temperature of the cosmic microwave background, i.e. the CMB.

The two mini Hubble spheres can also be two complete Hubble spheres.We will simply note that the possibility of a double universe with two opposite time arrows proposed by the Soviet physicist Andrei Sakarov in 1967 is taken up here. But that as far as the Hubble sphere is concerned, the $M^{+}_{H_0}$ and $M^{-}_{H_0}$ universes are included in the same universe. The ideas that derive from the hypothesis of Andrei Sakarov should be re-examined according to the author. The hypothesis of Andrei Sakarov has given rise to few scientific works. Among the scientists who have worked on his hypothesis are Nathan Rosen, Jean Pierre Pettitt, Gabriel Chardin, Michael Boris Green, John Henry Schwarz, Abdus Salam (Nobel Prize in Physics in 1979), or Sabine Hossenfelder.

C.2) Proposal of determination of the cosmological constant.

In classical mechanics the gravitational interaction between two masses is instantaneous but in general relativity this interaction cannot be faster than the speed of light c. We will use this property of the theory of general relativity to propose a value of the cosmological constant. However we will encounter a problem of dimensional coherence that we will circumvent in a very debatable way for lack of a better explanation for the moment. The value which is questionable from the dimensional point of view is however in agreement with the Planck 2018 results as we will highlight later.

Since the velocity of the gravitational interaction $FM_{H_0}^{\pm}$ between $M_{H_0}^{+}$ and $M_{H_0}^{-}$ is limited to c we assume that the power of $FM_{H_0}^{\pm}$ is $PM_{H_0}^{\pm}$ Watts such that:

$$PM_{H_0}^{\pm} = FM_{H_0}^{\pm} c \qquad \text{(Equation 21)}$$

$$PM_{H_0}^{\pm} = 9,0706\ 10^{51} kg.m^2.s^{-3} \qquad \text{(Equation 22)}$$

We will look for what could balance this power. As we have already used the opposite with $M_{H_0}^{+}$ and $M_{H_0}^{-}$ to find $FM_{H_0}^{\pm}$, this time we will use the inverse of $PM_{H_0}^{\pm}$ to get the neutrality egal to 1 of the mathematical operation:

$$\frac{1}{PM_{H_0}^{\pm}} = 1,1025\ 10^{-52} kg^{-1}.m^{-2}.s^{3} \qquad \text{(Equation 23)}$$

The Watt is also the measure of energy flow. The latter is by definition the measure of the total power of electromagnetic radiation emitted or received by a real or virtual surface. We assume that c is an electromagnetic radiation. We will also assume to obtain the dimension [L^{-2}] of the cosmological constant Λ, that the "1" in the numerator of Eq.23 is of dimension [$M\ T^{-3}$], i.e. kgs^{-3}. This is the dimension of a power surface density in electromagnetism. The author admits that this approach to obtaining the dimension of Λ from $PM_{H_0}^{\pm}$ is most certainly wrong, but the value of keeping the numerical value of Λ approximated in this way for its dimension seems to him to be most important at this time. This approximate solution brings in his eyes the advantage of consistently solving many open questions in the ΛCDM model by leaving only one open question in this alternative cosmological model.

C.3) Validation of the value of the proposed cosmological constant.

The density parameter of the cosmological constant Ω_Λ in the ΛCDM model is defined by Friedmann equation for a flat universe as follows:

$$\Omega_\Lambda = \frac{c^2 \Lambda}{3 H_0^2} \qquad \text{(Equation 24)}$$

i.e . with Planck 2018 results and the proposed value of Λ:

$$\Omega_\Lambda = \frac{299792458^2\ .\ 1,1025\ 10^{-52}}{3\ .\ 2,1844\ 10^{-18}} \qquad \text{(Equation 25)}$$

$$\Omega_\Lambda = 0,6923 \qquad \text{(Equation 26)}$$

By simplifying, today, the matter density parameter $\Omega_m = 1 - \Omega_\Lambda$, i.e. $\Omega_m = 0,3077.$

Planck 2018 results[1] gives Ωm = 0.315 ± 0.007. If Ωm = 0.315 - 0.007, then Ωm = 0.3080. The theoretical value of Λ gives a result extremely close to the lower bound of Ωm with the Planck 2018 results[1]. This is the main reason why the author thinks that the important open question about the determination of the dimension of Λ seems acceptable to him. This alternative cosmological model would give the origin of dark energy where the ΛCDM model fails.

D) Proposal of determination of the CMB temperature in this alternative cosmological model.

I had stressed the importance of considering the Hubble sphere as a black hole at the end of paragraph C.1). Here, I will partially repeat the work of the article "A Rotating Model of a Light Speed Expanding Hubble-Hawking Universe" by U. V. Satya Seshavatharam and S. Lakshminarayana[3] because they give, with an approximation that I would not use, the CMB temperature from the Hawking temperature of black holes.

"(3) Following Hawking's formula for the temperature of black holes [26], the current cosmic temperature can be expressed as follows: "

$$T_{H_0} = \frac{\hbar c^3}{8\pi k_B G \sqrt{m_{Pl} M_{H_0}}} \quad \text{(Equation 27)}$$

where $\hbar$ is the reduced Planck constant, or Dirac constant and k_B the Boltzmann constant. The Planck 2018 results give a value of H0 = (67.40 ± 0.5) km s-1 Mpc-1. Taking the lower bound of the confidence index, we obtain H0 = 66.90 km s-1 Mpc-1 i.e. $t_{H0} = 4,6124\ 10^{17} s$. We obtain with Eq,14, $M_{H0} = 9,310\ 10^{52} kg.$

$$T_{H_0} = \frac{1,0545718\ 10^{34} * 299792458^3}{8\pi * 1.380649\ 10^{23} * 6.6743\ 10^{11} \sqrt{2,176434\ 10^{-8} * 9,310}\ 10^{52}} \quad \text{(Equation 28)}$$

note: an error in my latex editor makes it impossible to set the Boltzmann constant to the correct power of 10. Please rexify as follows for your calculations:
Boltzmann constant = 1.380649 10^{-23} m² kg s^2 K^{-1}

$$T_{H0} = 2,7256\ K \quad \text{(Equation 29)}$$

The CMB temperature measured today, i.e. for z=0, is :
TCMB(z = 0) = 2.72548 ±0.0005 7 K[3]. The upper bound of the uncertainty error is 2.72605 K. This measurement is therefore in perfect agreement with the calculation made by assimilating the Hubble sphere to a black hole and calculating its Hawking temperature.

Conclusion.

In this alternative model, the mass of the Hubble sphère is egal to $M_{H0} = \sum_{i=0}^{t_H/t_p} \frac{i\ m_{Pl}}{2}$ and appears as a "stacking" of Planck half masses on a Hubble timeline t_H instead of a density multiplied by a spherical volume in the ΛCDM model. This stacking of masses is compatible with the apparent isotropy and homogeneity of the universe. If we still hesitate on the value proposed here of the cosmological constant, we can be much more sure of its basis ($M_{H_0}^{+}$ and $M_{H_0}^{-}$ with $FM_{H_0}^{\pm}$) which allow to theorize the measurement of the CMB temperature.

Finally, we note that the idea of Bruno Valeixo Bento and Stav Zalel in their article "If time had no beginning"[4] seems correct. By linking it to a quantum space, we can assume that multi-universes could exist everywhere in a flat and infinite 4D space-time, as proposed in figure 1 with singularities inside and outside the Hubble sphere. This is true for each unit of Planck time that passes, but also before the Planck time of the Big Bang.

References :

[1] Collaboration Planck : Y. Akrami and al. Planck 2018 results, https://arxiv.org/abs/1807.06209
[2] Barrow & Gibbons, arXiv:1408.1820v3, décembre 2014.
[3] *Phys. Sci. Forum* **2023**, *7*(1), 43; https://doi.org/10.3390/ECU2023-14065
[4] Bruno Valeixo Bento and Stav Zalel, If time had no beginning, Sept 27, 2021 https://arxiv.org/pdf/2109.11953.pdf

1999-2016 Edward L. Wright calculator. Wright (2006, PASP, 118, 1711)

Readings done in connection with this document:

David W. Hogg , Distance measures in cosmology (14) and (15), 2000 December, https://arxiv.org/pdf/astro-ph/9905116v4.pdf, page 14, Eq.14

https://fr.wikipedia.org/wiki/Trou_noir_de_Schwarzschild

https://www.techno-science.net/glossaire-definition/Modele-cosmologique-gemellaire.html

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Author's final note:

To date, attempts to construct an alternative model to the ΛCDM model have failed to account for the CMB temperature. Certainly this alternative model is still incomplete. It lacks explanations of the power spectrum of the CMB polarization and the power spectrum of galaxies.