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From the Hubble Constant to the Black Hole Model. Universe Expansion with Matter Creation and a New Perspective on Dark Energy Observations

Paolo Christillin

University of Pisa, Pisa, Italy
Email: christ.pao@gmail.com

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Abstract

Comparison of the Hubble parameter with cosmological quantities strongly supports the black hole model for the description of the Universe evolution. Such evolution requires matter creation and has implications for what is currently referred to as "dark energy" and the "cosmological constant".

Keywords

Hubble Parameter, Universe Expansion, Black Hole Model, Matter Creation, Gravitational Self Energy, Dark Energy

1. Introduction

Fundamental cosmological information has come from the Hubble parameter and the CMB.

Restraining to the first one, its present value H_0 can be used to determine the approximate age of the Universe. Indeed, since $\left[1/H_0\right]=\left[t\right]$ the first obvious candidate is R/c where R stands for the dimension of the visible Universe and c for the velocity of light. Hence

$$t_U=\frac{1}{H_0}=\frac{R}{c}. \tag{1}$$

Numerically, with the value $R\simeq 10^{26}\ \text{m}$ it yields

$$t_U\simeq 0.3\times 10^{18}\ \text{s}.$$

2. Discussion

But, interestingly there is another quantity, which to the best of our knowledge has not been considered so far, with the same dimensions

$$t'_U = \frac{GM}{c^3} \tag{2}$$

which yields the same result for $M = Nm_N$, expressed in terms of the nucleon mass m_N and of the nucleon number $N \simeq 10^{80}$.

These two numbers are taken from [1].

The two values coincide as they should. In that case one immediately obtains

$$t_U = \frac{R}{c} = t'_U = \frac{GM}{c^3} \tag{3}$$

i.e.

$$\varepsilon = \frac{GM}{c^2 R} = 1$$

the well known black hole (*b.h.*) *condition* which supports the suggestion by [2] and forces us to use this relation.

Modeling the Universe as if it were a steadily-expanding black hole originating form a "singularity" state has a rich history [3]-[11] without apparently however addressing the present problem.

The preceding equation embodies the **striking relation between the age of the Universe and its mass content.** Now tautologically in the past the age must have been smaller and this implies that the (visible) mass must have been less or in other words that **there has been matter creation**. Restraining for simplicity to the matter dominated regime *i.e.* the post CMB times (where $R \simeq 10^{23}$) we have the situation represented in **Figure 1**.

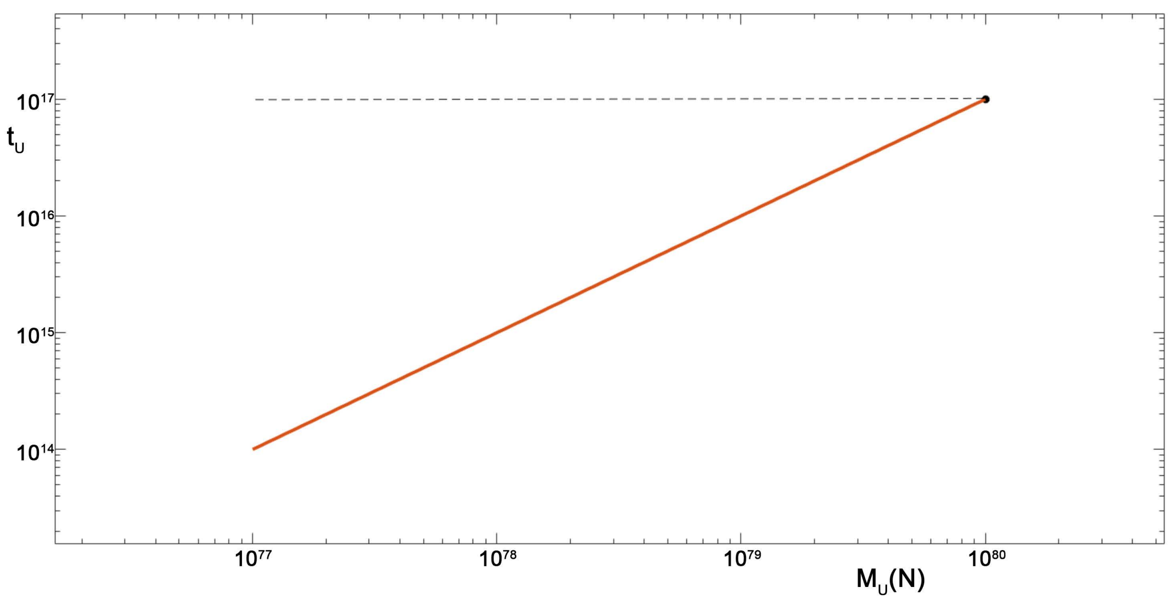

Figure 1. Age of the Universe t_U as a function of its mass content M_U. Horizontal line General Relativity (GR) matter conserving assumption. Slanted line matter nonconserving b.h. approach; starting for the present values of M (and R) it predicts a decrease in the matter dominated era by roughly 3 orders of magnitude. M expressed in terms of the number of nucleon (N) masses.

Thus the linear relation between mass and radius of Equation (3) can be regarded as almost model independent. Indeed it is also valid for Planck quantities

$$\frac{GM_P}{c^2 R_P} = 1$$

so that ε must be constant in times as proved in Ref. [12].

This has to be compared to the traditional approach [13] *where no connection is made with cosmological quantities and where the Hubble experimental value is used only to determine free parameters* (*dark energy and cosmological constant*). *See* **Figure 2**. *Therefore no prediction is made for its time dependence i.e. for the evolution of the Universe age*.

The mass variation required by Equation (3) has therefore another fundamental effect in the equations of motion

$$\mathrm{d}\varepsilon = 0 = -\frac{GM}{R^2} + \frac{G\mathrm{d}M}{R\mathrm{d}R} \tag{4}$$

where the first term represents the well known Newtonian acceleration counterbalanced by the second one, due to mass variation, *the same mass variation which determines the Hubble time in Eq.* [3]. This term, additionally justified because the potential is not a state function [14], predicts a steady expansion and represents the "mysterious force" (dark energy) which balances gravitational attraction. *So self energy is seen to provide the repulsive force since it increases the total energy when particles move away and can explain the* "*dark energy*" *observations*[1]

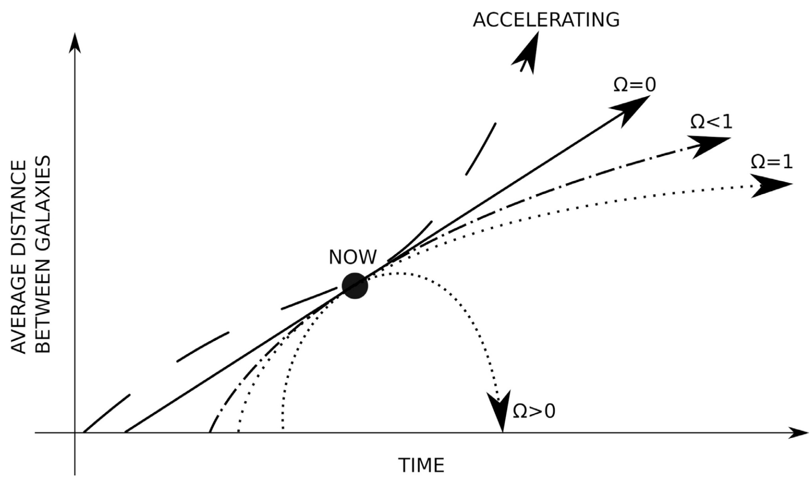

Figure 2. Standard way to determine the age of the Universe in terms of the critical density and of the content percentage Ω of matter and of the cosmological coupling constant or dark energy (from Ref. [13]). The curve with $\Omega = 0$ corresponding to $\Omega_m = 0$ should prove the irrelevance of matter and the necessity of dark energy. In any case the GR assumption of matter conservation together with the constancy of Ω_Λ would leave the prediction of the Hubble term at earlier times, even if not tackled, essentially constant as contradicted by what happens in the b.h. model where the varying matter content is just of the right amount to produce it and no dark energy is needed. The presence of the "mysterious" repulsive force due to the self energy is commented upon in the text.

[1]We report here Schutz's comment [15] about GR "*this neglects what in Newtonian language is called the gravitational self energy*".

In this connection, it is worth stressing once more that the reported supernovae acceleration is a model dependent effect existing only in the standard treatment and disappearing in the present approach.

The (im)possibility of detecting matter non conservation in present times has already been considered in Ref. [16].

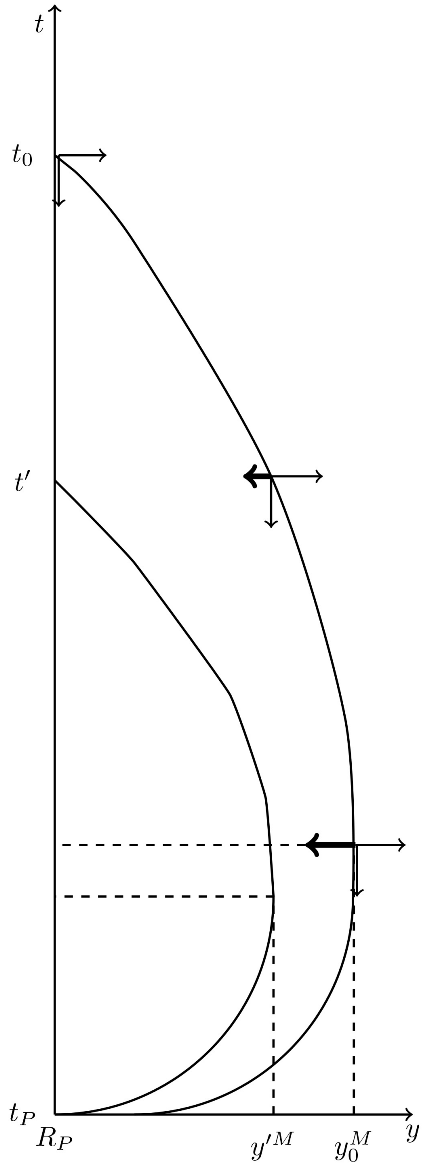

Figure 3. Light propagation in the (t, y) plane. Because of the vector composition of the local relativistic invariant light cone with the frame velocity determined by the varying Hubble parameter $H \simeq \frac{1}{t}$ (thick arrow), light deviates more and more when emitted at former times (with an analogous effect to light deviation in a static gravitational field). At $y = y^M$ the Hubble velocity becomes smaller than the transverse light component thus allowing all the "light" emitted at the Big Bang to reach the earth at different times. Since $y = y_0^M$ is bigger than $y = y'^M$ the maximal world "dimensions" identified with the Hubble radius increase with time. Not in scale.

The new term may be related at present to the GR "cosmological constant" as a vacuum density of the order of

$$\rho_V \simeq \frac{M}{R^3} \simeq 10^{-25}$$

to be compared to the same quantity at Planck (P) times

$$\rho_V^P \simeq 10^{97}$$

with the notorious ratio of $\simeq 10^{120}$ [17]. Of course at earlier times we would have different "cosmological constants".

More formal justifications of the present intuitive arguments have been given in Ref. [12] [14] [16], where also other properties of the model have been highlighted: causality and absence of inflation.

This also shows the misleading parallelism with Newtonian treatment which is seen to represent correctly only a local description of gravitation and the inadequacy of GR and therefore of the Λ-CDM model to account for reality.

For completeness, we report hereafter the Universe time development in the Painleve'-Gullstrand metric [14] (see **Figure 3**). It is particularly relevant to show the local validity of Special Relativity and that the age of the Universe is larger than predicted at the beginning in terms of the Hubble parameter only.

3. Conclusion

To sum up, a judicious consideration of the present Hubble parameter allows us also to shed light on the past thanks to the black hole mechanism and questions the adequacy of the current treatment. In that respect, it is indeed strange how people have refused such an approach whereas they have enthusiastically seen black holes even if they are not there (remember that M an R must be in the above ratio. It is not enough to have a large amount of "dark" matter at the center of galaxies.) The above finding proves once more that one can have a black hole with relatively little mass in a tiny region and big mass in a large volume. And the creation of matter is just the opposite of the traditionally accepted swallowing.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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