

# **THE MASS OF THE OBSERVABLE UNIVERSE ON THE BASIS OF ITS AGE IN BLACK-HOLE COSMOLOGY.**

**By**

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## **Abstract:**

**On the assumption of black-hole cosmology, it is straightforward to calculate the mass of the observable Universe on the basis of its age. It will be shown here that this calculation is in agreement with one based on a relationship between fundamental physical constants, providing strong support for black-hole cosmology.**

**Keywords: cosmology (theory); large-scale structure of the Universe; cosmological parameters; black holes.**

**Abbreviations used: FLRW = Friedman-Lemaître-Robertson-Walker (metric); Planck 2018 refers to the results from the Planck space observatory released in July 2018.**

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**Note: All units in S.I. Source of values of physical constants: <https://physics.nist.gov/cuu/Constants/index.html>.**

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## **1. Introduction.**

Black-hole cosmology is the claim that the Universe we live in is an enormous black hole. It has had few advocates, among them Pathria (1972 [1]), Derney and Farnsworth (1983 [2]), Zhang (2009 [3]),

Seshavatharam and Lakshminarayana (2014 [4]), Perelman (2020 [5]), and Popławski (2020 [6]). Part of the problem is that these authors, whilst advocating a black-hole cosmology, do not agree with one another regarding its details.

Another part – the bigger one – is that black-hole cosmology, or cosmologies, do not appear to be consistent with the observation that the Universe is not merely expanding, but that its expansion is accelerating (Riess *et al*, 1998 [7]; Perlmutter, Turner and White, 1999 [8]; Perlmutter, 2000 [9]; but see Vishwakarma, 2003 [10]).

Even the promoters of the idea of an accelerating expansion of the Universe would be forced to concede that we should not, in fact, use the present tense when discussing its expansion, still less any putative acceleration of it, because what we see of red-shifted distant galaxies, and the Type Ia supernovae in them, is very ancient light indeed – billions of years old (Leibendgut, 2001 [11], p.91). Any expansion, and any acceleration of it, *if* it took place, took place long ago.

Not all researchers agree that the Universe's expansion is (or *was*) accelerating, not just Vishwakarma (op.cit.): Nielsen, Guffanti and Sarkar (2016 [12]), Mohayaee, Rameez and Sarkar (2021 [13]), Ni *et al* (2022 [14]), *inter alios*, are among those who have questioned the reliability of the observational data on which the assumptions regarding the accelerated expansion have been based.

## **2. A Black-Hole Cosmology.**

A black-hole cosmology is not, in fact, wholly dissimilar to the Newtonian one described by McCrea and Milne (1934 [15], pp.73-75). There would have to be an absolute cosmic time coordinate, for reasons adduced by Gödel (1949 [16], pp.447, 449-450), and is assumed in the 'FLRW' metric (Robertson, 1935 [17], 1936a [18] & b [19]; Walker, 1937 [20]), provided that the Universe is isotropic and homogeneous, conforming to the 'cosmological principle' (Einstein, 1917 [21]; Milne, 1933 [22], pp.1, 3-4; see Barrow, 1989 [23]). This, however, is denied by many, if not most, advocates of black-hole cosmology, including Popławski (op.cit.).

Furthermore, the cosmic horizon would *not* be a particle horizon, but an *event* horizon, as they are both defined by Rindler (1956 [24], p.663). This point is affirmed by Melia (2007 [25], pp.1919-1920; see Schwarzschild, 1916, 1999 [26]). Melia is one of those denying the existence of an absolute cosmic time, but he also claims that the interior of a black hole's space-time should be 'flat' and describable using the Minkowski metric (Minkowski, 1909, 2011 [27]), citing Birkhoff's theorem (Birkhoff, 1923 [28]; see Johansen and Ravndal, 2005, 2006 [29]). As Melia points out, the Schwarzschild metric applies to the exterior of the black hole (ibid.). If our space-time is Minkowskian, the appropriate formula for calculating redshifts is that of the *Special*, not *General*, Theory of Relativity (Melia, 2012 [30], pp.1419-1421), i.e., the formula is *not* for 'gravitational redshifts', being:  $z = [(1 + \beta)/(1 - \beta)]^{1/2} - 1$ , where  $\beta = v/c$ ,  $v$  being the recessional velocity of distant celestial objects relative to the observer. When  $v = c$ ,  $z = \infty$ . As Melia (2007, op.cit., p.1919, and 2012, op.cit., p.1419) points out, it easy to show that the FLRW metric reduces to the Minkowski one when the scale-factor  $a(t_0) = H_0(t_0) = 1$ , and the Hubble parameter,  $H_0 \equiv t_0^{-1} \equiv \tau_0^{-1}$ , where  $\tau$  is the Hubble time. We can also write  $R_0 = ct_0 = c\tau_0 = c/H_0$ , where  $R_0$  is the Hubble radius. The General Theory applies at the local scale, but not at the cosmic scale.

It is assumed here that the Universe is not merely isotropic and homogeneous, but spherically symmetric and stationary (i.e., not rotating about an axis, as the Gödel universe does [op.cit.]) – that, in other words, it is a Schwarzschild black hole (op.cit.), but its space-time singularity, being in the past, is now at its circumference, not at its centre, which represents the observer's present. We are, as it were, at the centre of a neo- or quasi-Ptolemaic cosmic chronosphere.

If our Universe is, indeed, an enormous black hole, its present age will be given by:

$$t_0 = 2GM/c^3 . \tag{1}$$

As  $t_0 = 13.801$  billion years  $= 4.355264376 \times 10^{17}$  s (Aghanim *et al*, 2020 [31], Table 1, p.7 pdf.), it is easy to see, by rearrangement of (1), that the mass,  $M$ , of the observable Universe will equal

$$c^3 t_0 / 2G = 8.791053 \times 10^{52} \text{ kg.} \quad (2)$$

As Davies (1982 [32]) points out (pp.77, 82; but substituting the present age of the Universe for the Hubble time), it is the case that:

$$N_E = (\hbar c / G m_p^2) (m_p c^2 t_0 / \hbar) = c^3 t_0 / G m_p = 1.05117 \times 10^{80} . \quad (3a)$$

Here,  $N_E$  is Eddington's number, the number of protons and electrons in the Universe,  $m_p$  is the rest-mass of the proton, and the expression  $\hbar c / G m_p^2$  is the inverse of the gravitational fine-structure constant  $= \alpha_G^{-1} = M_P^2 / m_p^2$ , where  $M_P$  is the Planck mass  $= 2.176434 \times 10^{-8} \text{ kg}$ .

The expression  $M_P^2 / m_e$ , where  $m_e$  is the rest-mass of the electron, yields a mass,  $5.19984 \times 10^{14} \text{ kg}$  – that of a modest-sized asteroid. However, multiply this by  $\alpha_G^{-1}$ , and one obtains:

$$M = (\hbar c)^2 / (G m_p)^2 m_e = M_P^4 / m_p^2 m_e = 8.80435 \times 10^{52} \text{ kg} . \quad (4)$$

Combining equations (2) and (3) gives us

$$M = N_E m_p / 2 = 8.791053 \times 10^{52} \text{ kg} . \quad (5)$$

The figures in (2), (4) and (5), it should be noted, are about a third of that given by Corbeel and Magain (2023 [33], p.6, pdf. – their figure is  $2.7846 \times 10^{53} \text{ kg}$ , or  $1.4 \times 10^{23}$  solar masses; their figure is clearly excessive, but they *are* advocates of black-hole cosmology). How to reconcile equations (2) and (5) with (4)? The simplest answer is to adjust the value of  $t_0$  – and it does not need much adjustment, on the scale we are considering.

Substituting the value for  $M$  obtained from (4) in equation (1) gives us a value for  $t_0$  of  $4.361851836 \times 10^{17} \text{ s} = 13,821,874,400$  years, 20,874,400 years more than the Planck 2018 figure (Aghanim *et al*, *ibid.*). It is possible, of course, that the Planck 2018 figure is correct,

and the time in equations (1), (2) and (3) is not the *present* age of the Universe, but the age,  $t_{\text{MAX}}$ , at which it will reach its maximum size, given by its Schwarzschild radius:

$$R_S = 2GM/c^2 = 1.307650283 \times 10^{27} \text{ m} = 13,821,874,400 \text{ l.y.} \quad (6)$$

What happens to it after then may depend on the amount of entropy it contains at that time, given the Bekenstein-Hawking formula (Bekenstein, 2008 [34]):

$$S_{\text{BH}} = 4GM^2k/\hbar c = 9.037467145 \times 10^{98} \text{ J K}^{-1}. \quad (7)$$

This may well correspond to the ‘heat-death’ of the Universe, or state of thermodynamic equilibrium, envisaged by Lord Kelvin (Kelvin, 1862 [35]), provided only that the Universe is closed and finite, rather than infinite, especially if, as Penrose (2010 [36], pp.72, 76-77, 98-99) asserts, the ‘Big Bang’ had very low – even ‘tiny’ – entropy.

### 3. Conclusion.

We have in this paper seen ample evidence to support the assertion that our observable Universe is an enormous black hole, with maximum horizon surface area =  $2.1487856 \times 10^{55} \text{ m}^2$  and maximum volume =  $9.3662 \times 10^{81} \text{ m}^3$ .

The matter inside that black hole has yet to fill all of the available space, and has just over 20.87 million years to do so, if the suggestion made here is correct. This is just ~0.385% of the remaining main-sequence life-span of our Sun, which is ~5.42 billion years (Schröder and Cannon Smith, 2008 [37]).

Cosmic expansion is here not a question of space expanding, as with the FLRW metric (see above), but of matter expanding to fill a finite proportion of an infinite space, the bulk of which is empty. Our Universe is thus, on this view, a finite, closed space-time pseudo-Riemannian manifold in an infinite Euclidean space-time, but causally isolated from it (Huby, 1971 [38]). It is also quasi-Ptolemaic, in that

we, as observers, are privileged – being at the centre of it – for our viewpoint is the centre of the sphere that constitutes the black hole, with the singularity at its circumference. At  $R_S = ct_{\text{MAX}}$ , the redshift  $z = \infty$ . There is neither ‘dark energy’ nor ‘dark matter’, only the kind with which we are familiar here on Earth. Furthermore, there was no ‘cosmic inflation’: the hypothesis is redundant, because the velocity of cosmic expansion has always been  $v_E \leq c$ .

The minimum density of matter in the observable Universe will be  $\rho_{\text{MIN}} = 9.4 \times 10^{-30} \text{ kg m}^{-3}$ , with the energy density  $8.4484 \times 10^{-13} \text{ J m}^{-3}$  and the proton-electron particle density,  $N_E/V = 0.011239994 \text{ m}^{-3}$ , given

$$N_E = c^3 t_{\text{MAX}} / G m_p = 1.05276 \times 10^{80} . \quad (3b)$$

Given the value of  $t_{\text{MAX}} \equiv \tau_{\text{MAX}}$ , the final value of the Hubble parameter,  $H_{\text{MAX}}$ , will be  $2.2926 \times 10^{-18} \text{ s}^{-1} \simeq 70.743 \text{ km s}^{-1} \text{ Mpc}^{-1}$ , compared to its current value,  $H_0$ , calculated from its age (as determined by Aghanim *et al*, op.cit.), of  $\sim 70.85 \text{ km s}^{-1} \text{ Mpc}^{-1}$ .

The final acceleration parameter of the Universe,  $q_{\text{MAX}}$ , will be given by:

$$q_{\text{MAX}} = 4\pi G \rho_{\text{MIN}} t_{\text{MAX}}^2 / 3 \simeq 0.0005. \quad (8)$$

The final density parameter,  $\Omega_{\text{MAX}} = 2q_{\text{MAX}} \simeq 0.001$ . This would normally entail a space-time with near-zero curvature, but – as already stated – the General Theory of Relativity, although it applies at local scales, does not apply at the cosmic scale, and thus the curvature of space-time remains zero, or ‘flat’, i.e., Euclidean, regardless of the values of  $q_{\text{MAX}}$  and  $\Omega_{\text{MAX}}$ . The finite cosmos is thus the Newtonian one of McCrea and Milne (op.cit.), with escape velocity, or – more correctly – speed, as it is independent of direction, given by:

$$v_e = (8\pi G \rho_{\text{MIN}} R_S^2 / 3)^{1/2} = (2GM/R_S)^{1/2} = c. \quad (9)$$

It is clear, however, that black-hole cosmologies will remain controversial pending further, decisive, empirical evidence in their favour, of the kind supplied by Shamir (2022 [39]). It must be accepted, though, that this evidence may well support an anisotropic Universe.

**Data Availability Statement:** There are no data additional to that contained herein and in the references.

**NOTE ADDED IN PROOF:** The value for Eddington's number ( $N_E$ ) given here differs by a factor of  $\sim 10^4$  from that stated in the paper, 'The Possible Existence of a "Gravito-Electric" Current' (2023) by the present author, being there equal to  $\alpha_G^{-2} = (\hbar c/Gm_p^2)^2 = (M_P/m_p)^4$ , and is *not* dependent on cosmic time, or only valid at any given cosmic time.

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