ON THE MEASUREMENT OF ABSOLUTE TIME.

By

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Abstract: If ‘absolute time’ is to be a meaningful concept, it must be measurable. Here, we set out to show how it may be measured, using both cosmic black hole thermodynamics and the Solar System’s absolute motion relative to the CMB.
Keywords: Cosmology: theory; cosmological parameters.

Section 1: Introduction.

Let it be first understood that what is meant here by ‘absolute time’ is ‘absolute *cosmic* time’. The present author has argued in an earlier paper (Blaber, 2020) that, although Einstein (1905) had apparently abolished absolute time and space by means of his Special Theory of Relativity (SR), replacing them with relative space-time (Minkowski, 1909), this was by no means the last word on the subject.

The Lorentz-Poincaré transformations (Lorentz, 1904; Poincaré, 1905), used by Einstein (op. cit.) in SR, do not require his principle of relativity to work, and are consistent with an aether, a preferred reference-frame, and thus absolute time and space, as was pointed out by Lorentz (1910). Furthermore, Larmor continued to argue that absolute, Newtonian time was essential to astronomy (Larmor, 1927a & b).

The implications for absolute time of Einstein’s *General* Theory of Relativity (GR, Einstein, 1914) were first pointed out by Gödel (1949), who argued (as this author, op. cit., has noted) that the cosmological models ensuing from GR, and incorporating expansion, all required an absolute time-coordinate. This was the only way they could also conform to the requirement of homogeneity and isotropy in cosmic models. Gödel introduced a static model whose metric was an exact solution of the field equations of GR, but was homogeneous and *anisotropic*, with an absolute rotation about a ‘compass of inertia’. It incorporated CTCs – ‘closed time-like curves’ – allowing time-travel into the past, resulting in catastrophic causal paradoxes. Raychaudhuri (1955) showed that a CTC-including model could be constructed that allowed for cosmic expansion.

One of the cosmological models that included an absolute cosmic time coordinate is that of Einstein and de Sitter (1932), the line-element of the metric of which reads (in Cartesian coordinates):

$$ds^2 = c^2dt^2 - R^2(dx^2 + dy^2 + dz^2)\,. \tag{1a}$$

Here, R, the scale-factor, is a function of t, and c is the speed of light (electromagnetic radiation) in vacuum = 2.99792548×10^8 m s^{-1}. If $dx^2 + dy^2 + dz^2 = 1$, R has the dimension of length, and equation (1a) reduces to:

$$ds = |cdt - R|\,, \tag{1b}$$

and at the present epoch, where cosmic time $t = t_C$ = the present age of the universe, t_0 = the present value of the Hubble time, τ_0 (the reciprocal of the Hubble parameter at the current epoch, H_0, see Hubble, 1929), given that the density parameter, $\Omega = 1$ and the curvature parameter, $k = 0$, which is consistent with the empirical findings of Hinshaw, *et al* (2013), and Aghanim, *et al* (2019), this further reduces to:

$$s = c(t_0 - \tau_0) = 0\,. \tag{1c}$$

It is, in any event, the in-built assumption of the Einstein-de Sitter model that space has zero curvature at cosmic scale, and cosmological constant $\Lambda = 0$, the latter in contrast to the Gödel metric.

Section 2: Calculating Cosmic Time.

We shall examine the implications of the zero length in equation (1c) in just a moment – but first, let us see how cosmic time may be calculated. In Blaber (2020, op. cit.) the present author argued that $R = ct_0 = c\tau_0$ was equal to $2GM/c^2$, the Schwarzschild radius of the universe (Schwarzschild, 1916), and that therefore the universe was an enormous black hole. This implies that the mass of the universe, M, is given by:

$$M = \frac{M_P^4}{m_p^2 m_e} = \frac{M_P^2}{\alpha_G m_e} = 8.804353 \times 10^{52}\ \mathrm{kg}\,. \tag{2a}$$

N.B., this is a constant. Here, M_P = Planck mass = $(\hbar c/G)^{½}$ = 2.176434×10^{-8} kg; $\hbar = h/2\pi = 1.054571817 \times 10^{-34}$ J s (Dirac constant); G = Newtonian constant of gravitation = 6.6743×10^{-11} m^3 kg^{-1} s^{-2}; m_p = proton mass = $1.67262192369 \times 10^{-27}$ kg; m_e = $9.1093837015 \times 10^{-31}$ kg (source: NIST); and $\alpha_G = Gm_p^2/\hbar c$ = $5.9061494 \times 10^{-39}$ = gravitational fine-structure constant (α_G^{-1} = 1.6931505×10^{38}). The total rest-energy of the universe is then given by:

$$E = Mc^2 = 7.912958\ \times 10^{69}\ \mathrm{J}\,. \tag{2b}$$

It follows that the total span of cosmic time is given by:

$$\frac{R_S}{c} = t_0 = \tau_0 = t_S = \frac{2GM}{c^3} = \frac{2}{\alpha_G \omega_e} = 4.36185 \times 10^{17}\ \mathrm{s}\,. \tag{3}$$

This is ~13.822 billion years, the age of the present cosmic epoch. Here, ω_e = the angular Compton frequency of the electron = $m_e c^2/\hbar$ = $7.76344071 \times 10^{20}$ rad s^{-1}.

It would seem, then, that the present age of the universe is also the end-point of cosmic time, and that – to quote Harry Hotspur in Henry IV, Part I, Act V, Sc. IV, ll.82-3 – ‘And time, that makes survey of all the world,/Must have a stop.’

Section 3: The Hubble Sphere and its 'Cosmic Horizon'.

The inner surface-area of the 4-ball that constitutes our universe – the surface-area of the Hubble sphere (the radius of which is now determined by c/H_0, see Hubble, op. cit.) – is what Melia (2007), terms a 'cosmic horizon', and constitutes, in Rindler's (1956, p.663) terminology, an event horizon. (Strictly speaking, in mathematical terms, what is usually called the 'Hubble sphere' should be called the 'Hubble hyperball', and its horizon the 'Hubble hypersphere', the former being four-dimensional, the latter three-dimensional.)

The 4-volume of this hyperball is given by $V_4 = \pi^2(ct_0 - c\tau_0)^4/2 = 0$, which contrasts with its 3-volume = $4\pi(ct_0)^3/3 \simeq 9.3662 \times 10^{78}$ m^3. Likewise, the three-dimensional inner surface area of the hypersphere, $S_3 = 2\pi^2(ct_0 - c\tau_0)^3 = 0$, whereas the two-dimensional surface area of the Hubble 3-sphere, $S_2 = 2\pi(ct_0)^2 = 1.0743919 \times 10^{53}$ m^2. We can understand this if we look at the implications of Hubble's Law (Hubble, op. cit.):

$$v_r = H_0 d\ ;\ v_r = c \text{ when } d = ct_0\ . \tag{4}$$

Furthermore, when $v_r = c$, the redshift, z, is given by:

$$z = \sqrt{\left[\frac{(1+\beta)}{(1-\beta)}\right]} - 1 = \infty\ , \tag{5}$$

where $\beta = v/c$. (The redshift formula is not that for GR but is the same as for SR – in other words, Minkowski 'flat' space.)

This horizon coincides with the *fons et origo* of our universe – the so-called 'Big Bang', which was not 'big' but extremely small, and has now swelled to occupy the vast area of S_2. Not only, then, is it an event horizon (Rindler, op. cit.), but it is a one-way street to a space-time singularity (Penrose in Lebovitz, Reid and Vandervoot, 1978; Penrose in Hawking and Israel, 1979).

A space-time singularity, of the kind from which our universe emerged at cosmic time $t_C = 0$, had zero volume, infinite density and pressure, infinite temperature, and zero entropy, as we shall show.

Section 4: Cosmic Thermodynamic History.

If our universe is a black hole, then its entropy at the present epoch, given that the temperature of the CMB (cosmic microwave background) is ~2.27548 K (Fixsen, 2009, pp.916, 920), is given by:

$$S_{now} = \frac{8\pi^2 G M^2 k c}{h} = 2.5517511 \times 10^{116}\ \mathrm{JK}^{-1}\,. \tag{6}$$

Equation (6) is the Bekenstein-Hawking formula for black hole entropy (Bekenstein, 1973, 2008; Hawking, 1974). Here k is the Boltzmann constant (Boltzmann, 1877) = 1.380649×10^{-23} J K^{-1}, and h = Planck's constant = $6.62607015 \times 10^{-34}$ J s (source: NIST, as above, p.3).

The Second Law of Thermodynamics – the idea that the entropy (a word meaning 'transformation of content', from Greek, *en*, 'in', *tropē*, 'turning') of a closed thermodynamic system always increases over time – was worked out in the 19th Century by Carnot (1824), William Thomson (Lord Kelvin) (1852), Clausius (1865), and Boltzmann (op. cit.), and with it the concomitant notion of the 'heat death' of the universe. Physicists have been premature in their rejection of this idea, as is clear from what follows.

At the beginning of cosmic time, when $t_C = 0$, $S = 0$; then, at $t_C = t_P$, the Planck time = $(G\hbar/c^5)^{½} = 5.391247 \times 10^{-44}$ s, when the temperature would have been:

$$T = \frac{E}{k} = 5.73133 \times 10^{92}\ \mathrm{K}\,, \tag{7}$$

the entropy then would have been:

$$S_{Planck} = \frac{2\pi l_p^2 kc}{h} = 1.96245 \times 10^{19}\ \mathrm{JK}^{-1}\ . \tag{8}$$

Here, l_p = the Planck length = $(G\hbar/c^3)^{½}$ = 1.616255 × 10^{-35} m. Entropy then grows in increments, given in part by the number of Planck time units, and there are:

$$N_p = \frac{t_0}{t_p} = 8.090614 \times 10^{60} \tag{9}$$

such units in the total cosmic time, t_0. We find that the rate of increase is:

$$\frac{S_{now}}{S_{Planck} N_p} = 1.6071567 \times 10^{36} \tag{10}$$

units of entropy per Planck time unit.

What this entails is that the volume of the Gibbs phase space (Gibbs, 1902), which appears in the modern version of the Boltzmann equation, $S = k \log_e V$ (Boltzmann, op. cit.), now, given by:

$$\log_e V = \frac{8\pi^2 G M^2 c}{h} = 1.8482258 \times 10^{139}\ , \therefore$$

$$V = e^{1.8482258\ \times 10^{139}} \cong 10^{10^{139}} \tag{11}$$

is truly enormous, and consequently, so is the probability of the universe falling into an irretrievable state of thermodynamic equilibrium. Eddington (in Čapek, 1976) was clearly right to speak of the Second Law of Thermodynamics providing a unidirectional ‘arrow of time’, distinguishing time from the spatial dimensions, and to link it with the ‘expansion’ of space (in reality, as Milne, 1933, pointed out, the expansion of matter *in* space).

Section 5: Local, Relative Time *versus* Absolute Cosmic Time.

The experiments of Kennedy and Thorndike (1932) and Ives and Stilwell (1938) appear to uphold the relativity of time, and the findings of SR, as opposed to the Lorentz aether theory (Lorentz, 1904, op. cit.). This is, however, not the case, for these experiments were conducted at a local level, and their results only apply at a local level.

The metre is now defined internationally, in the S.I. system of units, as the distance travelled by light in vacuum in 1/299,792,458th of a second (BIPM), and the second is defined as the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the unperturbed ground state of an atom of caesium-133 (BIPM2). Light thus travels one metre in ~30.66332 of those periods.

Caesium atomic clocks are highly accurate. The one at the National Physical Laboratory, Teddington, Middlesex, UK, is accurate to 1 second in every 158 million years (NPL, 2014).

Wolf and Petit (1995) give a set of equations enabling such clocks to be synchronised and ‘syntonised’ (i.e., coordinated), in spite of travelling at different speeds and at different heights relative to each other and to a geocentric system of coordinates, given the effect of the Earth’s gravitational field. Again, this in no way invalidates the concept of absolute time, or that of the preferred frame of reference, as these are valid at a local level only.

As Gift (2007) has argued, the principle of relativity in SR depends on the postulate of the constancy of the *one-way* speed of light, and it is that, and only that, that differentiates SR from the Lorentz aether theory, and allows the proponents of SR to deny the existence of absolute time and space, and of a preferred reference-frame (p.2). He offers evidence that, whereas the two-way speed is constant, relative to the preferred frame, its one-way speed for an observer changes according to that observer’s motion relative to the preferred frame (p.4).

Gift (2016) followed this up with an experiment to measure the one-way speed of light using the Global Positioning System (GPS), and obtained a result showing that it was, as the Lorentz aether theory predicted, a variable, with the one-way speed different for light travelling east between two points fixed on the surface of the (rotating) Earth at the same latitude (= $c - v$), and for light travelling west between two such points (= $c + v$), as predicted also by GR (Gift, 2016, op. cit., pp.4-6; see Alley, *et al*, 1983, pp.245, 257; Alley, *et al*, 1988, 1992). Here v is the surface speed of the Earth at the latitude of the points (Gift, op. cit., p.6).

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Section 6: Conclusion.

Szostek and Szostek (op. cit.), using their equations (67), and assuming the CMB is homogeneous in the system of the aether, with the temperature of a black body (see Fixsen, op. cit.), obtain a velocity of the Solar System relative to the CMB preferred reference-frame of 369.3 ± 3.3 km s^{-1}, in the direction Right Ascension 11h 13m 58.8s; Declination: –6° 57′ 24″ (2020), in the constellation Leo.

This implies a very small Lorentz-Poincaré transformation correction to the measurement of Earth time of:

$$t' = t(1-\beta^2)^{½} \; ; \; \beta = \frac{v}{c} \simeq 1.2318522 \times 10^{-6} \, . \tag{12}$$

This amounts to 0.99999999999848254 s for every 1 s that passes – in other words, the duration of 1 s on Earth is reduced to 0.99999999999848254 s by the Solar System’s motion relative to the CMB. Given the S.I. definition of the metre (see above, p.7), the Solar System’s velocity can be expressed as ~369,300 × 1/299,792,458 × 0.99999999999848254 = 0.0012318522 s = 1,000βs.

This can then be used as a basic time unit (t_{btu}) for measuring cosmic time. We find that, using this measure, the universe is 3.54088745 × 10^{20} t_{btu} old, and – for reasons we have adumbrated – has now reached its senescence, where it may, at any moment, and with a very high degree of probability, enter a state of thermal equilibrium.

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[1] Abbreviations used: BibCode = Bibliographic Code; DOI = Digital Object Identifier; hdbk. = hardback; pbk. = paperback; ISBN = International Standard Book Number; ISSN = International Standard Serial Number.

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