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Generalized Large Number Hypothesis and Cosmological Constant

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By generalizing Dirac's large number hypothesis we infer that the cosmological "constant" varies with t^{-2}, as expected from earlier studies.

Barrow (1990) has reviewed the search for a physical meaning concerning the "large numbers" (see also references therein). By writing

$$N_1 = \frac{ct}{e^2/m_e c^2} \sim 10^{39} \tag{1}$$

$$N_2 = \frac{e^2}{Gm_p m_e} \sim 10^{39} \tag{2}$$

$$N = \frac{4\pi(ct)^3\rho}{3m_p} \sim \frac{ct^3}{Gm_p} \sim 10^{78} \tag{3}$$

(where e, G, m_p, m_e, and ρ stand, respectively, for electron charge, Newton's gravitational constant, the proton and electron masses, and the rest-energy density of the universe), we must have, according to Dirac's hypothesis,

$$N_1 \sim N_2 \sim \sqrt{N} \propto t \tag{4}$$

This implies that

$$G \propto t^{-1} \tag{5}$$

$$\rho \propto t^{-1} \tag{6}$$

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The prediction I want to deal with refers to the cosmological "constant" Λ. According to Barrow (1990), Eddington (1935) noticed another large number,

$$N_3 = c\hbar\left(\frac{m_p m_e}{\Lambda}\right)^{1/2} \sim 10^{39} \tag{7}$$

where $\hbar$ stands for Planck's constant.

Instead of arguing, like Dirac (1938), that relation (7) points to a very likely null value for Λ, I shall now write the generalized large number hypothesis (GLNH) as

$$N_1 \approx N_2 \approx N_3 \approx \sqrt{N} \propto t \tag{8}$$

In this way, we recognize that Λ is time-varying, and specifically,

$$\Lambda \propto t^{-2} \tag{9}$$

which is the relation that must be added to (5) and (6).

This time variation for Λ solves the particle physicist's problem, which did not exist in 1938, of explaining why Λ is so small today, while it had a huge value in the early universe. Such a time variation for Λ was proposed by Bertolami (1986) and in several other papers (Berman *et al.*, 1989; Berman and Som 1990*a*,*b*; Berman, 1991*a*,*b*). As can be seen in those references, relation (9) occurs in many different scenarios, even in static models. In fact, relation (9) suggests an alternative scenario to the inflationary one. Berman (1992) explains how the standard large number hypothesis give the "correct" time variation for G and ρ in several theories. In a future "theory of everything," relation (9) must be given a sound foundation, along with (5) and (6).

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