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ORIGINAL ARTICLE

Universality of the self gravitational potential energy of any fundamental particle

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Abstract Using the relation proposed by Weinberg in 1972, combining quantum and cosmological parameters, we prove that the self gravitational potential energy of any fundamental particle is a quantum, with physical properties independent of the mass of the particle. It is a universal quantum of gravitational energy, and its physical properties depend only on the cosmological scale factor R and the physical constants $\hbar$ and c. We propose a modification of the Weinberg's relation, keeping the same numerical value, but substituting the cosmological parameter H/c by $1/R$.

Keywords Cosmology · Quantum mechanics · Gravitational energy · Cosmological scale factor · Weinberg's relation

Weinberg (1972) advanced a clue to suggest that large numbers are determined by both, microphysics and the influence of the whole universe. He constructed a mass using the physical constants G, $\hbar$, c and the Hubble parameter H. This mass was not too different from the mass of a typical elementary particle and is given by

$$m \approx (\hbar^2 H/Gc)^{1/3} \tag{1}$$

We consider also a general elementary particle of mass m. The self gravitational potential energy E_g of this quantum of mass m (and size its Compton wavelength $\hbar/mc$) is given by

$$E_g = Gm^2/(\hbar/mc) = Gm^3c/\hbar \tag{2}$$

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Combining (1) and (2) we can eliminate the mass m to obtain

$$E_g \approx \hbar H \tag{3}$$

This expression has an important quantum-cosmological interpretation. We know today that the cosmological scale factor R is of the order of ct, t the age of the universe (Alfonso-Faus 2011). In this reference (Alfonso-Faus 2011) the cosmological scale factor R is obtained in terms of the cosmological time t as

$$R(x)/R(1) = [2x/(3-x)]^{2/3} \tag{4}$$

where $x = t/t_0$ is the dimensionless parameter for cosmological time in terms of the present age of the universe t_0. For $t = t_0$ we have $x = 1$. $R(1)$ in (4) is the present value of the cosmological scale factor. The following Fig. 1 gives the graphical plot of this cosmological scale factor $R(x)$.

In this plot of $R(x)$ versus x we see that there is an almost linear expansion law from $x = 0$ to about $x = 1.4$. A series Taylor expansion of (4) around $x = 1$ (today) gives

$$\begin{aligned} R(x)/R(1) = {} & 1 + R'(1)/R(1)(x-1)/1¡ \\ & + R''(1)/R(1)(x-1)^2/2¡ + \cdots \end{aligned} \tag{5}$$

Substituting the derivatives of $R(x)$ from (4) into (5) we get

$$R(x)/R(1) \approx x + (x-1)^2/4 + O(x-1)^3 \tag{6}$$

The speed of expansion is then

$$\begin{aligned} R'(x)/R(1) &\approx 1 + (x-1)/2 + O(x-1)^2 \\ &= (1+x)/2 + O(x-1)^2 \end{aligned} \tag{7}$$

The acceleration is then

$$R''(x)/R(1) \approx 1/2 + O(x-1) \tag{8}$$