Einstein energies of electrons

©Mark Loewe, Austin, 26 December 2019

An unpublished manuscript by Irving Ezra Segal[1] states that

"The masses of particles that appear stable on the cosmic time scale, such as electrons and protons, may be explained as in the case of the CBR, by the conjunction of Mach's principle with the periodicity of free wave functions when extended from $\mathcal{M}_0$ to $\mathcal{M}$, under z, whose action represents scattering. The probability of the interaction of an electron with the energetic contents of the universe is extremely small on the laboratory time scale, and possibly also on the much longer scale of all of Minkowski time as assumed in conventional scattering theory formalism, but it can not be precisely zero. In consequence, on the ultracosmic time scale, — in the course of many eons, each of which represents the full Minkowski time scale, — with probability 1 the electron will interact nontrivially with the background, not only once, but infinitely often. In chronounits, the Einstein energy of the electron has the discrete values $\frac{5}{2}$, $\frac{7}{2}$, $\frac{9}{2}$, ..., and so changes by integral amounts in the course of this interaction. In consequence, successive relatively rare but repetitious interactions with the background on the Einstein time scale would be expected to change the electron energy to a random variable m, whose distribution is approximately Poisson, even starting with a bare electron of energy $\frac{5}{2}$. The mean and variance of m would then be expected to be of the same order of magnitude. With the estimate of R in (54), $m_{\rm e} \simeq 10^{37}$ in chronounits; this implies that the dispersion in m would be less than 1 part in 10^{17}, consistently with the observed sharp value.

A rough quantitative check on this mechanism is provided by a comparison of the mass ratio of protons and electrons, with the ratio of the energy densities of the components of the cosmic background with which these particles primarily interact, and in proportion to which the masses would be expected to scale. These are the ensemble of baryons in the universe in the case of the proton, and the CBR in the case of the electron. Current estimates of the (poorly known) average baryonic mass density and the energy density of the CBR have a ratio in the approximate range 1000-2000, in reasonable agreement with the observed ratio."

According to Segal, the Einstein energy of an electron can take any value

$$E_n = \left(n + \tfrac{5}{2}\right)\tfrac{\hbar c}{R}, \qquad n \in \{0, 1, 2, \ldots, \infty\}\,, \tag{1}$$

where $\hbar = \frac{h}{2\pi}$, h is Planck's constant, c is the speed of light, and R is the radius of the universe.

If probabilities of the electron Einstein energies E_n are given by the Poisson distribution,

$$P_n = \tfrac{\lambda^n}{n!} e^{-\lambda}, \tag{2}$$

then the average, variance, and standard deviation of electron Einstein energy are

$$E_{\rm ave} = \sum_{n=0}^{\infty} P_n E_n = \left(\lambda + \tfrac{5}{2}\right)\tfrac{\hbar c}{R}, \qquad \sigma^2 = \sum_{n=0}^{\infty} P_n (E_n - E_{\rm ave})^2 = \lambda\left(\tfrac{\hbar c}{R}\right)^2, \qquad \sigma = \sqrt{\sigma^2} = \sqrt{\lambda}\,\tfrac{\hbar c}{R}, \tag{3}$$

and the variance and standard deviation are given in terms of the average by

$$\sigma^2 = \left(E_{\rm ave} - \tfrac{5}{2}\tfrac{\hbar c}{R}\right)\tfrac{\hbar c}{R}, \qquad \sigma = \sqrt{\left(E_{\rm ave} - \tfrac{5}{2}\tfrac{\hbar c}{R}\right)\tfrac{\hbar c}{R}}. \tag{4}$$

If the radius of the universe is $R = 504.6 \pm 126$ million lightyears,[2] then the chronometric unit of energy is

$$\tfrac{\hbar c}{R} = \left(4.134^{+1.38}_{-0.83}\right) \times 10^{-38}\ \text{MeV}, \tag{5}$$

the minimum Einstein energy of an electron is $E_0 = \frac{5}{2}\frac{\hbar c}{R} \simeq 1.033 \times 10^{-37}$ MeV, and the Minkowski rest energy of the electron is[3]

$$m_{\rm e} c^2 = 0.51099895000 \pm 0.00000000015\ \text{MeV} \simeq 1.236 \times 10^{37}\ \tfrac{\hbar c}{R}. \tag{6}$$

Einstein energy is the sum of Minkowski energy and gravitational energy and, if Einstein energy is positive, then so are Minkowski energy and gravitational energy. If we ignore electron gravitational energy and approximate the average electron Einstein energy as the electron Minkowski rest energy, $E_{\rm ave} \simeq m_{\rm e} c^2$, then Eqs. (5) and (6) may be used in Eq. (4) to obtain an approximate standard deviation of electron Einstein energy,

$$\sigma = \sqrt{\left(E_{\rm ave} - \tfrac{5}{2}\tfrac{\hbar c}{R}\right)\tfrac{\hbar c}{R}} \simeq 1.453 \times 10^{-19}\ \text{MeV} \simeq 3.516 \times 10^{18}\ \tfrac{\hbar c}{R}. \tag{7}$$

This is a billion times sharper (smaller) than the sharp observed uncertainty of the Minkowski rest energy of the electron.

Improved empirical methods may result in improved confirmation, or modification, of Segal's chronometric theory.

---

[1] "The Nature of Gravity", I. E. Segal, Massachusetts Institute of Technology, unpublished manuscript and draft responses to referees last modified on 29 August 1998.

[2] "Apparent superluminal sources, comparative cosmology and the cosmic distance scale", I. E. Segal, *Monthly Notices of the Royal Astronomical Society* **242**, 423-427 (1990) gives the estimate $R = 160 \pm 40$ million parsecs. My fit to the same observed data gives $R \simeq 154.7$ million parsecs $\simeq 504.6$ million lightyears.

[3] Fundamental Physical Constants — Complete Listing, 2018 CODATA adjustment, https://physics.nist.gov/cuu /Constants/Table/allascii.txt.