This fluctuation corresponds roughly to a fractional spacetime distortion given by Eq.(13),

$$\Delta l/l \approx \Delta\phi/c^2 \approx \sqrt{\hbar G/c^3}/l, \ \Delta l \approx \sqrt{\hbar G/c^3} = l_p \tag{35}$$

That is, the allowed nonzero value of the energy density of the gravitational field corresponds to Newtonian potential fluctuations and thus metric and distance fluctuations; the distance fluctuations are, once again, about the Planck length.

VIII. EQUALITY OF GRAVITY AND ELECTRIC FORCES

Our final argument characterizes the Planck scale in terms of the mass or energy at which gravitational effects become comparable to electromagnetic effects and thus cannot be ignored in particle theory. The argument is simple to remember and provides a good mnemonic for quickly deriving the Planck mass.

In most situations we encounter gravity as an extremely weak force; for example the gravitational force between electron and proton in a hydrogen atom is roughly 40 orders of magnitude less than the electric force, and can safely be ignored.[3] However if we instead consider two objects of very large mass M (or rest energy) with the electron charge e, then the gravitational and electric forces become equal when

$$\frac{GM^2}{r^2} \cong \frac{e^2}{r^2}, \ M^2 \cong \frac{e^2}{G} \tag{36}$$

The dimensionless fine structure constant is defined by $\alpha \equiv e^2/\hbar c \cong 1/137$, so we may also express Eq.(36) in terms of the Planck mass as

$$M^2 \cong \alpha\frac{\hbar c}{G} = \alpha M_p^2, \ M \cong \sqrt{\alpha} M_p \cong \frac{M_p}{12} \tag{37}$$

That is equality occurs within a few orders of magnitude of the Planck mass, at least in terms of Newtonian gravity. We may plausibly infer that such equality also occurs when charged massive particles scatter at near the Planck energy.[38]

Quantum electrodynamics (QED), describing the electromagnetic interactions of electrons and other charged particles, ignores gravitational effects. Clearly this is not reasonable for energies near the Planck scale. Thus virtual processes described by loop integrals are clearly not handled correctly since they involve arbitrarily high energies, and indeed most of them diverge.[3,32,33] We may therefore hope that a more comprehensive theory that includes gravity might be free of such divergences.