

Physical meaning of the Stoney Mass.

The Stoney mass was invented by George Stoney first presented in 1881 [1] as an ad hoc combination of fundamental constants which overall dimension is mass (kg in SI), which formula is:

$$m_S = \sqrt{\frac{1}{4\pi\epsilon_0 G}} e \quad (\text{Eq. 1})$$

where $e > 0$.

Despite occasional speculations, no clear interpretation of the Stoney mass existed until a 2003 publication [2] providing the explanation of its physical meaning. According to this explanation, the Stoney mass does not represent any physical mass, but has a one-to-one correspondence with the electron charge. The rationale of this rather unusual claim, is the effect of the deliberate choice in establishing SI base units of mass (kg) and the electric charge derived unit (coulomb: C = As). They are inherently incommensurable in the SI, as well as in CGS units.

The commensurability of physical quantities may depend on the definition of base units in a given system. The experimental "Rationalized Metric System (RMS) developed in [2] eliminates the SI mass and charge units (kg and As, respectively), which both become derived units with dimensions of $[m^3 s^{-2}]$. The RMS ratio of the electron charge to the electron mass became non-dimensional and equal to 2.04098×10^{21} , that is the square root of the electric to gravitational force ratio for the electron. The conversion of the Stoney mass from SI to RMS proceeds as follows:

With the electron charge e in SI, and \bar{e} in the RMS, the conversion expression to the RMS charge unit is:

$$\bar{e} = e \sqrt{\frac{G}{4\pi\epsilon_0}} \quad (\text{Eq. 2})$$

For the SI mass m and the RMS \bar{m} , the formula is:

$$\bar{m} = 4\pi G m \quad (\text{Eq. 3})$$

Transforming the Stoney mass m_S yields:

$$\bar{m}_S = 4\pi G m_S = 4\pi G \sqrt{\frac{1}{4\pi\epsilon_0 G}} e = \sqrt{\frac{4\pi G}{\epsilon_0}} e \equiv \bar{e}. \quad (\text{Eq. 4})$$

The Stoney mass reduces to the exact representation of the electron charge quantity which was pre-defined by (Eq. 2) in the RMS units, not combined with other fundamental constants as it is the case in the Stoney mass SI representation. Hence the Stoney mass does not represent any real mass quantity and in SI this is an artifact of incommensurable mass and charge units in SI.

Reference:

[1] Stoney G J, "On the Physical Units of Nature," in *The Scientific Proceedings of the Royal Dublin Society*. Dublin: The Roal Dublin Society, 1883, vol. III, pp. 54-58.

[2] Wutke, A. (23 November 2023). "From Newton to universal Planck natural units –disentangling the constants of nature". *J. Phys. Commun.* 7 (11).