Quick and Easy Derivation of the Electron's Electromagnetic Mass: a Comment on *Physics-Uspekhi* **54** (4) 371-374 (2011)

Ron Bourgoin

Edgecombe Community College

Rocky Mount, North Carolina, USA

Abstract

Obtaining the electron's electromagnetic mass has just been made much easier now that the electron has been measured to be aspheric. We show here that the electron can be modeled as a right circular cylinder whose front face is connected to its back face. We show that there must be a circulating magnetic field along the axis of this ring.

The author of reference 1 provides a profound derivation of the electron's electromagnetic mass.[1] We were happy to see it. Very recent work however reveals that the electron is aspheric,[2] which brings to mind right away a toroid. We visualize this toroid as containing circulating magnetic field lines at its interior. For simplicity we shall assume the torus, or ring, has volume

$$V = (\pi r^2)(2\pi r) \tag{1}$$

We see from (1) that all we have done is take a right-circular cylinder and bent it around so that its front face connects to its back face. There must exist a magnetic field along the axis of this ring. Then in EMU, we write

$$2\pi r H = 4\pi I = 4\pi e f \tag{2}$$

where the symbol *H* represents the magnetic field strength (See Appendix I), *e* is the electronic charge, and *f* is the circulation frequency. The energy density in the interior is then

$$\tfrac{1}{2}H^2 = \frac{2e^2 f^2}{r^2} \tag{3}$$

The volume of the toroid, from equation (1), is now written as

$$V = 2\pi^2 r^3 \tag{4}$$

The electromagnetic energy is therefore[3]

$$E = \left(\frac{2e^2 f^2}{r^2}\right)\left(2\pi^2 r^3\right) = (2\pi r f)^2 \frac{e^2}{r} \tag{5}$$

We observe that equation (5) can be written in the form

$$E = c^2 m \tag{6}$$

where the ratio e^2/r represents the electron's total mass in electromagnetic units.

Appendix I[4]

In the cgs electromagnetic system of units (EMU), the unit of flux is the maxwell and one maxwell is represented graphically by one line of force. The unit of flux density in this system is the **gauss**. One gauss is defined as one maxwell per square centimeter and is represented by one line per cm^2. In terms of a hypothetical unit of magnetic pole in cgs units, a magnetic field strength of one gauss is that flux density which would exert a force of one dyne per unit pole on a pole placed in the field.

It is customary to distinguish between the magnetizing field which may produce magnetization in any medium and the magnetization which is produced. The term magnetizing field intensity refers to the former quantity and is represented by the letter *H*, while the term **flux density** resulting chiefly from magnetization of the material or medium is represented by *B*. The mks unit of magnetic flux is the weber, and the weber per square meter is the unit of flux density:

$$1 \text{ weber} = 10^8 \text{ maxwells} = 10^8 \text{ lines}$$

$$1 \text{ weber/m}^2 = 10{,}000 \text{ gauss}$$

A magnetic field having a flux density of one weber per square meter or 10,000 gauss is a quite intense magnetic field.

References

1. Morozov, V.B., “On the question of the electromagnetic momentum of a charged body”, *Physics-Uspekhi* **54** (4) 371-374 (2011)
2. Hudson, J.J., *et al.*, “Improved measurement of the shape of the electron”, *Nature* **473**, 493-496, 26 May 2011.
3. Carroll, R.L., The Energy of Physical Creation, Carroll Research Institute, Columbia, South Carolina, 1985, p.8-9.
4. Rusk, R.D., Introduction to College Physics, 2nd Edition, Appleton-Century-Crofts, Inc, 1960, pp. 449, 544-546.