Classical Electromagnetism's Production of $E = Mc^2$

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Abstract

With a little help from the wave equation, we show that the square of the first derivative of the psi-function with respect to time is an energy density. We then use potential and electromagnetic theories to develop special relativity's mass-energy relation.

The square of the first derivative with respect to time of the wave equation's psi-function yields special relativity's mass-energy,

$$\left(\frac{\partial\psi}{\partial t}\right)^2 = mc^2 \tag{1}$$

We prove this by recalling that

$$\frac{\partial\psi}{\partial t} = \frac{\partial\psi}{\partial r}\frac{\partial r}{\partial t} \tag{2}$$

In potential theory, we have mass potential, electric potential, and magnetic potential, each of which has a distribution from a source center

$$\psi = \frac{k}{r} \tag{3}$$

where k is the quantity distributed along the radius vector r. We take the first derivative of (3) with respect to the radial vector,

$$\frac{\partial \psi}{\partial r} = -\frac{k}{r^2} \tag{4}$$

which is, as we know, the classical inverse square law. We now multiply equation (4) by velocity:

$$\frac{\partial \psi}{\partial r}\frac{\partial r}{\partial t} = -\frac{k}{r^2}c \tag{5}$$

where c is taken to be the limit of velocity. The square of (5) produces

$$\left(\frac{\partial \psi}{\partial t}\right)^2 = \frac{k^2}{r^4}c^2 \tag{6}$$

where the left-hand side of the equality is the expression for energy per unit volume. This means that the ratio k^2/r^4 represents the mass density, which we now prove.

In electromagnetism, mass is defined as

$$m = \frac{e^2}{r} \tag{7}$$

where e is electric charge in electromagnetic units (emu). We see therefore that the k^2 in equation (6) is in fact e^2, allowing us to rewrite (6) as

$$\left(\frac{\partial \psi}{\partial t}\right)^2 = \frac{e^2/r}{r^3}c^2 \tag{8}$$

where we observe that $\frac{e^2/r}{r^3}$ is a mass density. After eliminating the volume from both sides of the equation, we obtain

$$E = mc^2 \tag{9}$$

Bibliography

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