

Particle Rest Mass as Electrostatic Potential Energy

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In the current quark model of nucleons, quark rest masses are taken to be small compared to the binding energies (1).

This reasoning is a basis for rejecting a new theory of fundamental particles (2) wherein the constituent particles (Diracons) are very massive compared to the current quark mass assignments.

However, it is herein argued that the assumption that particles maintain their rest mass regardless of their proximity to an oppositely charged particle is not correct.

In other words, it is proposed that rest mass IS electrostatic potential energy, and as two oppositely charged particles accelerate towards each other, rest mass is converted to kinetic energy and radiation, such that the total of (relativistic mass + remaining rest mass + radiation) remains the same. ("Relativistic mass" is defined herein as mass due to motion.)

Support for this proposal is in careful analysis of the atom, and positron electron annihilation.

First, let us assume we have a closed system consisting of a proton and electron at rest and separated by a relatively large distance. The total mass of this system will be essentially the sum of their rest masses.

Now, as the electron accelerates toward the proton to form the hydrogen atom, there is radiation out of the closed system, and thus the total mass of the atom must be less than the total mass of the separated proton and electron. That is, rest mass must have been lost, and as we will see below, the amount lost exactly equals the radiation emitted.

From another perspective, to ionize this atom to the state we started from, wherein the proton and electron are at rest and separated by a large distance, we need to input energy. This energy must increase total mass, but since the particles are now motionless, rest mass must have increased.

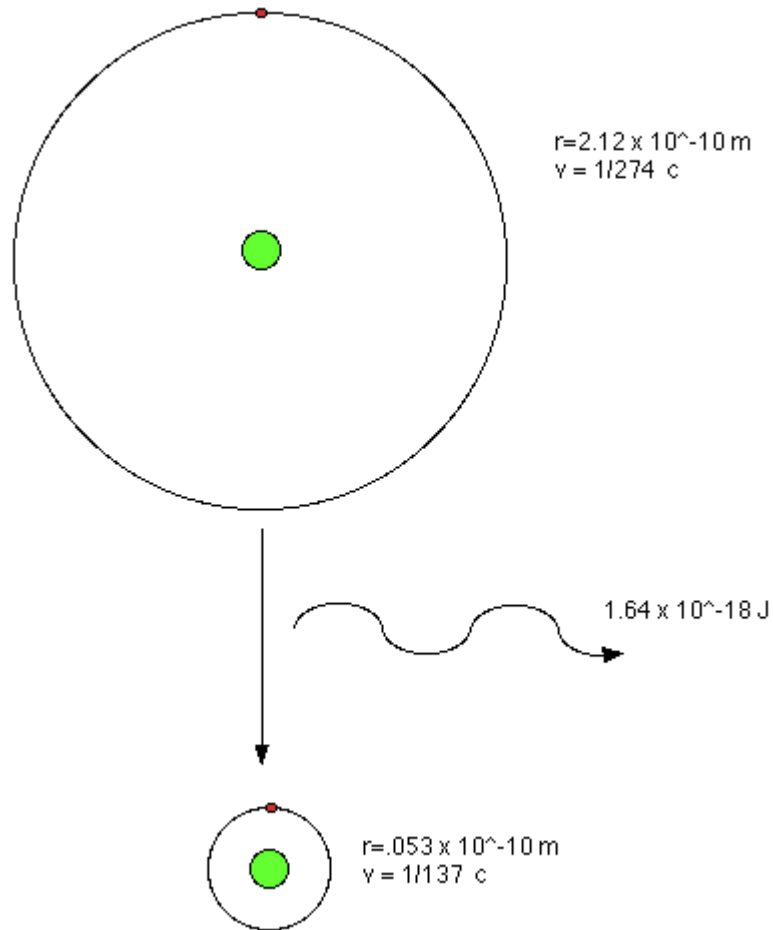
Considering positron electron annihilation, for an electron accelerating from infinity within a stationary field of a positron, its speed is given by

$$v = (ke^2/mr)^{1/2}, \text{ or about } (254/r)^{1/2}$$

Even if it is assumed that annihilation occurs at a distance of the radius of the proton at about 9×10^{-16} m, then the speed of the electron at that distance from the positron would be 5.3×10^8 m/s, or 1.8 times the speed of light.

Therefore if we assume that the electron is smaller than the proton, and that annihilation occurs with contact of the electron and positron, then it is clearly impossible that the electron and positron will retain their rest mass during their approach.

It is interesting to apply the concept, that rest mass is potential energy, to Bohr hydrogen atom as shown in the figure.



The energy of the emitted photon as the electron goes from $n=2$ to $n=1$ is known to be

$$1.63 \times 10^{-18} \text{ J}$$

and is equal the difference in kinetic energy of the electron in the $n=1$ state minus that in $n=2$.

$$E_1 = \frac{1}{2} m_e \left(\frac{1}{137}\right)^2 = 2.18 \times 10^{-18} \text{ J}$$

$$E_2 = \frac{1}{2} m_e \left(\frac{1}{274}\right)^2 = 0.55 \times 10^{-18} \text{ J}$$

$$E_1 - E_2 = 2.18 \times 10^{-18} \text{ J} - 0.55 \times 10^{-18} \text{ J} = 1.63 \times 10^{-18} \text{ J}$$

In other words, the increase in kinetic energy of the electron as it falls from $n=2$ to $n=1$ is equal the radiation emitted.

From another perspective, the energy radiated is also equal to the difference in relativistic mass of the $n=1$ and $n=2$ states.

Taking the speed of the electron in $n=1$ as $(1/137)c$, relativistic mass equals $2.43 \times 10^{-35} \text{ Kg}$, or $2.18 \times 10^{-18} \text{ J}$.

With the speed of the electron in $n=2$ as $(1/274)c$, relativistic mass equals $0.61 \times 10^{-35} \text{ Kg}$ or $0.55 \times 10^{-18} \text{ J}$

Subtracting the relativistic mass at $n=2$ from that at $n=1$ we obtain

$$2.18 \times 10^{-18} \text{ J} - 0.55 \times 10^{-18} \text{ J} = 1.63 \times 10^{-18} \text{ J}$$

Assuming that the electron loses mass equal to the energy of the photon it emits, we see the electron's concurrent

increase in relativistic mass results in the total mass of the electron remaining essentially constant; and that the source of essentially all the mass consumed in photon emission is from the slowly moving proton.

Lastly, I'm inescapably drawn to the fascinating possibility that "kinetic energy" and "relativistic mass" are phenomenologically identical.