COLLISION OF TWO IDENTICAL PARTICLES

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References: Griffiths, David J. (2007), Introduction to Electrodynamics, 3rd Edition; Pearson Education - Chapter 12, Post 32.

Here's another example of using the conservation of relativistic energy and momentum to analyze the interaction of elementary particles. A particle of mass m with a total energy equal to twice its rest energy (as measured in the lab frame) collides with an identical particle at rest, after which the two particles stick together to form a single particle of rest mass M.

Working in the lab frame, we have from conservation of energy:

$$E_{tot} = 2mc^2 + mc^2 = \gamma_M Mc^2 \tag{0.1}$$

where

$$\gamma_M = \frac{1}{\sqrt{1 - u_M^2/c^2}} \tag{0.2}$$

From conservation of momentum:

$$2mu_m + 0 = \gamma_M Mu_M \tag{0.3}$$

Since

$$\frac{1}{\sqrt{1 - u_m^2/c^2}} = 2 \tag{0.4}$$

we have

$$u_m = \frac{\sqrt{3}}{2}c \tag{0.5}$$

so we can solve 0.1 and 0.3 to get

$$u_M = \frac{\sqrt{3}}{3}c \tag{0.6}$$

$$M = \sqrt{6}m \tag{0.7}$$

Note that the rest mass of the new particle is greater than the sum of the rest masses of the two original particles, indicating that some of the kinetic energy has been converted to rest mass (or rest energy).