Representation of Energy in High Energy Physics

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The charged particle beam in accelerator such as LHC at CERN is subject to Lorentz force until beam collision or extraction. The magnetic force in the transverse direction keeps the beam in a curved path. The gravitational force in the downward direction puts the particle of the beam into projectile motion. Conservation of momentum is expected in the longitudinal direction for all forces are in the transverse direction. However, a rigorous examination proves the discrepancy. The representation of energy and momentum can not uphold the law of conservation of momentum.

I. INTRODUCTION

In high energy physics, the energy of a charged particle is represented by γmc^2. This expression characterizes the collision energy of the accelerator such as the 7 TeV proton beam from LHC at CERN[1].

The operation of particle accelerator utilizes quadrupole magnets and other magnetic multipoles to focus the beam so that the beam stays inside the vacuum chamber. The Lorentz force from the magnet counteracts other interactions that each beam suffers such as gravitational interactions over protons and electromagnetic interactions among bunches. These transverse forces play an important role in the direction of the beam.

The lack of force in the longitudinal direction requires momentum to be conserved. The energy expression should lead to the conservation of momentum in the longitudinal direction.

II. PROOF

A. Representation of Energy

The energy of a charged particle increases due to the work done by an external force. The force changes the momentum of the particle in time.

Let E be the energy of the particle. $\vec{F}$ be the external force. $\vec{P}$ be the momentum of the particle. E_i be the initial energy of the particle before the application of force.

$$E - E_i = \int \vec{F} \bullet d\vec{r} \tag{1}$$

$$= \int \frac{d\vec{P}}{dt} \bullet d\vec{r} \tag{2}$$

$$= \int d\vec{P} \bullet \frac{d\vec{r}}{dt} \tag{3}$$

$$= \int d\vec{P} \bullet \vec{v} \tag{4}$$

The energy representation in particle physics is currently

$$E = \gamma mc^2 \tag{5}$$

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{6}$$

The energy of a particle increases when it passes through a linear accelerator.

$$\frac{dE}{dv} = \frac{d\gamma}{dv} mc^2 = \gamma^3 mv \tag{7}$$

B. Transverse Force

Let a charged particle be under an external force in the transverse direction. Its velocity will be altered by the force. Let x denote the longitudinal direction. Let y denote the transverse direction.

From equation (4),

$$E - E_i = \int (dP_x, dP_y) \bullet (v_x, v_y) \tag{8}$$

$$= \int v_x dP_x + \int v_y dP_y \tag{9}$$

The momentum in the longitudinal direction is conserved because there is no force in the longitudinal direction.

$$\frac{dP_x}{dt} = F_x = 0 \tag{10}$$

$$\int v_x dP_x = 0 \tag{11}$$

From equations (9,11),

$$E - E_i = \int v_y dP_y \tag{12}$$

$$\frac{dE}{dP_y} = v_y \tag{13}$$

$$\frac{dE}{dv}\frac{dv}{dP_y} = v_y \tag{14}$$

The momentum representation in particle physics is currently

$$P_y = \gamma m v_y \tag{15}$$

$$\frac{dP_y}{dv} = m(\frac{d\gamma}{dv}v_y + \gamma\frac{dv_y}{dv}) \tag{16}$$

v_x is inertial under the transverse force.

$$v^2 = v_x^2 + v_y^2 \tag{17}$$

$$\frac{dv}{dv_y} = \frac{v_y}{v} \tag{18}$$

From equations (16,18),

$$\frac{dP_y}{dv} = m(\frac{d\gamma}{dv}v_y + \gamma\frac{v}{v_y}) \tag{19}$$

From equations (7,19),

$$\frac{dP_y}{dv} = m(\frac{dE}{dv}\frac{v_y}{mc^2} + \gamma\frac{v}{v_y}) \tag{20}$$

From equations (14,20),

$$\frac{dE}{dv}\frac{1}{v_y} = m(\frac{dE}{dv}\frac{v_y}{mc^2} + \gamma\frac{v}{v_y}) \tag{21}$$

$$\frac{dE}{dv} = \frac{dE}{dv}\frac{v_y^2}{c^2} + \gamma m v \tag{22}$$

$$\frac{dE}{dv} = \gamma m v(1 - \frac{v_y^2}{c^2})^{-1} \tag{23}$$

Equation (23) contradicts equation (7). Therefore, equation (5) is not a proper representation of energy.

III. CONCLUSION

The relativistic energy representation in high energy physics is not a proper expression. The problem becomes evident when a charged particle is subject to transverse force. Under the law of conservation of momentum, the representation of energy results in contradiction and inconsistency.

This is an alarming issue in particle physics. A more precise representation of energy is urgently needed to describe the physics accurately in high energy physics.

Conservation of momentum is a fundamental law of modern physics. All theories and representations are required to follow the law of physics.

[1] CERN: "Taking a closer look at LHC". http://www.lhc-closer.es/taking_a_closer_look_at_lhc/0.relativity

[2] Eric Su: list of publications, http://vixra.org/author/eric_su

[3] Eric Su: list of publications on google, https://sites.google.com/view/physics-news/home/updates