From deriving Mass-Energy equivalence with classical physics to Mass-Velocity relation and Charge-Velocity relation of electrons

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There are controversies on mass-velocity relation and charge of moving electrons, which are related with mass-energy equivalence. Author thought that mass-energy equivalence was expressing the energy relation of bodies and space as mass. In this paper author proposed relative kinetic energy $E_{rk} = mv^2$ to explain this relation. With relative kinetic energy theory, author inferred the equations for mass-energy equivalence and mass-velocity relation. While analyzing the electron acceleration movement, author found the reasons for the two unreal equation of mass-velocity relation, and determined the equations of mass-velocity relation and charge-velocity relation of electrons. These determinations are of important significance for relativity theory and electrodynamics, even for superconducting research.

Usage: Relativity theory, Quantum physics, Electrodynamics

keywords: Relative kinetic energy, Mass-energy equivalence, Mass-velocity relation, Charge-velocity relation

Mass-energy equivalence is was proposed by Albert Einstein in 1905[1]. Mass-velocity relation is associated with mass-energy equivalence. There are three different equations for mass-velocity relation as follows.

Transverse mass of Einstein[2] is $m = m_0/(1 - v^2/c^2)$.

Transverse mass of Lorentz[3] is $m = m_0/\sqrt{1 - v^2/c^2}$.

Longitudinal mass of Einstein[2] and Lorentz[3] is

$$m = m_0/(\sqrt{1 - v^2/c^2})^3.$$

The equation $m = m_0/\sqrt{1 - v^2/c^2}$ was widely used and proved with experiments, but Einstein didn't agree with it. In the letter to Lincoln Barnett on 19 June 1948[4], He wrote that It is not good to introduce the concept of mass $m = m_0/\sqrt{1 - v^2/c^2}$ of a moving body for which no clear definition can be given. While disputing on mass-velocity relation, the controversies on charge of electrons came into being. The charge of electrons was usually assumed constant, but some researchers proposed that the electron's charge will decrease as the velocity increases[5][6][7][8]. To solve these controversy, author thinks that we should study the logic of mass-energy equivalence.

I. RELATIVE KINETIC ENERGY AND MASS-ENERGY EQUIVALENCE

Mass can express as energy, and Energy can express as mass. How does it express? What works in the expressing process? The simple energy is that a body moves in space. Let's assume a body moving in the space. m_a is its mass. We can think that it moves with a constant velocity of v during a short time, and along a little arc with radius of R. R can be very small to infinity. According to the theories of classical physics, its potential energy relative to space is E_p as follows.

$$E_p = -m_a v^2 \tag{1}$$

$$\therefore E_p + m_a v^2 = 0 \tag{2}$$

As we can think with equation (2): The space attracts the body with potential energy E_p to balance mv^2. Conversely, the body pushes the surround space with mv^2 and make it change. Author defined mv^2 as relative kinetic energy E_{rk} for body's motion relative to space.

$$E_{rk} = m_a v^2 \tag{3}$$

When the surround space has been changed, space will transmit this change outward. This is the transmission of energy, the transmission velocity is equal to light speed of c. This transmission is equivalent to that some space move with light speed. At rest, these space has no effect on other space, and has no mass. All of the mass m' is expressed by its relative kinetic energy E'_{rk}. With equation (3), the relation of them as following.

$$E'_{rk} = m'c^2 \tag{4}$$

It means that: the relative kinetic energy $E_{rk} = m_a v^2$ is equivalent to $E'_{rk} = m'c^2$, and m' is one part of m_a.

$$E_{rk} = m_a v^2 \equiv E'_{rk} = m'c^2 \tag{5}$$

Everybody is composed of many smaller bodies layer by layer. Each body is in motion which forms relative kinetic energy E_{rki}. All relative kinetic energies add up to the total E_{rk}, which express the total mass m. In mass-energy equation, relative kinetic energy is defined as the energy E. With the equation (5), can get

$$E = E_{rk} = \sum_{i=0}^{n} E_{rki} \equiv \sum_{i=0}^{n} (m_i c^2) = mc^2 \tag{6}$$

$$E = E_{rk} \equiv mc^2 \tag{7}$$

Above is of mass-energy equivalence of Einstein[1].

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II. MASS-VELOCITY RELATION

Mass-velocity relation is an especial sample of mass-energy equivalence. With mass-energy equivalence, a body with rest mass of m_0 moves with the velocity of v, its mass will be m. With equation (6), total relative kinetic energy E_{rk} of mass m can be divided into the relative kinetic energy E_{rk0} of rest mass m_0 and the relative kinetic energy E_{rk1} of velocity v as follows.

$$E = E_{rk} = E_{rk0} + E_{rk1} \tag{8}$$

And with equation (3, 7), can get

$$E_{rk1} = mv^2 \qquad E_{rk0} \equiv m_0c^2 \qquad E = E_{rk} \equiv mc^2$$

With equation (8), then

$$mc^2 = m_0c^2 + mv^2 \tag{9}$$

$$m = m_0/(1 - v^2/c^2) \tag{10}$$

Equation (10) is the real equation of mass-velocity relation, which is same with the transverse mass of Einstein[2]. But what's wrong with the other two mass-velocity equations? Author think we should study the experiments about mass-velocity relation.

III. CHARGE-VELOCITY RELATION AND MASS-VELOCITY RELATION IN EXPERIMENT

#1. Because electrons are easy to be accelerated with electric field or magnetic field, electrons are usually used for experiments to verify mass-velocity relation. The charge of electron is always assumed constant Q_{e0}. But experiments showed that charge Q_e of electron becomes smaller as its velocity v increases[6].

Proton and electron are a pair of particles, electrons are matching with protons in atoms. Electrons form static positive charges and static negative charges, which form the electric field, so electrons are matching with the energy quantum of electric field. Electrons at low velocity form magnetic field, so electrons are matching with the energy quantum of magnetic field. The attraction forms because of these matching. As an electron is accelerated, its mass m_e (also its energy E_e) increases, the matching becomes worse and the attraction becomes smaller, which expresses that charge Q_e of electron becomes smaller. We assume a correction factor of x to define the relation of the charge and the mass. And with equation (10), can get the express of charge-mass relation and charge-velocity relation as follows.

$$Q_e \propto (1/E_e)^x \propto (1/m_e)^x \propto (1 - v^2/c^2)^x \tag{11}$$

$$\therefore Q_e = Q_{e0}(1 - v^2/c^2)^x \tag{12}$$

When accelerating electrons with uniform electric field or magnetic field, the attraction F of the electron can be simplified as follows.

$$F = kQ_e \tag{13}$$

k is a fixed value which depends on the device. m_{e0} is its rest mass, Q_{e0} is its rest charge. v is velocity of electron, and t is the time, l is the path length of acceleration, m_e is its mass, Q_e is its charge. Can get

$$dv/dt = F/m_e \tag{14}$$

$$v = dl/dt \tag{15}$$

With equation (14, 13, 12, 10), can get

$$\frac{dv}{dt} = \frac{F}{m_e} = \frac{kQ_e}{m_e} = \frac{kQ_{e0}(1 - v^2/c^2)^{1+x}}{m_{e0}} \tag{16}$$

When $l = 0$, $v = 0$, and when $l = l$, $v = v$. With equation (15, 16), can get

$$\int_0^l kQ_{e0}dl = \int_0^v \frac{m_{e0}vdv}{(1 - v^2/c^2)^{1+x}} = \int_0^v \frac{m_{e0}c^2 d(v^2/c^2)}{2(1 - v^2/c^2)^{1+x}} = \frac{m_{e0}c^2}{2x}\int_0^v d\frac{1}{(1 - v^2/c^2)^x}$$

$$kQ_{e0}l = \frac{m_{e0}c^2}{2x(1 - v^2/c^2)^x} - \frac{m_{e0}c^2}{2x} \tag{17}$$

If assume charge of electron fixed, $Q'_e = Q_{e0}$, with equation (13), will get the theoretical increased energy of electron.

$$\triangle E = Fl = kQ'_e l = kQ_{e0}l \tag{18}$$

With mass-energy equation, can get

$$\triangle E = m'_e c^2 - m_{e0}c^2 \tag{19}$$

With equation (17, 18, 19), can get

$$m'_e - \frac{m_{e0}}{2x(1 - v^2/c^2)^x} + \frac{m_{e0}}{2x} - m_{e0} = 0 \tag{20}$$

Because m'_e and v are variable, can solve above equation simplely with the constant term is 0.

$$\frac{m_{e0}}{2x} - m_{e0} = 0 \tag{21}$$

$$\therefore x = 1/2 \tag{22}$$

With equation (11, 12, 22), can get the equation for charge-velocity relation of electron.

$$Q_e \propto \sqrt{1/E_e} \propto \sqrt{1/m_e} \propto \sqrt{1 - v^2/c^2} \tag{23}$$

$$Q_e = Q_{e0}\sqrt{m_{e0}/m_e} = Q_{e0}\sqrt{1 - v^2/c^2} \tag{24}$$

With equation (20, 21, 22), can also get

$$m'_e = \frac{m_{e0}}{2x(1 - v^2/c^2)^x} = \frac{m_{e0}}{\sqrt{1 - v^2/c^2}} \tag{25}$$

As it means: When accelerating electrons for a distance in uniform electric field or magnetic field, for the relation of the condition of accelerator and velocity of an electron, the real mass-velocity relation and real charge-velocity relation is equivalent to the fixed charge and the unreal mass-velocity relation of $m = m_0/\sqrt{1 - v^2/c^2}$.

This equation is same with transverse mass of Lorentz[3], which was supported with the experimental graph of electron's mass-velocity relation[9].

#2. When calculating the force of a moving electron in electric field or magnetic field, with equation (13, 10, 24), its acceleration is as follows:

$$a = \frac{F}{m_e} = \frac{kQ_e}{m_e} = \frac{kQ_{e0}\sqrt{1-v^2/c^2}}{m_{e0}/1-v^2/c^2} = \frac{kQ_{e0}(\sqrt{1-v^2/c^2})^3}{m_{e0}} \tag{26}$$

If consider that $Q_e = Q_{e0}$, its acceleration will be

$$a'' = F''/m_e'' = kQ_e''/m_e'' = Q_{e0}/m_e'' \tag{27}$$

With equation (26, 27), $a'' = a$, can get

$$m_e'' = m_{e0}/(\sqrt{1-v^2/c^2})^3 \tag{28}$$

As it means: For the relation of acceleration and velocity of an electron, the real mass-velocity relation and real charge-velocity relation is equivalent to the fixed charge and the unreal mass-velocity relation of $m = m_0/(\sqrt{1-v^2/c^2})^3$. This equation is same with longitudinal mass of Einstein[2] and Lorentz[3].

IV. DISCUSSION

Author thinks that essence of mass-energy equivalence is the relation between bodies and space. Relative kinetic energy $E_{rk} = mv^2$ has the same structure as energy $E = mc^2$, but the current derivation of mass-energy equation is out of energy and didn't correlate the structure of $E = mc^2$, so the relative kinetic energy of $E_{rk} = mv^2$ is suitable to define the energy of a body's motion. The theory of relative kinetic energy conforms to classical physics and relativity theory, and becomes the key to solve mass-energy equivalence and mass-velocity relation. It is logical to infer mass-energy equivalence and mass-velocity relation with relative kinetic energy.

For experiments to verify mass-velocity relation, the key is the charge-velocity relation of electron. Many researchers had studied this problem, and proposed several formulas. From the view of energy, author proposed the matching of electrons and electromagnetic fields to explain the charge-mass relation of electron, and determined the charge-velocity equation of electron. $Q_e = Q_{e0}\sqrt{1-v^2/c^2}$. This equation was also deduced with Maxwell equation[7] and with analyzing the motion characteristics of photons and electrons[8].

$m = m_0/\sqrt{1-v^2/c^2}$ and $m = m_0/(\sqrt{1-v^2/c^2})^3$ are the equivalent equations of using fixed charge instead of variable charge of electron in different occasions, which can prove the real mass-velocity relations and the charge-velocity equation of electron.

Author thinks that energy is the key to solve the problems for everything, and mass is the express of energy. For mass-velocity relation and charge-velocity relation, only considering the macroscopic velocity is not perfect. It is necessary to consider all changes of energy to ensure the calculation accuracy.

V. SUMMARY

The relative kinetic energy of mv^2 is the origin of mass-energy equivalence, which is suitable to solve the problems about mass-energy equivalence. After this paper, we can determine mass-velocity relation of $m = m_0/\sqrt{1-v^2/c^2}$ and electron's charge-velocity relation of $Q_e = Q_{e0}\sqrt{1-v^2/c^2}$. These determinations are of important significance for relativity theory and electrodynamics, even for superconducting research.

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