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A NEW STUDY ON THE ENERGY OF MICROSCOPIC PARTICLES CONCERNING ITS MATTER WAVES

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Abstract. *The volatility of microscopic particles has been verified by a lot of physical experiments. The moving microscopic particle is a type of matter waves, and we know that the volatility of some matter must contain corresponding wave energy, so the moving microscopic particles should contain energy of the volatility apart from kinetic energy and potential energy. Based on the wavelength formula of De Broglie and the hypothesis that microscopic particles contain the energy of matter waves, this paper deduces a new-form of energy formula of microscopic particles. On this basis, concerning the rectilinear motion and the common curvilinear motion, this paper builds a new-form formula of Newton's second law which describes the motion of microscopic particles, and puts forward some new concepts about microscopic particles, including the generalized momentum, generalized mass, Newton mass, motion inertia mass and the resistance to accelerated movement, and deduces corresponding formulas. According to the deduced formulas, there exists a strictly positive correlation between the generalized mass, Newton mass, motion inertia mass of microscopic particles and the square of kinematic velocity of microscopic particles. With the increasing of kinematic velocity of microscopic particles, the proportion of the energy of matter waves in the gross energy of microscopic particles increases, which inevitably makes it harder to speed up the microscopic particles. Finally, this paper presents an assumed experiment of accelerating charged particle to reach the superluminal level through adjusting the orientation of the electrostatic field.*
Keywords: Matter waves, Microscopic particles, Energy of matter waves, Motion equation, Special relativity

1. **Introduction.** The volatility is an important and basic attribute of microscopic particles and it is fully verified by interference experiments of electron current, proton current and neutron current. Meanwhile, the correctness of the wavelength formula of De Broglie is also verified. In the existing researches on the dynamics problems of microscopic particles, the calculation of the energy of microscopic particles is generally only concerned with the kinetic energy decided by mass and velocity, and the potential energy of microscopic particles is also considered when it comes to the case of motion of charged particles in the electric field. In this process, the energy of matter waves of moving particles is not considered. Even though the dynamics problems of microscopic particles are studied by the use of special relativity, the energy of matter waves is ignored. When researching the theory of the hydrogen spectrum, Bohr only uses the kinetic energy and potential energy of electrons to calculate the energy of the electron revolving around the nucleus. In various calculations of the modern high-energy particle acceleration experiment, physicists use the mass formula of Einstein's relativity theory, but do not consider the energy of matter waves. In the complex theory of quantum mechanics, various physical quantities describing microscopic particles do not contain the ones which are directly associated

with the energy of matter waves. According to the normal reasoning logic, since "microscopic particles in the state of motion have volatility" is an undisputed fact and that "the volatility with physical properties has energy" should be a reasonable assumption, not only their kinetic energy and potential energy, but also the energy of the volatility should be considered, when the computational formula of the energy of microscopic particles is built. The result inevitably leads to a new-form energy formula of microscopic particles. At the same time, the relationship between the force on the microscopic particle and the acceleration it produces must be closely related to its kinematic velocity.

According to the wavelength formula of De Broglie, the wavelength of matter waves is inversely proportional to the kinematic velocity of microscopic particles. Assume that the amplitude of matter waves of a microscopic particle does not change with its kinematic velocity, it can be imagined that when some external force acts on a microscopic particle and makes it in accelerated motion, with the kinematic velocity of the microscopic particles increasing, the energy of matter waves of the microscopic particle will increase because of the shortening of the wavelength (thus the frequency of matter waves increases). That is, part of the energy that the external force transfers to the microscopic particle is used to increase its kinematic velocity, and there must be another part of the energy to increase its wave energy. If the Newton's second law is still used in form to describe the motion of the microscopic particle under the action of the external force, it will be found that in a certain time, under the action of a known force, the particle does not achieve the desired velocity, because the work the external force has done on it is not entirely used to increase its kinetic energy. In the theory of special relativity, the particle does not achieve the desired velocity is because its inertial mass increases with the increase of its kinematic velocity. However, the viewpoints of this paper is that the increase of the particle's wave energy consumes part of the work the external force has done on the particle, which causes that the particle fails to achieve the desired velocity.

In this paper, the starting point of the research is to bring the energy of the matter waves of a microscopic particle into the calculation of the particle's energy, and then this paper will study the new motion equation which a moving particle satisfies. The research content of this paper is different from the classical Newton's laws of mechanics, the Einstein's relativistic mechanics and the theory of quantum mechanics. Although the research content of quantum mechanics includes the energy state of matter waves, the theory of quantum mechanics has given up on the descriptions of the particle's location, motional orbit and kinematic velocity. Therefore, in quantum mechanics, the motion equation decided by Newton's second law is no longer used to describe the particle's motion state under force. Most of the formulas derived in this paper are not found in existing physical theory. The interpretation of the physical meaning of these new formulas is not complete, and these new formulas need to accept the testing of the special designed particle acceleration experiment. The research methods used in this paper belong to the methods of the classical Newtonian mechanics.

In Section 2, the new-form energy formula containing the energy of matter waves of microscopic particles and the concept of the particle's motion inertia mass are introduced. In the classical formula of kinetic energy, the microscopic particle's formula of kinetic energy can be obtained by substituting its mass with its motion inertia mass. In Section 3, combined with the mass formula of Einstein's theory of relativity, the problems of motion inertia mass and the amplitude of matter waves of microscopic particles are discussed. In Section 4, the motion equation of microscopic particles in rectilinear motion is acquired by means of calculus tools, and it is a new form of Newton's second law for microscopic particles. In Section 5, different deformation derivations of microscopic particles' motion equation are done and the concepts of generalized momentum, generalized mass and

Newtonian mass are introduced. In Section 6, the concept of the resistance to accelerated motion is introduced, and the formula for the change of the particle's velocity over time is obtained, when the particle is under the force whose size and orientation are unchanged. In Section 7, the motion equation that microscopic particles in general curvilinear motion satisfy is deduced. In Section 8, an assumed physical experiment is given. Through the proposed experiment, charged microscopic particle may be accelerating faster than light speed. The last section is conclusion.

2. **The New-Form Energy Formula of Microscopic Particles.** No matter what is vibrating in matter waves of microscopic particles, the interference effect of the vibration can be measured. Therefore, matter waves are a sort of physical vibration, and that the vibration of matter waves has energy should be an undisputed fact. That uncharged microscopic particles have volatility is the experimental fact, so the energy of matter waves of microscopic particles cannot be simply boiled down to electrical properties or magnetic properties. Modeled on the energy formula of the mechanical vibration of the harmonic oscillator, it can be assumed that the wave energy of a microscopic particle is proportional to its mass and to the square of its vibration frequency. This assumption should be reasonable. A moving microscopic particle is metaphorically a bullet shot from the rifle, the high-speed bullet pivots quickly on its flight direction. Hence, this bullet has not only kinetic energy but also rotational energy. The faster its muzzle velocity is, the faster its rotational velocity is, and then the greater its rotational energy is. The kinetic energy of the bullet is just part of its mechanical energy.

In this paper, it is assumed that matter waves of microscopic particles are produced when microscopic particles are in motion as well as in the state of some mechanical vibration. According to the energy formula of harmonic oscillator, it can be assumed that the energy formula of microscopic particles' volatility is:

$$E_{wave} = \frac{1}{2} m\omega^2 A^2 \tag{1}$$

In this formula, m is the mass of a microscopic particle, ω is the angular frequency of the volatility, and A is the amplitude. The physical meaning and value of the amplitude A need discussion. The energy Formula (1) is only used in form.

Suppose that a microscopic particle is moving in a vacuum space where there is not any force field, its velocity is presented by V, and the increment of its energy only includes the increment of kinetic energy and the increment of vibration energy of matter waves. The particle's energy is presented by E, and E is the function of m, V, ω, A. So we have:

$$E = \frac{1}{2} mV^2 + E_{wave} = \frac{1}{2} mV^2 + \frac{1}{2} m\omega^2 A^2 \tag{2}$$

According to the theory of matter waves of De Broglie, there is:

$$\lambda = \frac{h}{mV} \tag{3}$$

In this formula, h is Planck constant, and λ is the wavelength of matter waves. The relationship between the angular frequency ω and λ is that $\omega = 2\pi V/\lambda$. After Formula (3) is substituted into it, it is obtained that $\omega = 2\pi mV^2/h$. This formula is substituted into Formula (2), and then it can be rewritten as:

$$E = \frac{1}{2} m \left(1 + \left(\frac{2A\pi mV}{h}\right)^2\right) V^2 \tag{4}$$

Formula (4) is a new energy formula of microscopic particles. It is not hard to see that the energy of microscopic particles contains not only V^2 but also V^4. The expression (4) is similar to the kinetic energy formula of microscopic particles. Noting:

$$m_i = m\left(1 + \left(\frac{2A\pi mV}{h}\right)^2\right)$$

m_i is called the motion inertia mass of microscopic particles, and then the expression (4) can be rewritten as the same as the classical formula of kinetic energy:

$$E = \frac{1}{2}m_i V^2 \tag{5}$$

It is worth noting that m_i is related to the square of kinematic velocity V^2 of microscopic particles.

3. **Discussion about the Motion Inertia Mass m_i and the Amplitude of Matter Waves.** It is known that part of the work that external force has done on a microscopic particle is used to increase the energy of its matter waves. However, if the motion of the microscopic particle is only regarded as a rigid motion without rotation or vibration, and we want the form of the formula of kinetic energy stays the same, then the mass of the microscopic particle must be m_i. There is a strictly positive correlation between m_i and the square of the microscopic particle's kinematic velocity (V^2), which is similar to the conclusion of the mass formula of Einstein's relativity theory.

In Einstein's special relativity, there is a relativity mass formula $m_A = m_0/\sqrt{1-(V/C)^2}$. m_0 is the rest mass of a microscopic particle and C is the light speed. The greater V is, the greater m_A is. When $(V/C)^2$ much less than 1, there is an approximate expression $m_A \approx m_0(1 + V^2/(2C^2))$. It can be seen that the approximate expression of m_A is similar to the expression of m_i.

The relations between the matter wave's amplitude A and the microscopic particle's mass m and velocity V are important, but people know little of those. The mass formula of Einstein's relativity theory has been verified by a large number of physical experiments. When V much less than the light speed, a reasonable assumption is that m_i is equal to m_A because correct energy value can be obtained by using $\frac{1}{2}m_A V^2$ in Einstein's relativity theory. However, in this paper, under the hypotheses that the energy of a microscopic particle contains the energy of matter waves, the energy formula of the particle is $\frac{1}{2}m_i V^2$. It is obvious that $\frac{1}{2}m_A V^2 = \frac{1}{2}m_i V^2$ is tenable. It is noted that in the expression of m_i, m is the mass of the particle, of course m is the rest mass m_0, that is $m = m_0$. The expression m_i is contrasted with that of m_A, and there is:

$$1/(2C^2) = (2A\pi m)^2/h^2 \tag{6}$$

The left side of expression (6) is a constant, and in its right side, π and h are both constants. This expression shows that the matter wave's amplitude A is inversely proportional to the microscopic particle's mass m, and is irrelevant to the microscopic particle's velocity V. We assume that for all microscopic particles the expression (6) is always tenableno matter how great the mass of a microscopic particle is and no matter how great the velocity of a microscopic particle is. This means that the product of the amplitude of a microscopic particle's matter waves and its mass is a constant. It is easily acquired from the expression (6):

$$A = \frac{h}{2\sqrt{2}\pi C m}$$

For electrons, it is easily to obtain that $A = 0.273\times 10^{-12}m$, but the physical significance of this value is still unknown. The condition for the establishment of the expression (6) is that the mass formula of Einstein's relativity theory: $m_A = m_0/\sqrt{1-(V/C)^2}$ is tenable. For a microscopic particle whose mass is much less than an electron, like neutrino, according to the expression (6), the amplitude of neutrino's matter waves will be many times larger than that of electrons; likewise, for proton and neutron, their mass is many times larger than that of electrons, so the amplitude of the corresponding matter waves is many times less than that of electrons; for macroscopic objects, m in the expression (6) will become the maximum value, so the amplitude A become minimum, which means the motion of macroscopic objects can completely leave out the problem of matter waves.

According to the expression (6), the inertia mass formula and kinetic energy formula can be written out in a more brief way:

$$m_i = m\left(1+\frac{V^2}{2C^2}\right)$$
$$E = \frac{1}{2}m\left(1+\frac{V^2}{2C^2}\right)V^2$$

It is known that the fundamental assumption of Einstein's special relativity is the principle of constancy of light velocity, and that the relativistic mass formula of a microscopic particle is deduced according to this assumption. The energy Formula (4) of a microscopic particle deduced in this paper does not need this assumption, the conclusion that there is a strictly positive correlation between m_i and the square of microscopic particles' kinematic velocity is also derived. Whether or not this conclusion implies some more profound physical meanings is still unclear.

4. **The Motion Equation of Microscopic Particles in Rectilinear Motion.** Assume that a microscopic particle is in rectilinear accelerated motion under an external force, and that from the moment 0 to T, the microscopic particle moves from the position 0 to S, and its velocity increases from 0 to V_0. W is used to present the work the external force has done in this process, $V(t)$ is used to present the particle's velocity at the moment t, $x(t)$ presents the position of the particle at the moment t, and $F(t)$ presents the value of the external force whose direction is the same as that of the particle's motion direction. And we have $x'(t) = V(t)$, $V(t)dt = dx(t)$. For the convenience of deduction, it is denoted as $\delta = \left(\frac{2A\pi m}{h}\right)^2$. According to the expression (4), there is:

$$W = \frac{1}{2}m(1+\delta V_0^2)V_0^2 = \int_0^T \frac{d}{dt}\left(\frac{1}{2}m(1+\delta V^2)V^2\right)dt = \int_0^T m(1+2\delta V^2)\frac{dV}{dt}V\,dt \tag{7}$$

Because $V dt = dx$, the expression (7) can be rewritten as:

$$W = \int_0^S m(1+2\delta V^2)\frac{dV}{dt}dx$$

And because:

$$m(1+2\delta V^2)\frac{dV}{dt} = \frac{d}{dt}\left(mV + \frac{2}{3}m\delta V^3\right)$$

There is:

$$W = \int_0^S \frac{d}{dt}\left(mV+\frac{2}{3}m\delta V^3\right)dx = \int_0^S \frac{d}{dt}\left(m\left(1+\frac{2}{3}\delta V^2\right)V\right)dx \tag{8}$$

According to the definition of work, the work of a variable force $Q(x)$ does is $W = \int_0^S Q(x)dx$. $\frac{d}{dt}\left(m\left(1+\frac{2}{3}\delta V^2\right)V\right)$ in the expression (8) should be the external force placed on a microscopic particle at the moment t in the position $x(t)$. This external force is the function of x and x is the function of t, so the expression in the sign of integration of the expression (8) is the function of t, which is $F(t)$. The new form of Newton's second law describing the motion of a microscopic particle is obtained as follows:

$$F(t) = \frac{d}{dt}\left(m\left(1+\frac{2}{3}\left(\frac{2A\pi mV}{h}\right)^2\right)V\right) \tag{9}$$

In Formula (9), V is the value of the particle's velocity and is not a vector but a scalar, and $F(t)$ is the value of the force placed on the particle and is also a scalar.

According to the expression (6), the new form of Newton's second law can be rewritten as:

$$F(t) = \frac{d}{dt}\left(m\left(1+\frac{V^2}{3C^2}\right)V\right)$$

5. **Several Discussions about the Motion Equation of Microscopic Particles in Rectilinear Motion.** Here, the expression (9) will be analyzed from different angles. If the expression (9) is consistent with the classical form of Newton's second law, then in the expression (9), $m\left(1+\frac{2}{3}\left(\frac{2A\pi mV}{h}\right)^2\right)V$ behind the sign of differentiation should be the momentum of microscopic particles, we call $m\left(1+\frac{2}{3}\left(\frac{2A\pi mV}{h}\right)^2\right)V$ the generalized momentum and presented by p_g. p_g is a scalar, and there is:

$$p_g = m\left(1+\frac{2}{3}\left(\frac{2A\pi mV}{h}\right)^2\right)V \tag{10}$$

According to the definition that momentum is the product of mass and velocity, it is stipulated that the generalized momentum is the product of generalized mass and velocity. m_g is used to present the generalized mass of a microscopic particle, and let:

$$m_g = m\left(1+\frac{2}{3}\left(\frac{2A\pi mV}{h}\right)^2\right) = m\left(1+\frac{V^2}{3C^2}\right) \tag{11}$$

The expression of generalized momentum of microscopic particles is:

$$p_g = m_g V = m\left(1+\frac{V^2}{3C^2}\right)V$$

The expression (9) can be rewritten as:

$$F(t) = \frac{d}{dt}(m_g V) = \frac{d}{dt}p_g \tag{12}$$

From the definition Formula (11), it can be observed that m_g is proportional to the square of V and that m_g is slightly different from m_i. The expression (12) has the same form as the classical Newton's second law, and m_g is the function of V.

After the derivative of the expression (9) is solved, the expression (9) can also be rewritten as:

$$F(t) = m\left(1+2\left(\frac{2A\pi mV}{h}\right)^2\right)\frac{dV}{dt}$$

$\frac{dV}{dt}$ is the acceleration, so the coefficient $m\left(1+2\left(\frac{2A\pi mV}{h}\right)^2\right)$ in front of $\frac{dV}{dt}$ should be some mass and it is denoted as:

$$m_n = m\left(1+2\left(\frac{2A\pi mV}{h}\right)^2\right) = m\left(1+\frac{V^2}{C^2}\right) \tag{13}$$

m_n is called the Newtonian mass, and again the expression (9) can be rewritten as:

$$F(t) = m_n\frac{dV}{dt} = m\left(1+\frac{V^2}{C^2}\right)\frac{dV}{dt} \tag{14}$$

The expression (14) also has the same form as the classical Newton's second law and m_n is the function of V.

If generalized mass m_g is used as the mass of a microscopic particle, the form of Newton's second law $F(t) = \frac{d}{dt}(m_gV)$ can be kept. If Newtonian mass m_n is used as the mass of a microscopic particle, the form of Newton's second law $F(t) = m_n\frac{dV}{dt}$ can be kept. If motion inertia mass m_i is used as the mass of a microscopic particle, the form of kinetic energy formula $E = \frac{1}{2}m_iV^2$ can be kept. Expressions of m_g, m_n, m_i are not exactly the same.

6. **Research on the Law of Accelerated Motion Based on the Equation of Rectilinear Motion.** Hereinafter, the relation between Formula (9) and the classical Newton's laws is discussed. According to Formula (14), there is:

$$F(t) = m\left(1+2\left(\frac{2A\pi m}{h}\right)^2 V^2\right)\frac{dV}{dt}$$

After it is expanded and rewritten, it is obtained that:

$$F(t) - 2m\left(\frac{2A\pi m}{h}\right)^2 V^2\frac{dV}{dt} = m\frac{dV}{dt} \tag{15}$$

In form, Formula (15) is the motion equation when the force $F(t)$ overcomes the resistance $2m\left(\frac{2A\pi m}{h}\right)^2 V^2\frac{dV}{dt}$ and acts on the object whose mass is m. The use of Formula (15) can enable people to leave out the change of the mass of particles, and to equivalently study the motion law when the particle is stressed through the kinetic resistance. It is denoted as:

$$f(t) = 2m\left(\frac{2A\pi m}{h}\right)^2 V^2\frac{dV}{dt} = m\left(\frac{V}{C}\right)^2\frac{dV}{dt} \tag{16}$$

$f(t)$ is called the particle's resistance to accelerated motion. According to the expression (16), when the particle's linear acceleration $\frac{dV}{dt}$ is zero, no matter what the value of V is, $f(t)$ is zero. In addition, the resistance $f(t)$ is proportional to $V^2\frac{dV}{dt}$ and m. If $f(t)$ is regarded as a resistance, Formula (15) indicates that Newton's second law keeps the original form:

$$F(t) - f(t) = m\frac{dV}{dt} \tag{17}$$

Or it can be written as:

$$F(t) - m\left(\frac{V}{C}\right)^2\frac{dV}{dt} = m\frac{dV}{dt}$$

According to Formula (15), when $F(t) > 0$, there are $\frac{dV}{dt} > 0$ and $f(t) > 0$ in which $f(t)$ hinders the particle's accelerated motion; when $F(t) < 0$, there are $\frac{dV}{dt} < 0$ and $f(t) < 0$ in which $f(t)$ hinders the particle's decelerated motion.

Hereinafter, we study the change law of the velocity of a microscopic particle under some constant force. Suppose there is a constant force F whose size and orientation are unchanged. According to Formula (14), there is:

$$\frac{dV}{dt}=\frac{F}{m\left(1+\left(\frac{V}{C}\right)^2\right)}$$

When the particle's velocity V is greater, $m\left(1+\left(\frac{V}{C}\right)^2\right)$ is greater. Under the constant force F, the acceleration $\frac{dV}{dt}$ will decrease with V increasing.

According to the expression (9), there is:

$$Fdt=d\left(m\left(1+\frac{1}{3}\left(\frac{V}{C}\right)^2\right)V\right)$$

After this expression is integrated, the algebraic equation of the particle's velocity $V(t)$ is acquired:

$$V(t)\left(1+\frac{1}{3}\left(\frac{V(t)}{C}\right)^2\right)=\frac{F}{m}t \tag{18}$$

The analytical expression of the particle's velocity $V(t)$ can be derived from the root of cubic Equation (18) with one unknown and there is:

$$V(t)=C^{\frac{2}{3}}\left(\sqrt[3]{\frac{3Ft}{2m}+\sqrt{\left(\frac{3Ft}{2m}\right)^2+C^2}}+\sqrt[3]{\frac{3Ft}{2m}-\sqrt{\left(\frac{3Ft}{2m}\right)^2+C^2}}\right) \tag{19}$$

Hereinafter, taking an electron for an example, the curve of the velocity is calculated when an electron is accelerated in an electrostatic field. Suppose that the electric field intensity of the accelerating field is $E=10^4$ N/C, the electron's mass is $m=9.1\times10^{-31}$ kg, electric quantity of an electron is $q=1.6\times10^{-19}$ C. The force F acting on the electron in the electrostatic field is $F=E\cdot q=1.6\times10^{-15}$ N, and the ratio of the force and the electron's mass is $F/m=1.8\times10^{15}$. After those value is substituted into the expression (19), the curve of the velocity is calculated when the electron is accelerated in the electrostatic field.

In Figure 1, the abscissa axis presents time whose unit is 0.5×10^{-9} s, and the ordinate axis presents velocity whose unit is 10^8 m/s. The straight line is $V(t)=\frac{F}{m}t$, and the curve is the one that the expression (19) presents. The slope of the curve's tangent monotonously decreases indicates that the acceleration of the electron monotonously decreases.

7. The Motion Equation that a Microscopic Particle in Curve Motion Satisfies.

In this section, the motion equation is discussed on condition that the direction of force and motion direction of a microscopic particle are unlimited. In classical Newtonian mechanics, $\boldsymbol{p}$ is used to present the momentum of a material particle, $\boldsymbol{V}$ is velocity, $\boldsymbol{x}$ is position, $\boldsymbol{F}$ is the force acting on it, and m is mass. $\boldsymbol{p}$, $\boldsymbol{V}$, $\boldsymbol{x}$ and $\boldsymbol{F}$ are all vectors of three-dimensional space. The following Newton's second law is tenable:

$$\boldsymbol{F}=\frac{d}{dt}\boldsymbol{p}$$

Owing to $\boldsymbol{p}=m\boldsymbol{V}$, Newton's second law can be rewritten as $\boldsymbol{F}=m\frac{d\boldsymbol{V}}{dt}$. Because of $\boldsymbol{V}=\frac{d\boldsymbol{x}}{dt}$, Newton's second law can also be rewritten as $\boldsymbol{F}=m\frac{d^2\boldsymbol{x}}{dt^2}$.

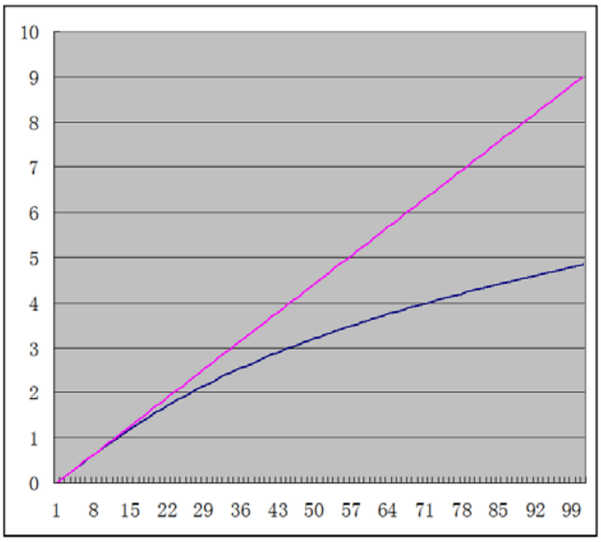

FIGURE 1. The curve of the velocity when an electron is accelerated in an electrostatic field

In the theory of Einstein's relativity, the mass of matter is related to its velocity, and the momentum $\boldsymbol{p}$ is $m\boldsymbol{V}/\sqrt{1-V^2/C^2}$. Newton's second law can be rewritten as the following form:

$$\boldsymbol{F} = \frac{d}{dt}\boldsymbol{p} = \frac{d}{dt}\frac{m\boldsymbol{V}}{\sqrt{1-V^2/C^2}}$$

Hereinafter, based on the assumption that the matter waves of a microscopic particle have energy, the energy Formula (4) of a microscopic particle hold, the corresponding motion equation is deduced. Assume that a microscopic particle is in curvilinear motion under the external force $\boldsymbol{F}$, and that from the moment 0 to T the particle moves from the position $\boldsymbol{x}(0)$ to $\boldsymbol{x}(T)$, and its velocity increases from 0 to V_0. W presents the work that the external force has done on the particle in the process, $\boldsymbol{V}(t)$ is the velocity vector at the moment t, $\boldsymbol{x}(t)$ is the position vector at the moment t, and $\boldsymbol{F}(\boldsymbol{x}(t))$ is the external force vector at the moment t. $\boldsymbol{x}'(t) = \boldsymbol{V}(t)$, $\boldsymbol{V}(t)dt = d\boldsymbol{x}(t)$. For the convenience of deduction, it is denoted as $\delta = \left(\frac{2A\pi m}{h}\right)^2$. According to Formula (4), there is:

$$W = \frac{1}{2}m(1+\delta V_0^2)V_0^2 = \int_0^T \frac{d}{dt}\left(\frac{1}{2}m(1+\delta\boldsymbol{V}\cdot\boldsymbol{V})\boldsymbol{V}\cdot\boldsymbol{V}\right)dt$$

$\boldsymbol{V}\cdot\boldsymbol{V}$ presents the dot product of the vector $\boldsymbol{V}$ with its self. Because $\frac{d}{dt}(\boldsymbol{V}\cdot\boldsymbol{V}) = 2\frac{d\boldsymbol{V}}{dt}\cdot\boldsymbol{V}$, there is:

$$W = \int_0^T m(1+2\delta\boldsymbol{V}\cdot\boldsymbol{V})\frac{d\boldsymbol{V}}{dt}\cdot\boldsymbol{V}dt$$

Because $\boldsymbol{V}dt = d\boldsymbol{x}(t)$, this expression can be rewritten as:

$$W = \int_{\boldsymbol{x}(0)}^{\boldsymbol{x}(T)} m(1+2\delta\boldsymbol{V}\cdot\boldsymbol{V})\frac{d\boldsymbol{V}}{dt}\cdot d\boldsymbol{x}(t) \tag{20}$$

In accordance with the definition of work, from position $\boldsymbol{x}(0)$ to $\boldsymbol{x}(T)$ the work that the variable force $\boldsymbol{F}(\boldsymbol{x}(t))$ has done is:

$$W = \int_{\boldsymbol{x}(0)}^{\boldsymbol{x}(T)} \boldsymbol{F}(\boldsymbol{x}(t)) \cdot d\boldsymbol{x}(t) \tag{21}$$

The expression (20) is compared with the expression (21), we know that the integrated term in the expression (20) is the force acting on the particle. The following motion equation that the microscopic particle in curve motion satisfies is tenable:

$$\boldsymbol{F}(\boldsymbol{x}(t)) = m(1 + 2\delta \boldsymbol{V} \cdot \boldsymbol{V}) \frac{d\boldsymbol{V}}{dt} \tag{22}$$

In the expression (22), $m(1 + 2\delta \boldsymbol{V} \cdot \boldsymbol{V})$ is the Newtonian mass that the expression (13) defines and there is:

$$\boldsymbol{F}(\boldsymbol{x}(t)) = m_n \frac{d\boldsymbol{V}}{dt}$$

Generally, let:

$$m_n \frac{d\boldsymbol{V}}{dt} = m(1 + 2\delta \boldsymbol{V} \cdot \boldsymbol{V}) \frac{d\boldsymbol{V}}{dt} = \frac{d}{dt}(m_g \boldsymbol{V}) \tag{23}$$

It is expected to obtain a simple expression of m_g. If expression (23) exists, m_g is a sort of generalized mass and $m_g \boldsymbol{V}$ is a sort of generalized momentum. There is:

$$\frac{d}{dt} m_g \boldsymbol{V} = \frac{dm_g}{dt} \boldsymbol{V} + m_g \frac{d\boldsymbol{V}}{dt}$$

The expression (23) indicates that $\frac{d}{dt} m_g \boldsymbol{V}$ is parallel to the vector $\frac{d\boldsymbol{V}}{dt}$. This expression shows that either $\frac{dm_g}{dt} = 0$ or $\boldsymbol{V}$ is parallel to $\frac{d\boldsymbol{V}}{dt}$. Under other situations, it is impossible that the expression (23) is tenable. That $\boldsymbol{V}$ is parallel to $\frac{d\boldsymbol{V}}{dt}$ means that the microscopic particle is in rectilinear motion and that the direction of force is parallel to its motion direction, which is the same as the situation in Section 4. $\frac{dm_g}{dt} = 0$ means m_g stays the same, which ought to indicate that the microscopic particle is in uniform motion. At this time $\boldsymbol{V} \cdot \boldsymbol{V}$ is a constant. $\frac{d\boldsymbol{V} \cdot \boldsymbol{V}}{dt} = 2\boldsymbol{V} \cdot \frac{d\boldsymbol{V}}{dt}$, so if $\boldsymbol{V} \cdot \boldsymbol{V}$ is constant, there must be $\boldsymbol{V} \cdot \frac{d\boldsymbol{V}}{dt} = 0$. It is easy to verify that when $\boldsymbol{V} \cdot \frac{d\boldsymbol{V}}{dt} = 0$, the following expression is tenable:

$$m(1 + 2\delta \boldsymbol{V} \cdot \boldsymbol{V}) \frac{d\boldsymbol{V}}{dt} = \frac{d}{dt}\left(m\left(1 + \frac{2}{3}\delta \boldsymbol{V} \cdot \boldsymbol{V}\right)\boldsymbol{V}\right)$$

It is denoted as:

$$m_g = m\left(1 + \frac{2}{3}\delta \boldsymbol{V} \cdot \boldsymbol{V}\right)$$

m_g is called the generalized mass of a microscopic particle and $\boldsymbol{p}_g = m_g \boldsymbol{V}$ is its generalized momentum. At this time, the following motion equation is tenable:

$$\boldsymbol{F} = \frac{d}{dt} \boldsymbol{p}_g = \frac{d}{dt} m_g \boldsymbol{V} \tag{24}$$

Equation (24) is the motion equation that the microscopic particle with a constant speed satisfies. At this time, the external force acting on the particle is perpendicular to its motion direction.

If the value of $\boldsymbol{V}$ is changing over time and $\boldsymbol{F}$ is not parallel to $\boldsymbol{V}$, the generalized mass m_g in Equation (24) cannot be defined, neither is $\boldsymbol{p}_g = m_g \boldsymbol{V}$. At this time, the motion Equation (22) must be used.

8. **An Assumed Experiment of Accelerating Charged Particle to Make Its Speed Faster than Light Speed.** If all the time a microscopic particle is under the force whose size and orientation are unchanged, in accordance with the laws of classical Newtonian mechanics, the velocity of the particle will be the linear function of the time t and will increase without limit. According to Formula (19) deduced in the paper, the velocity of the particle will also increase without limit, which obviously does not conform to the theory in modern physics that light speed is the upper limit of the relative velocity of objects. In fact, the discussion in this paper includes many things unclear. In the physical world, it cannot be confirmed whether a way exists or not in which a sort of force with unchanged size and orientation can act on a microscopic particle all the time. Even if for the charged electron in the uniform electric field, the viewpoint of asserting that the charged electron is still under the force which is calculated by the theory of electrostatic field when its velocity is close to light speed is questionable. As for the research content of this paper, the amplitude of matter waves may not be strictly inversely proportional to the mass of a microscopic particle when the particle's velocity is close to light speed, which is inconsistent with the assumption in this paper. The research content of this paper is suitable for the situation where the velocity of a microscopic particle is much less than light speed.

Hereinafter, a bold assumption to make the velocity of a charged electron faster than light speed is discussed. Superluminal motion has become an important problem in theoretical physics. Many physicists hold that people should not be restrained by the theory that light speed is the upper limit of the relative velocity of objects. It is known that the propagation velocity of electromagnetic waves is light speed and that the rate of electromagnetic interaction is also light speed. Assume that the motion direction of a charged particle is the same as the direction of the electric field, and a moving charged particle goes through the electrostatic field, if the velocity of the charged particle is less than light speed, the electric field will thrust the charged particle. If the velocity of the charged particle has reached light speed, and the electric field will still thrust the charged particle, this means the rate of electromagnetic interaction is greater than light speed, which does not conform to the known property of the electromagnetic interaction.

Suppose that there is a sailing ship sailing in the calm sea, whose velocity is V, that the wind velocity of this moment is also V and that the wind direction is strictly the same as the normal of the sail. It can be asserted that wind cannot accelerate the sailing ship, just like electrostatic field cannot accelerate the charged particle which has reached light speed. However, there is another situation where the wind with a slower speed can actually thrust and accelerate the sailing ship with a faster speed; the only requirement is to adjust the direction of the sail to make the velocity component of the sailing ship's velocity vector in the wind direction which is slower than wind speed. Analogously, perhaps people can use electrostatic field to accelerate a charged particle to make its velocity much faster than light speed.

As shown in Figure 2, E presents the electric field direction, the direction of the vector AC is the motion direction of the positively charged particle, the length of the vector AC presents the velocity of the charged particle, the dot A is the position of the charged particle, and the length of AB is the projection of the vector AC in the direction of electric field direction E. It is guessed that only if the length of AB is less than that of light speed, the electric field E will thrust the charged particle to increase V by adjusting the included angle between the direction of E and that of the vector AC. Because the direction of the force is inconsistent with the motion direction, on the one hand the velocity of the charged particle will increase, but on the other hand its motion direction will change. The above-mentioned speculation is based on the following assumption: in the direction

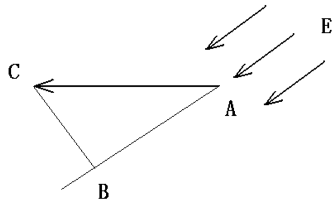

FIGURE 2. Sketch map of electric field direction and the motion direction and velocity of the charged particle

of the electric-field intensity vector, if the projection velocity of the charged particle is less than light speed, the electric field will exert a force on the charged particle. In an existing cyclotron, the accelerating field may be designed to have an included angle with the motion direction of a charged particle, for example the included angle can be 45°. According to trigonometric function relationship, the velocity of the charged particle can be accelerated to be 1.414 times the speed of light. The result of this experiment will verify whether a charged particle can be accelerated to be faster than light speed or not.

9. **Conclusion.** Based on the hypothesis that microscopic particles contain the energy of matter waves, this paper deduces a new-form energy formula of microscopic particles and builds a new form of the formula of Newton's second law which describes the motion of microscopic particles, including the motion equations of microscopic particles in rectilinear motion and in general curvilinear motion. By analyzing these new-form formulas and combining the concept and methods of classical mechanics, this paper puts forward concepts of generalized momentum, generalized mass, Newton mass, motion inertia mass and the resistance to accelerated movement, and deduces corresponding formulas for these concepts. Combining the mass formula of Einstein's relativity, this paper also discusses related problems of the amplitude of matter waves. According to the deduced formulas, with the kinematic velocity of microscopic particles increasing, the proportion of the energy of matter waves in the gross energy of microscopic particles increases, which inevitably makes it harder to speed up the microscopic particles. Based on the hypothesis that matter waves contain energy, the conclusion is drew that there is a strictly positive correlation between the mass (including generalized mass, Newton mass and motion inertia mass) and the squared of kinematic velocity of microscopic particles. And this conclusion has no demand for the hypothesis that the light speed is the upper limit speed of objects. Finally, this paper presents an assumed experiment of accelerating charged particle to reach the superluminal level by the use of the electrostatic field.

This study is carried out based on generally accepted theories in physics, but the question brought forward in this paper is significant, fire-new and uncared-for. The theories and experimental facts quoted in this paper are all of great acquaintance to physicists, and the references should be those physics literature generally accepted by them, so the author believes that it is not necessary to list a series of references for this paper.

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