

Thinking About the Concept of Matter

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Abstract: The concept of matter is examined in plain nature-views; emphasize the identity of mass and energy; the intrinsic property of matter is electromagnetics; and the principle of constancy of light velocity is ubiquitous. For the above understanding of matter, reconsider the concept of force, hereby consolidate the fundamental relations between energy, inertial mass and gravitational mass, force, and momentum in mechanics.

Key words: matter; inertia; energy; mass; relativity

1 The concept of matter

The understanding of the concept of matter can be broadly divided into two types on philosophical sense and physical meanings. Through the human visual, olfactory, tactile and other methods are intuitive perceptions; the detection for matter by physical or chemical methods, is the indirect perception, also proved to be in existence of matter. Apparently, the abilities of consciousness reflecting a material depend on the development of science and technology, human cognition on existence is of endless.

Along with the progress of science and technology, men's cognition on matter are deepening, the philosophical and physical meaning of matter will get unity from form to content. For general meanings, matter is a kind of existence, in appearance, it occupy a certain space, and has the exclusiveness, i.e. impenetrability.

The impenetrability means, that when the space occupied by an object are intruded by others, it will cause in changes of the object's characters. Because the action is mutual, its own characters of the intrusive object also will be changed simultaneously in causing changes of the characters of the intruded object. The meanings of invasion here, is not only refers to the conflicts between the matters that can be detected by our sense organs, but also include indirect detections, that is to say the physical and/or chemical characteristic changes of matters detected by scientific instruments.

From the above, we can suggest that the state changes of matter must be accompanied by energy exchange. So we must admit that the energy (in whatever forms) is also a kind of existence. Energy has all the features of matter, the so-called matter, by its very nature, is energy.

The unity of the two conservative laws of energy and mass in the theory of relativity, is a great leap for understanding the concept of matter. It points out the mass-energy equivalence, and the quantitative relationship between mass and energy, that is $E = mc^2$, where m is believed to be the inertial mass of the matter. Thus, Einstein had been aware of "The inertial mass of a system of bodies can even be regarded as a measure of its energy".^[1] Actually, there have been unmistakably indicated all the contents matter contains. That a matter can be regarded as a matter is in its energy aggregation. It can be perceived by others, conflicts between them, the results of the conflicts or interaction is the transfer of energy, or exchange energy between them. Matter is a representation of its own energy, no energy is gathered no matter. It can only be perceived as it can interact with others. There is no matter that would not interact

with others.

The amount of an object's original measuring, is namely weight or heaviness, derived from the gravitational mass. Here, we can clearly be abandoned the concept of mass completely, the only measuring of the amount of a substance is energy.

At least, energy has the following characteristics: ① Spatial property. It occupied a certain space, and has the exclusiveness or impenetrability. ② Additivity. Energy in quantity are additive, it is the requirement of the fundamental rule of energy conservation. ③ Cohesion. This is the foundation of a substance to be itself, and the natural requirement for existence. Otherwise, there would be no distinct things, movement will not occur. Though under certain conditions, mass can be used instead of energy for calculations, but fundamentally speaking, the concept of mass here can be completely abandoned, and will not affect our calculation.

2 Energy Conservation

Entities in the phenomenon of all changes remain in existence, its quantity in nature is neither increasing nor decreasing. Creating and vanishing is not the changes of creating and vanishing things itself. Change is a kind of mode of entity, it followed another mode of entity of the same object. Therefore, all the changing things are retained, but its status changed.^[2] Having no exchanging with externals, no substance (or energy) can increase or decrease, the object does not change with time, being in existence eternally. That is energy conservation law:

$$\frac{dE}{dt} = 0 \quad (1)$$

For n systems in which energy transfers between them, formula (1) can be written as:

$$\sum \frac{dE_i}{dt} = 0 \quad (2)$$

That is to say, the physical world is eternal, by now the state can be inferred from the past that is the case, the future will continue to be so.

The essence of a substance is energy, no matter can exists if there is no energy. The temperature is a macro measurement of an object's inside micro motion state. As the temperature of an object is lowered, its internal energy is reduced gradually, absolute zero means that the energy is completely lost, so the original object is completely dissolved and ceased to exist. But it does not mean that the object had vanished, it just be converted into other forms of energy. The temperature of an object can not achieve absolute zero, means that the objects can not be the one that isn't itself. At absolute zero, i.e. absolute vacuum, talking about the existence of matter (or temperature) is meaningless.

Setting a temperature or environmental condition, corresponds to a stable matter's existence status. Modern experimental physics has revealed many microscopic particles in existence, as can be expected, with advancing the abilities of extreme conditions of human could made, more new particles will be discovered. Due to restriction of the human's condition itself, new particle exploration has not an end point.

3 The electromagnetic properties of matter

Matter (energy) exists, means in a particular time, the changes concentrated in a certain region of space. "Since according to our present conceptions the elementary particles of matter are also, in their essence, nothing else than condensations of the electromagnetic field" 错误！未找到引用源。 . The electromagnetic field is the most basic elements which compose the matter. It exists in two forms: free state, i.e. we currently know electromagnetic waves; another is in self restraint, or coiled state, thereby forming a variety of particles. By recognizing the particle composition properties, quantized energy level phenomenon comes naturally.

Matter is the unity constructed by field in space and time. The motion of electromagnetic waves in space can't cease, electromagnetic field of space is unfettered free field. Microscopically, particle is a kind of electromagnetic structure bound in a smaller scale, the electromagnetic waves intertwined, forming a three-dimensional surrounding motion. If the internal three-dimensional motion is equal probability, particle has no spin, otherwise, will appear spin property. (It should be noted here that the particle's physical structure is not given.)

If the velocity of light is invariable, it can be inferred that the moving speed of an object can not exceed the speed of light. In other words, the movement of an object itself cannot be surpassed by its own.

Double slit electron diffraction experiment is a very good description of particle's electromagnetic properties. Even if electrons passed a double slit one by one separately, also can produce interference pattern, wanting to know which gap the electron went through is obviously useless, and also meaningless. In order to illustrate the electromagnetic properties of matter, the current electronic double slit diffraction experiment can be improved as follows: *In the current position of receiving screen, one more double slit is set, electrons undergoing two times interference project to a screen. The strips of last interference pattern observed should be limited or single stripe. And this is to illustrate that the behavior of an electron at a particular moment is only determined by its state.*

Anaximander, the second philosopher of the Ancient Greek Milesian school, he held that all things come from a single primal substance, It is infinite, eternal. ^[3] However this may be, Plato and Aristotle agree that Heraclitus taught that "nothing ever is, everything is becoming" (Plato), and that "nothing steadfastly is" (Aristotle). ^[5]

Here again, we consider the impenetrability of matter, namely the two objects cannot occupy the same space at the same time. The particle radius that can be regarded as its impenetrability, refers to how can other object reach inside the particle without destructing its integrity. It should be beginning with intuitionistic sense perception for apperceiving an object. For example, a pebble, having a relatively fixed shape (or appearance), occupy the space in a certain position, where another pebble can't be placed in, we say it has strong exclusiveness. If the pebble is replaced by a resilient rubber in the same shape, another pebble is likely to squeeze the rubber and occupy a more close position to the center of the pebble, which explains its exclusiveness decreased.

In special cases, visible light cannot pass through a pebble, therefore, the pebble to visible light is impenetrable. For transparent glass, although light can pass through it, but the route has changed to zigzag due to refraction. That means interaction (in electromagnetics) occurred between them. Hence, strictly speaking, glasses also have impenetrability to light.

Constant speed of light not only refers to super speed of light, in fact, it can not move in less than the speed of light in vacuum. The speed reduction of light through a medium is a macroscopic effect but not its essence. Light propagating in the medium barricaded by the inside particles of medium, have to “circumambulate”. The medium refraction coefficient is the effect of the interactions.

4 The inertia of matter

Macroscopic matter or particles are electromagnetic waves in a bounded state, and move at the speed c as internal motion. An Object, being still relative to a selected reference frame S , its internal motions in each direction is in equal probability, demonstrating the field strength is spherically symmetric, with energy E_0 .

When the object moves in speed v relative to the S system, due to the restriction of invariance of light speed, the spherical symmetry of the object internal motion is destroyed, the ball is compressed in velocity space, as shown in fig.1.

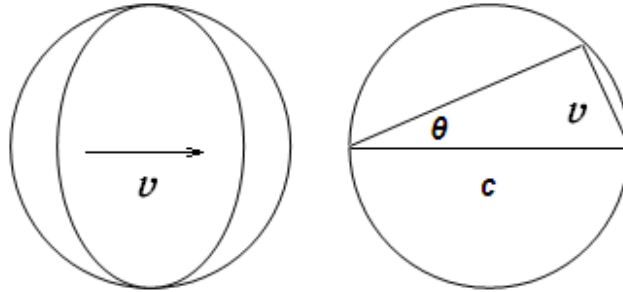


Fig.1 in velocity space of a moving object in speed v relative to S

Compared to a resting state, object’s behavioral changes in speed v relative to S system, in essence, is the change of energy, being derived from the invariable characteristics of light velocity c . Objects from the static to be accelerated to speed v relative to the S frame, the original mass m_0 in accelerating process did not change, the so-called static energy:

$$E_0 = m_0 c^2$$

Here, mass m can be defined by E , but the energy relative to S depends on the speed v .

Obviously, this part of the energy (the kinetic energy) generated by the relative movement have a relation to the change of the state of the motion or the selected frame of reference. When an object moves in speed v , its original energy E_0 in perpendicular to v remains unchanged (due to conservation of energy).

Therefore:

$$E_0 = E \cos \theta$$

or

$$E = \gamma m_0 c^2 \tag{3}$$

Where

$$\gamma = \frac{1}{\cos \theta} = \frac{1}{\sqrt{1 - \left(\frac{v}{c}\right)^2}}$$

The total energy E has been increased. It can be seen from above, that changes of the state of a matter in

existence inevitably require energy exchanging to external; and the other way round, without energy exchange, the original state of matter will maintains unchanged.

From above we can inferred that, the origin of inertia is derived in two aspects:① the electromagnetic properties; and ② the constancy of the velocity of light. Obviously, this deduction is reasonable: when the particle's microscopic properties are not symmetric in three dimensions, the inertia will be anisotropic.

Well then, an object with a length l in standstill, the length will be l' in the direction of movement with speed v . Similar to the change of energy, l' can be expressed as:

$$l' = l \cos \theta = l \sqrt{1 - \left(\frac{v}{c}\right)^2}$$

And this contraction is physical.

5 The concept of force

Force is not an entitative concept. It is designed as an intermediary virtual parameter in processing physical problems. The force is said to be intermediary, because when we use the concept of force, it always appears in the interaction manner. The virtual property of force is that it does not have objective substantiality, can not exist alone in breaking away from entities.

In Newton's law of motion, the two concepts of force and mass are defined in one equation. The mass here is usually considered as inertial mass, confusion also arising from the relationship between inertial and gravitational mass. Aside from the confusion, from a logical point of view, force and mass in the second law played a role of mutual definition logically out of place, this can not be satisfied.

To define the force by momentum differential to time, are related to the definition of momentum its own, and the momentum is an educed quantity. Momentum cannot be expressed as the inherent attribute of substance. The physical meaning of interactive force of relatively stationary objects is not clear, and the force and time have no sense of the nature of contact.

In-depth studying the role of concept of force in study of physical processes, it can be found that, force seems to be the motivity of causing changes of the position of objects, as a result, it can be really changed, also it can be relatively stationary, but have a trend to make the object position changing. In fact, the real causation of this trend is the requirement of system energy distribution, a tendency of changes of an object's nature (energy) in space.

So, the force is an image of causing matter changes, but not as a basic physical quantity, yet it can be used as a convenient tool to study physical process.

In accordance with the expression of classical mechanics, so defined force will better reveal the force essence: force is the amount of the energy changes dE with displacement ds in space:

$$F = \frac{dE}{ds} \quad (4)$$

Displacement is a relative quantity, therefore, force also has relative significance. At the same time, force inevitably represents a kind of external space attribute of energy.

6 The physical meaning of the basic laws of mechanics

6.1 Newton's first law or the law of inertia

An object with energy E in an inertial body S as selected does not vary with changes of spatial position (or time), namely, the inertial law, by using mathematical equation it can be expressed as:

$$\frac{dE}{ds} = \frac{dE}{vdt} = 0 \quad (5)$$

The law of inertia is essentially that the energy conservation law (v can be any values).

6.2 Newton's second law or the law of force

In general, the energy of an object in relative inertial reference system with the speed v is $E = \gamma m_0 c^2$.

From

$$\frac{dE}{ds} = \frac{d}{ds} \left(\frac{m_0 c^2}{\sqrt{1 - \frac{v^2}{c^2}}} \right) = \frac{d}{vdt} \left(\frac{m_0 c^2}{\sqrt{1 - \frac{v^2}{c^2}}} \right)$$

We can deduce a more universal Newton's second law:

$$F = \frac{dE}{ds} = m_0 \left(1 - \frac{v^2}{c^2}\right)^{-\frac{3}{2}} \frac{dv}{dt} = m_0 \left(1 - \frac{v^2}{c^2}\right)^{-\frac{3}{2}} a$$

Or

$$F = m_0 \gamma^3 a \quad (6)$$

And then, come back to survey the distinction between the inertial mass defined in $F = ma$ and the equation above. The movement mass m will be expressed as:

$$m = m_0 \gamma^3 = m_0 \left(1 - \frac{v^2}{c^2}\right)^{-\frac{3}{2}}$$

We contrast the above equation with the (3), the mass m_0 defined in Newton's second law may be rest mass, but the movement mass so defined and that defined in mass-energy relation is not compatible. It is true for equation $E_0 = m_0 c^2$, but if, $v \neq 0$, there will be $E \neq mc^2$. From here we can see that, the concept of mass may only be used in solving specific problems, and is not of universality.

If, $v \ll c^2$, equation (6) can be simplified to the classical form of Newton's second law:

$$F = m_0 a \quad (7)$$

Needing an explanation, $F \cdot ds = W$ only being considered as the energy changes caused by working, is a representation outside substance, rather than the inherent nature of matter.

Obviously, if the energy distribution of a particle does not meet for sphere symmetrical (having spin), will not apply to the Newton's second law.

6.3 Newton's third law

A system composed of two objects has the total energy E , and $E_1 + E_2 = E = const.$, or

$\left(\frac{dE_1}{ds} + \frac{dE_2}{ds}\right) \cdot \frac{ds}{dt} = 0$, s is the distance between them. then, we have:

$$\left(\frac{dE_1}{ds} + \frac{dE_2}{ds}\right) = 0 \quad \text{or} \quad \frac{dE_1}{ds} = -\frac{dE_2}{ds} \quad \text{or}$$

$$F_1 = -F_2 \quad (8)$$

For application of the virtual work principle, need considering the constraint relationship between multiple E_i and its corresponding ds_i .

The direction of movement of the object will cause the change of energy redistribution in all directions, even if the absolute value does not change. If considering the vectorial property of force, we can rewrite equation (6) as follows:

$$\mathbf{F} = m_0\gamma^3\mathbf{a} = m_0\gamma^3(a_x\mathbf{i} + a_y\mathbf{j}) = m_0\gamma^3a_x\mathbf{i} + m_0\gamma^3a_y\mathbf{j}$$

If we want to make

$$\mathbf{F} = F_x\mathbf{i} + F_y\mathbf{j}$$

There must be

$$F_x = m_0\gamma^3a_x \quad \text{and} \quad F_y = m_0\gamma^3a_y$$

This shows that the parallelogram rule of force accord with acceleration decomposition rule.

7 Momentum

Momentum is the representation of change of objects status in space, in order to describe the properties of moving object, use definition of momentum in relativity:

$$\frac{dp}{dt} = F \quad (9)$$

To solve for p :

$$p = \int F dt = \int \gamma^3 m_0 \frac{dv}{dt} dt = \int \gamma^3 m_0 dv = \gamma m_0 v + P_0$$

Let $p(v=0) = 0$, then:

$$p = \gamma m_0 v = E \frac{v}{c^2} \quad (10)$$

i.e.: momentum is the product of energy and speed. Obviously, equation (9) is equivalent to (10).

When $v \ll c$, this gives the classic formation of the momentum definition $p = m_0 v$.

By the way, we can draw the relationship of energy and momentum of photons as:

$$E = hv = h \frac{c}{\lambda}$$

From equation (10), we conclude the photon's momentum p :

$$p = E \frac{v}{c^2} = \frac{E}{c} = \frac{h}{\lambda}$$

Equation (10) also gives the general relationship between momentum and energy. From equation (10), we can also prove the energy - momentum equation (11) in relativity.

$$E^2 - (pc)^2 = (m_0c^2)^2 \quad (11)$$

8 Gravitational properties of matter - energy expression of gravitation law

Gravitation is the cohesion property of matter. It is the basis of forming the matter, is the natural requirement of exists. Otherwise, there will be no distinct things, and the world will tend to be dead. Gravity makes matter tends to aggregate. The inverse square relationship keeps matters of the world in steady state in space.

Since mass is a measure of energy, so, the law of universal gravitation, with energy instead of mass, will be more universal:

$$F = G \frac{m_1 m_2}{r^2} = G \frac{E_1 E_2}{c^4 r^2} = g \frac{E_1 E_2}{r^2}$$

Where $g = \frac{G}{c^4}$

Obviously, the gravity is not only related to mass, is also associated with the motion of objects. For a planet, moving speed boosts close to perihelion, gravity increase accordingly, so the motion track is no longer an ellipse, and produces the precession. Einstein did not completely abandon the concept of mass, resulting in uncertainty of definition of relativistic mass.

The gravitational redshift of photons leaving the sun can be estimated as follows:

The initial energy of a photon is $E_0 = h\nu_0$, energy loss for escaping sun is ΔE , then:

$$\Delta E = \int_{r_0}^{\infty} g \frac{M_{sun} c^2 E}{r^2} dr$$

Neglecting the higher-order terms, we can get:

$$\begin{aligned} \Delta E &= \int_{r_0}^{\infty} g \frac{M_{sun} c^2 E_0}{r^2} dr \\ &= g \frac{M_{sun} c^2 E_0}{r_0} = G \frac{M_{sun} E_0}{r_0 c^2} \\ \frac{\Delta E}{E_0} &= \frac{GM_{sun}}{r_0 c^2} \approx 2.122 \times 10^{-6} \end{aligned}$$

When $\Delta E = E_0$, photons energy is lost completely, would not be able to get rid of gravitational bound.

Then the maximum critical radius r_c of the star should meet:

$$\frac{\Delta E}{E_0} = \frac{GM}{r_c c^2} = 1 \quad \text{or} \quad r_c = \frac{GM}{c^2}$$

For the sun:

$$r_c = \frac{GM}{c^2} = 1477 \text{ m.}$$

Of course, the lost energy of the photon is not really faded, it transferred to the solar system.

9 Conclusions

Energy conservation is the most basic principle of the physical world, with the identity of energy and mass. Electromagnetic properties of matter not only gives matter's spatial properties, but also endows matter with motion (time) attributes. Due to the restriction of invariance of light velocity, makes the movement state of matter changes must be accompanied by the transfer of energy, resulting in the so-called "inertia".

The force is not a concept of entity, is a representation of the trend of matter (energy) changes. The force is defined as the energy changes with the spatial position of an object, avoid the predicament of mutual definition of mass and force in Newton's second law.

After established the basic concept of matter (energy) and force, naturally, the three basic classical mechanic laws can be written out, and give out the general expression of momentum, as well as the relationship between momentum and energy.

Unifying the concept of mass and energy, eliminated the perplexity of inertial mass and gravitational mass. Study of the physical world, whether macro or micro, changes of configuration of energy is essential. Quantization of energy in micro maintains the relative stability of the macroscopic morphology of matter, and gravity provides motivations for the evolution of the universe.

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