

## Inertia? It's very easy!

So, we are going to tell you about the physical mechanism of inertia of massive bodies. At that, we will tell a very simple and accessible language. In fact, it will be “at the elementary”, so-called “phenomenological” level. But in order to do this, we need to use a fairly big scope of human knowledge which was accumulated to the present day. Do not worry, you do not have to study thoroughly textbooks. You are familiar with all this knowledge since school. It is expected that you remember something from the school course, but, nevertheless, we will recall the basic facts and ideas along the narration.

So what is inertia? It is a physical phenomenon. When does it manifest itself? Of course, when we are trying to stop a rolling stone, or catch by hand a cannon ball... When we are trying to kick with foot a brick lying on the road. When we shoot and feel the blow-back of the shot. In short, whenever we try to change the character of the movement of weighable body, this body somehow resists such an attempt. Three hundred years ago, scientists established the laws by which a mechanical motion of weighable bodies proceeds, and since then virtually nothing was added to these laws. The laws are called “Newton's laws” and they differ in numbers (the 1st law, the 2nd and the 3rd) and tell us exactly how the interaction of weighable bodies proceeds and how it is connected with their movement.

Now we invite you to delve mentally into some weighable body (for example, into a brick) and to see what is inside him. Present knowledge level tells us that the brick is composed of molecules, and molecules are composed of atoms - the smallest particles of substance. In turn, atoms are composed of elementary particles which are impossible to be divided in parts. There are three types of elementary particles in the brick: electrons, protons and neutrons. We will ask you to forget about neutrons temporarily and solely for the purpose of compactness of the explanation (we will return to them later). Let our imaginary brick consist meanwhile only of protons and electrons. It is known that these two particles have the same electric charge which is exactly equal in magnitude but opposite in sign. Moreover, experience and physical pragmatism tell us that these particles, these tiny “building blocks” of the Universe have some size, since the size can be set for any object that behaves itself as a more or less compact one. And the electrons and protons are very, very compact. For example, using an electron beam now create an industrial scale sub-micron objects. Unfortunately, scientists can not agree, what is the size of these particles. He is so incredibly small that we still have no simple and obvious way to measure it. There is only a mass of complex and indirect techniques that allow very roughly judge the size of the particles. One thing is clear firmly - the size of their terribly low. That is  $10^{-15}$ , or  $10^{-18}$  degree m. At the same time the large size of the atoms are set much more accurately and clearly (e.g., radiographs), and the order of  $10^{-10} \div 10^{-11}$  m. Consequently, micro-agent is a tiny elementary particles are located at great distances, calculated at a minimum thousands of their own size. That is, substance inside like a mist of very rare and very small electrically charged "droplets."

A curious reader has already asked the question: what between these particles? This is where modern physics begins to "float". You can find the mystical claims that between the particles, they say, "emptiness," "Nothing," "empty space". Emptiness or "nothing" - are not objects of science, because they do not have, by definition, no physical properties. Let us leave these concepts mystics. Space is the same - only the geometric term coined in the mathematics, and also not having the physical properties. In more serious sources of statements can be found that the particles are "physical vacuum" or "quantum field". If you start to figure out what it is, then quickly swell his head. One thing is clear, is not an abstract emptiness, it's still kind of environment, physical substance, which has some physical properties. So, to be studied and somehow affects the processes taking place in the universe. This approach is already paving the

way for science. We call this environment the old-fashioned, with ether. We are on the variety of properties of this medium until the required very little: the fact that this medium is. Since this medium is between elementary particles, it is, therefore, is at least wherever there is a particular particle. Well, much like the air is between the droplets of mist.

Now focus your mind's eye to a single elementary particle of our brick, let it be, for example, an electron. Here is a brick in motion, namely, we will begin to accelerate. That is, moving faster and faster. It is clear that as soon as we accelerate all the bricks, then the one single electron, which we mentally look, too, is accelerating. And he, recall, electrically charged. That is, a moving charge. A moving charge is, by definition, is an electric current. Uniformly and rectilinearly moving - is a constant current, scientists call this current "convection current". Accelerated moving charge, respectively, is an alternating current, i.e. current, changing with time. And this is where the fun begins! It turns out that scientists for 200 years, since the Faraday knows that any current "do not want to" change, he resists the force that tries to change its value. This property of the currents to resist change in its value has been called the scientists' self-induction. "Self-inductance is described by the induction of Faraday and Lenz's rule. Originally self-induction currents was investigated by the example of conduction currents in the conductors. It is established that changing the current flowing through the conductor leads to the conductor (i.e., among the conductor in the metal) of the electric field induction, which prevents the movement of charges. Moreover, if the charges are trying to move faster and faster, the field of induction "stops" them, making it difficult to build up speed. If you are trying to stop the charges, ie move slower and slower, the field of induction, by contrast, "adjusts" them, trying to make to comply with the uniformity of movement. Later it was found that all types of currents known people behave the same way and obey the same laws. Consequently, the phenomenon of self-induction should be observed not only for the conduction currents in the wires, but also in electrolytes and insulators, and even for bias currents in a vacuum. And it is this phenomenon, as firmly established physicists, there is! This means that if a single electron is trying to move in a certain environment, faster and faster, it is a changing current, and Wednesday he opposes such behavior by creating a counteracting acceleration of the electron field. Consequently, in the world of the dielectric medium (air, the physical vacuum) is exactly the same thing! So here it is, the mechanism of inertia: the charged particle, moving rapidly in the world of the dielectric medium is a changing electric current in the medium and thus firmly established law of induction Faraday's causes in the environment of the electric field induction, which, by Lenz's law prevents the acceleration of particles. Well, as long as all the charged particles are accelerated by this power brick works, it also acts on the whole brick as a whole, adding of the tiny forces applied to each particle. A rigorous theory, which, however, is very simple, shows that this force for each particle is directly proportional to the acceleration acting on the particle, the square of the particle charge and inversely proportional to the size of the particles:. The ratio of the square of the charge to the size of the particles (taking into account the size factor in the SI) is exactly equal to the mass of the particles. The radius of the electron is approximately equal to  $m$ . Everything said about the electron is also true for the proton, with the difference that the mass of the proton is 1836 times greater than that of the electron, and radius, respectively, in 1836 times less, since the square of the charge they the same.

That's the case! It turned out that the heavy proton is several orders smaller than the light electron? Yes. That's it. But in the physics literature there are claims that the opposite is true, it is, they say, an electron in a thousand times smaller than a proton. But just try to find out what it should be, according to modern physicists. And you will be surprised. It turns out that it follows simply from the fact that so once decided. And decided to inertia: once the proton is heavier, then it is probably even more. Since then, all experiments were interpreted on the basis of the decision is that the proton is larger than the electron. In fact, there is no simple and direct way to measure the size of elementary particles, and all the complex and indirect tests require

interpretation difficult. In this interpretation, the system is already built strong opinion that the proton must be greater than the electron. Thus a vicious circle. At the same time, a simple calculation of the electrostatic energy of such a small charged body, which is an electron yields a value of electron self-energy three orders of magnitude greater than that observed in experiments (for example, in experiments on the annihilation of particles). The recognition of a more robust representation of the size of the particles removes these paradoxes.

Now back to the neutrons. What about them? Because these particles are, like, not have their own electric charge? Where have they taken the inertia and inertial mass? Indeed, in the 30s of the 20th century, when the neutron is discovered, physicists initially believed that this is truly elementary (indivisible) particles containing no electric charge, but it has mass. And not only the inertial mass, but also exactly equal to its "heavy", because the neutron beam in the experiment very well, "drops" down into the Earth's gravitational field. Then it became clear that the free, out-of-core neutron living is very small, something like 15 minutes and then spontaneously decay into a variety of other objects. This led to the idea that the neutron is not truly an elementary particle but a system of other particles. This conclusion is confirmed by the presence of the magnetic moment of the neutron. Since there is a magnetic moment - hence, the currents flowing inside it. Currents - it's always some movement of the charges. So, inside the neutron electric charges have yet! Already in the late 20th century, just found out that the neutron is really composed of oppositely charged areas. That is, the neutron can be thought of as a system of two (or more) of particles with opposite electric charges and therefore, it is not truly an elementary particle. But then immediately clear from the neutron momentum and mass: each charged particle inside a neutron obeys the same laws as the protons and electrons. And just as experienced by the induction of the global environment, when it was trying to accelerate with respect to this environment. The mass of the neutron as a superposition (we purposely avoided the word "sum" for a very good reason), the masses of its constituent particles.

Thus, the mechanism of inertia is described, and described a very compact and simple. But, any good theory must, except for the facts on the basis of which it was created, describe, and other facts, not inherent in the very beginning. For example, at school, people know that the nuclei of atoms collected in the elementary particles weigh slightly less than the sum of their weights, taken separately. This phenomenon is called "mass defect" and no clear explanation of the physical mechanism of today do not have. And whether above "induction" theory to explain the mass defect of the masses? Let's try!

It is known that an alternating current is subject to the phenomenon of self-induction, i.e. resisting their change. With respect to the conductors, this phenomenon is numerically characterized by a parameter of the inductance of the conductor. The larger the inductance, the greater the resistance of the conductor current change in him. We know that if you place two conductors with opposite currents flowing nearby, then the total inductance of the conductors is reduced. This is because the induction field, preventing the acceleration of electrons in the first conductor, will willy-nilly, to adjust the electrons in the second conductor (as they flee in the opposite direction!). In turn, the field of self-induction in the second conductor will adjust the electrons in the first. As a result, the total inductance in both conductors will be less than the sum of the self-inductance of each of them separately. They say that such a system of conductors reduced inductance. There are so-called bifilar conductors with an extremely low inductance, ie, slightly resistant to change current flowing in them. Consider two particles of different signs, which are side by side and equally accelerated. If the first particle is a current of the current, relatively speaking "forward", the second-it will shock the current "back" (because of the opposite sign of charge). It turns out that two adjacent accelerated particles are equivalent bifilar oppositely varying currents. And their overall "resistance" acceleration will be less than the sum of "resistance" of each particle separately. Here's to you and an explanation of "mass defect". It

turns out that even a defect of particle masses, as such, but a defect of the total inertia of the particles. This explanation of the mass defect takes away every veil of mysticism and translates into the category of obvious practical effects.

At the same time, it is possible to imagine a neutron, as a system of two particles: the proton and antiproton. They revolve around a common center of mass and almost touch each other. As a result, the mass defect of the system reaches a limiting value of nearly 50%. That's why we escaped above the words "the sum of the masses", replacing them with the word "superposition." Such a neutron in fact, we do not know, of course, but the model is very simple and consistent.

Most likely, you, dear reader, there will be many questions on the above notions of inertia. Surely some of these questions and their answers can be found in the section "Questions and Answers." Many questions and you answer to yourself for mature reflection. Well, if something remains unclear, please contact us, ask us questions.