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What is mass?

abstract:

Mass should be understood in terms of potential energy arising from vector potentials of force fields. It reevaluates Einstein's famous equation $\boldsymbol{E = mc^2}$ *and suggests that rest mass (denoted as* $\boldsymbol{m_r}$*) is essentially a form of potential energy. The text challenges traditional views by proposing that the rest mass of subatomic particles is not constant but varies with the potential of the fields in which they are located. Through a series of theoretical discussions and thought experiments, the author explores the implications of this view for understanding the universe, including the additivity of rest mass, the variability of subatomic particle masses, and the principle of minimum potential energy (or rest mass) governing all interactions and processes in the Universe.*

The parameter that remains a mystery in contemporary physics is mass. The laws of physics are expressed in mathematical formulas, and it is said that the Universe is mathematical. Therefore, a significant physical parameter such as mass should be defined by some mathematical formula. For example, the mass of a proton or an electron cannot be arbitrary, but should result from some physical law that would allow it to be calculated precisely. However, first and foremost, one needs to know what mass is.

To answer this question, let us begin with an analysis of the famous Einstein's equation:

$$\boldsymbol{E = mc^2} \tag{1}$$

From this equation, it follows that mass is equivalent to energy. Equivalent means that it is the same as energy, so the formula (1) can be written in the form of an identity:

$$\boldsymbol{E \equiv m} \tag{2}$$

So, what does $\boldsymbol{c^2}$ mean in equation (1)? It is simply a conversion factor from one unit of energy to another, just as we have conversion factors, for example, from joules to calories: $\mathbf{1}\,[\boldsymbol{J}] = \mathbf{0.238846}\,[\boldsymbol{cal}]$, or from joules to electronvolts: $\mathbf{1}\,[\boldsymbol{J}] = \mathbf{0.62415 \times 10^{19}}\,[\boldsymbol{eV}]$. Therefore, from equation (1), it follows that:

$$\mathbf{1}\,[\boldsymbol{J}] = \frac{\mathbf{1}}{\boldsymbol{c^2}}\,[\boldsymbol{kg}] \tag{3}$$

which means:

$$\mathbf{1}\,[\boldsymbol{J}] = \frac{\mathbf{1}}{\mathbf{89\,875\,517\,873\,681\,764}}\,[\boldsymbol{kg}] \tag{4}$$

From the above considerations, we can conclude that the kilogram is simply next unit of energy among many others, such as $[\boldsymbol{J}]$, $[\boldsymbol{eV}]$, $[\boldsymbol{cal}]$, $[\boldsymbol{erg}]$, $[\boldsymbol{kGm}]$, $[\boldsymbol{kWh}]$, etc. Therefore, in Einstein's equation, $\boldsymbol{c^2}$ is just a conversion factor for converting kilograms to joules. It has no fundamental meaning, and the equation (1) practically reduces to identity (2). This implies that mass can be expressed in various units of energy, for example, nuclear physicists commonly use electronvolts $[\boldsymbol{eV}]$ to express the rest mass of subatomic particles.

To understand what the symbols used in identity (2) mean, let's start with the symbol $\boldsymbol{m}$. It might seem that it is simply the mass and there is nothing to wonder about. However, so many adjectives have been added to the concept of "mass" over the years that it is easy to get confused in all of this. Just to name a few: rest mass, inertial mass, gravitational mass, relativistic mass, longitudinal mass, transverse mass, etc. Most physicists long ago agreed to use the term "mass" only in relation to rest mass. Therefore, to avoid any doubts, in this study the mass will always be denoted by the symbol $\boldsymbol{m_r}$ (rest mass). It would still be necessary to refer to those other masses that were mentioned above.

Inertial mass is a term that was used for the symbol $\boldsymbol{m}$ appearing in the second law of Newton's dynamics. However, after the publication of the special theory of relativity, this principle took on a different form. The relativistic formula for the acceleration $\vec{\boldsymbol{a}}$ of massive body according to the second law of dynamics (assuming constant rest mass) is as follows:

$$\vec{\boldsymbol{a}} = \frac{\boldsymbol{c^2}}{\boldsymbol{E_t}}\left[\vec{\boldsymbol{F}} - \frac{\mathbf{1}}{\boldsymbol{c^2}}\left(\vec{\boldsymbol{F}} \cdot \vec{\boldsymbol{v}}\right)\vec{\boldsymbol{v}}\right] \tag{5}$$

The equation given describes the total energy ($\boldsymbol{E_t}$) of a body, which is acted upon by a force $\vec{\boldsymbol{F}}$ and has a velocity $\vec{\boldsymbol{v}}$. The expression with the dot denotes the scalar product of the vectors. Assuming that the body in question has a temperature of absolute zero and no angular momentum, the total energy of the body is determined by the following equation:

$$\boldsymbol{E_t} = \frac{\boldsymbol{m_r c^2}}{\sqrt{\boldsymbol{1} - \frac{|\vec{\boldsymbol{v}}|^2}{\boldsymbol{c^2}}}} \tag{6}$$

where the total energy is given in joules and the rest mass in kilograms. After substituting (6) into (5) and taking into account the aforementioned reservations, the second law of dynamics can be written as follows:

$$\vec{\boldsymbol{a}} = \frac{\sqrt{\boldsymbol{1} - \frac{|\vec{\boldsymbol{v}}|^2}{\boldsymbol{c^2}}}}{\boldsymbol{m_r}} \left[\vec{\boldsymbol{F}} - \frac{\boldsymbol{1}}{\boldsymbol{c^2}} \left(\vec{\boldsymbol{F}} \cdot \vec{\boldsymbol{v}} \right) \vec{\boldsymbol{v}} \right] \tag{7}$$

The expression $\frac{\boldsymbol{m_r}}{\sqrt{\boldsymbol{1} - \frac{|\vec{\boldsymbol{v}}|^2}{\boldsymbol{c^2}}}}$, which appears in this formula, is called the relativistic mass. As we can see in equation (7), the concept of inertial mass has become blurred. It is not possible to unambiguously identify the proportionality coefficient between the acceleration vector and the force. We have a complex relationship involving the directions of vectors: force, acceleration, and velocity. The direction of the acceleration vector generally does not coincide with the direction of the force vector. However, there are two cases where their directions are the same. Once when the force and velocity vectors have the same direction. Two when they are perpendicular to each other. In these two situations, equation (7) takes on the following forms:

$$\vec{\boldsymbol{a}} = \frac{\left(\sqrt{\boldsymbol{1} - \frac{|\vec{\boldsymbol{v}}|^2}{\boldsymbol{c^2}}} \right)^{\boldsymbol{3}}}{\boldsymbol{m_r}} \vec{\boldsymbol{F}} \tag{8}$$

$$\vec{\boldsymbol{a}} = \frac{\sqrt{\boldsymbol{1} - \frac{|\vec{\boldsymbol{v}}|^2}{\boldsymbol{c^2}}}}{\boldsymbol{m_r}} \vec{\boldsymbol{F}} \tag{9}$$

Based on these formulas, two senseless terms were coined: longitudinal mass, which is the inverse of the coefficient before $\vec{\boldsymbol{F}}$ in equation (8), and transverse mass from equation (9), which in this case is equal to the expression called relativistic mass.

The concept of gravitational mass remains to be explained. It is the mass that appears in Newton's law of universal gravitation. The masses appearing in this formula simply represent gravitational charges contained in attracting bodies and are their rest mass. Why rest mass, since it is commonly believed that both rest mass and kinetic energy are gravitational charges? Treating kinetic energy as a gravitational charge needlessly complicates the picture of reality.

Kinetic energy depends on the reference frame, so in different reference frames the gravitational charge of a body, which should be its permanent parameter independent of the reference frame, is different. If we want to unify gravitational and electric interactions, and everyone believes that such unification exists, then the gravitational charge, like the electric charge, must be independent of the reference frame. Otherwise, we cannot even dream of unifying these two interactions. Rest mass is precisely the parameter of a body that is independent of the reference frame.

Now let's focus on the energy $\boldsymbol{E}$, which appears in the identity (2). In physics, there are basically two types of energy: potential energy $\boldsymbol{E_p}$ and kinetic energy $\boldsymbol{E_k}$. The total energy of an object (closed system) is the sum of its kinetic and potential energy. Kinetic energy is energy that arises from motion, and therefore depends on the reference frame. There are many types of kinetic energy:

1. The kinetic energy of a moving object - it can be both motion along a trajectory and rotational motion.

2. The energy resulting from the temperature of an object is the kinetic energy of its atoms measured in the reference frame of the center of mass of the object.

3. The energy of photons and other massless particles is solely kinetic energy dependent on the reference frame.

4. The spin of subatomic particles can represent not only a symbolic quantum number but also a portion of their internal kinetic energy. In that case, the expression (6) would always be subject to some error.

The potential energy of a body is derived from the potential of vector force fields, whose charges are possessed by the body. A freely moving body can convert potential energy into kinetic energy and vice versa by changing its position in a static vector force field, depending on whether it moves towards decreasing or increasing potential.

Let us conduct a thought experiment in the reference frame of the Earth. We have an immobile one-kilogram test weight at ground level. Its total energy is its rest mass equal to 1 [kg], which corresponds to 89 875 517 873 681 764 [J]. (We assume that the test weight is cooled down to absolute zero, meaning it does not have any kinetic energy due to temperature.) This mass consists of the rest masses of all atoms, i.e., protons, neutrons, and electrons. Let us take this test weight and bring it up to the tenth floor of a building, 30 [m] above the ground level. We perform work of about 294 [J] on this body. Therefore, at the tenth floor, the total energy of the test weight will be 89 875 517 873 682 058 [J] (an increase of 294 [J]). The test weight at the tenth floor is still at rest, so its rest mass has increased, and since the number of atoms remains the same, the rest mass of protons, neutrons, and electrons has increased.

The conclusion drawn from this experiment is that a change in the potential energy of an object changes its rest mass $\boldsymbol{m_r}$, and thus the rest mass is equal to its potential energy. Ultimately, we can clarify identity (2) and express it in the following way:

$$\boldsymbol{E_p \equiv m_r} \tag{10}$$

Finally, we have found the answer to the question: what is mass?

The (rest) mass is a potential energy arising from the vector potentials of force fields.

The above statement has many significant consequences:

1. The rest mass, contrary to popular belief, is additive.

2. The rest mass of subatomic particles is not constant and depends on the potentials of the fields in which they are located. For example, the rest mass of an electron located near a negatively charged electrode with a potential difference of $\boldsymbol{-511\,[kV]}$ is twice as large as it is when it is far from the electrode. (The rest mass of a free electron on Earth, when the electric potential is zero, is about $\boldsymbol{511\,[keV]}$).

3. If we knew precisely the quantitative structure of the vector fields of

all interactions, we could easily determine the rest mass (potential energy) of every particle.

4. Everything that happens in the Universe, the evolution of stars and galaxies, all chemistry, radioactive decay, biological life, etc., results from one principle, namely **the principle of minimum potential energy**, or alternatively, **the principle of minimum rest mass**. All interactions (forces) in Nature are based on this one principle.

The first point stems from the fact that potential energy is a scalar, i.e., rest mass (gravitational charge) is a scalar. Mathematics is the foundation of physics, and scalars are additive in mathematics. In dynamic systems, there are always flows between potential energy (rest mass) and kinetic energy. This applies to nuclear transformations and chemical reactions as well. Nonetheless, at any given moment, the rest mass of a system (potential energy of the system) is simply the sum of the rest masses of its components. The so-called rest energy of an object consists of its potential energy, i.e., its rest mass, and its kinetic energy resulting from the temperature of the object. Heat is not a component of rest mass, and thus, it is not a component of gravitational charge. However, heat as kinetic energy affects the inertia of an object, and thus, the equation of the second law of Newton's dynamics should remove the symbol of rest mass and replace it with the symbol of total energy.

From the above, it follows that two objects made of the same material (having the same specific heat), but at different temperatures, dropped simultaneously in a vacuum chamber will not fall to the ground at the same time. The cooler object will fall earlier because it has a smaller ratio of total energy (inertia) to rest mass (gravitational charge). Similarly, objects with the same temperature greater than absolute zero but different specific heat values or possessing different kinetic energies resulting from angular momentum will not fall simultaneously. Unfortunately, at the current stage of development of measuring techniques, this difference in falling is immeasurable.

Point two can be easily proven. Let us take the rest mass of a free electron and proton and compare it with the rest mass of hydrogen. It turns out that the rest mass of hydrogen is the sum of the rest masses of the proton and electron, reduced by the binding energy of the electron. Thus, as the electron approaches the proton (falling onto the proton), it is in an electric field with an increasingly lower potential and therefore loses some of its potential energy (rest mass) to kinetic energy. When the electron stops abruptly on the orbital, it converts this kinetic energy into the energy of a photon. Typically, this is the ground state orbital with the lowest energy. Similarly, the proton also loses some of its potential energy (rest mass). The question arises immediately, why does the electron stop at the lowest orbital and not fall further onto the proton? The answer is very complex and even more revolutionary than previous considerations, so we will discuss this issue further.

Point three will be considered using the example of an electron. We will determine its rest mass mathematically. Before we do that, we need to make some assumptions. We will start with Coulomb's law, which we will write in a slightly different way:

$$\boldsymbol{F = k_E q_1 q_2 f_E(r)} \tag{13}$$

where $\boldsymbol{F}$ is the force with which two electric charges, $\boldsymbol{q_1}$ and $\boldsymbol{q_2}$, interact with each other, $\boldsymbol{k_E}$ is the electric interaction constant, and the function $\boldsymbol{f_E(r)}$ in the case of Coulomb's law is a power function of the distance $\boldsymbol{r}$ between the charges:

$$\boldsymbol{f_E(r) = \frac{1}{r^2}} \tag{14}$$

There is only one fundamental question: how can we be sure that Nature employs precisely such a function across the entire distance range $\boldsymbol{r \in \langle 0, \infty)}$? After all, on subatomic scales, the original function $\boldsymbol{f_E(r)}$ can cross zero multiple times, creating local minima of potential. These minima would determine the locations of orbitals in atoms, thereby obviating the need to assume that electrons in orbitals are maintained by centrifugal force. It would also explain the problem of lack of electromagnetic radiation emission in a situation where electrons do not have to orbit the nucleus. (*If function (14) were applicable at subatomic distances, the binding energy of an electron in a hydrogen atom would be over twice the measured value = 13.6[eV]*).

Below is a schematic diagram showing a possible shape of the function $\boldsymbol{f_E(r)}$ in the range of distances on the order of the atomic radius, as well as the graph of the electric potential energy of a system of two charges, such as proton-electron or positron-electron. Of course, in this case, the function $\boldsymbol{f_E(r)}$ must be dimensionless, and the coefficient $\boldsymbol{k_E}$ in this case has the dimension $\left[\frac{\boldsymbol{N}}{\boldsymbol{C^2}}\right]$.

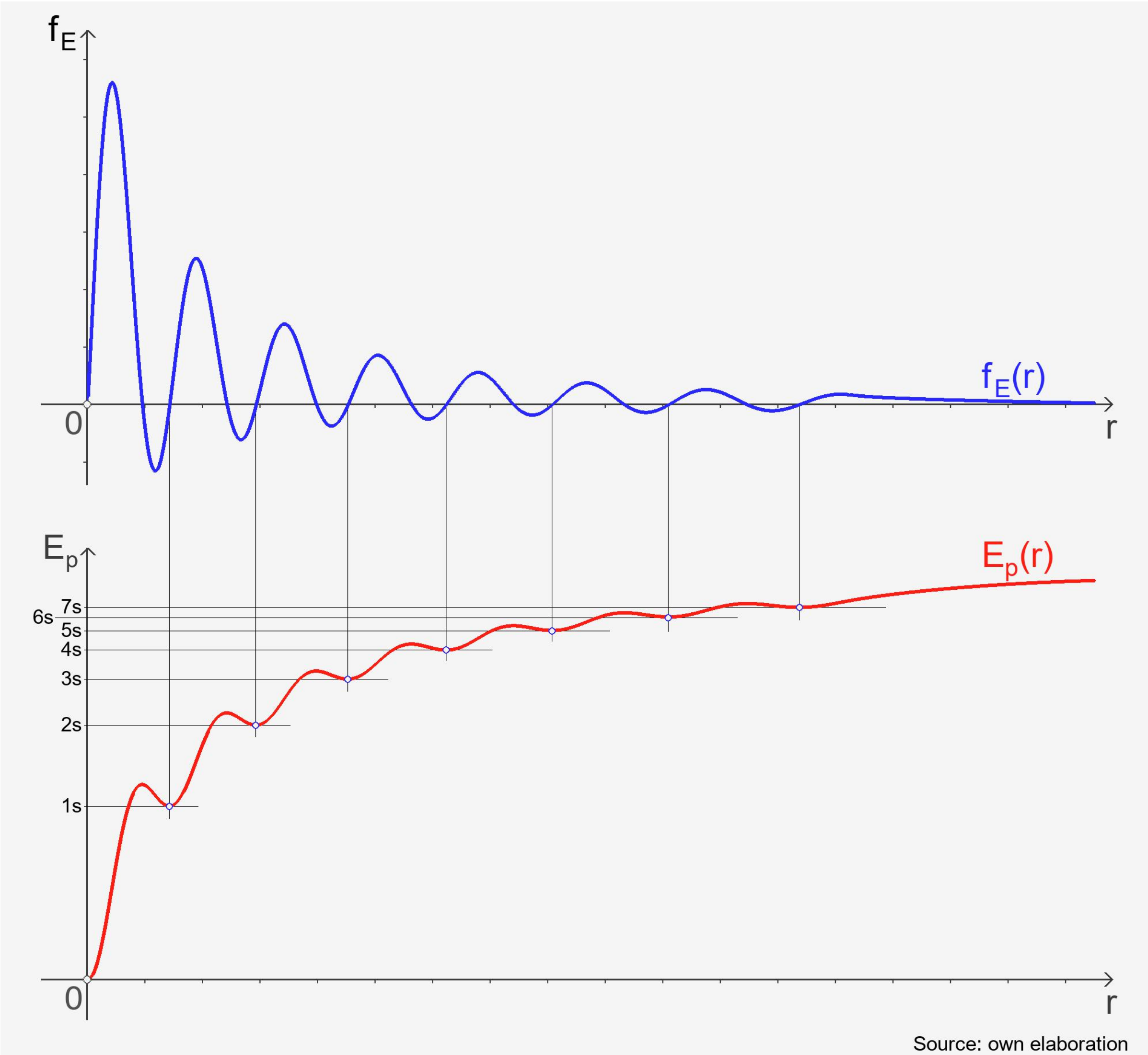


Figure 1

Note that such a shape of the function $\boldsymbol{f_E(r)}$ allows for the formation of stable Cooper pairs, where, at sufficiently low temperatures, two electrons from the conduction band of a metal are located in a local minimum (in a potential well). Only an increase in temperature above a critical value is able to break such a pair (eject it from the well).

Let us return to the topic of calculating the electron's rest mass. Let $\boldsymbol{\Gamma_E}$ denote the value of the integral:

$$\boldsymbol{\Gamma_E = \int_0^\infty f_E(r)\,dr} \tag{15}$$

Due to what we have said about Coulomb's law on subatomic ranges, the integral (15) has a finite value. Moreover, we assume that the proton actually consists of three elements. Examining the values of the electric charge of quarks, we conclude that the elementary electric charge contains $\frac{1}{3}\,[e]$ of the charge. It immediately follows that the electron consists of at least three elementary particles, each containing $-\frac{1}{3}\,[e]$ of electric charge. All observations made during collisions in accelerators indicate that the electron is a point particle, so these three elementary charges in the electron touch each other. To bring these three charges into contact, work must be done equal to the rest mass of the electron:

$$m_{re} = k_E \Gamma_E \left\{ \left(-\frac{1}{3}\,[e]\right)\left(-\frac{1}{3}\,[e]\right) + \left(-\frac{1}{3}\,[e]\right)\left(-\frac{2}{3}\,[e]\right) \right\}$$

$$m_{re} = k_E \Gamma_E \left(\frac{1}{3}\,\left[e^2\right]\right) \tag{16}$$

Taking into account that:

$m_{re} = 8,1871 \cdot 10^{-14}\,[J]$,
$k_E = 8,98755 \cdot 10^{9}\,\left[\frac{N}{C^2}\right]$,
$1\,[e] = 1,60217662 \cdot 10^{-19}\,[C]$,

we will get the result:

$$\Gamma_E \approx 1,0646 \cdot 10^{15}\ [m] \tag{17}$$

The measure of Γ_E is meter, as it is the integral of a dimensionless function with respect to distance - formula (15). We see that the rest mass of the electron is not arbitrary, but follows from well-known physical laws concerning potential fields, and with accurate data, we can precisely calculate it. This also applies to all subatomic particles.

Immediately, the question arises as to what to do to prevent these like electric charges, which repel each other by definition, from dispersing. Although in Figure 1 we *ad hoc* assumed that the force between touching electric charges is zero, this would be an unstable equilibrium state. To stabilize the electron, we need to add an elementary strong anticharge (anti-red, anti-green, and anti-blue) to each elementary electric charge of $-\frac{1}{3}\,[e]$. It is assumed that three different color or anticolor charges attract each other. This attractive force for zero distance must be finite and greater than finite repulsive force between like electric charges that touch each other. The strong interaction is governed by a function similar to the electric interaction function (13), which we will denote as $\boldsymbol{f_S(r)}$, and the strong interaction coefficient as $\boldsymbol{k_S}$. The range of the function $\boldsymbol{f_S(r)}$ is limited because the strong interaction is a short-range interaction.

In an electron, why should there be anticolor charges rather than color charges? This is because it was assumed that the proton is stabilized by color charges. It seems logical that the white color charge from the proton and the white anticolor charge from the electron form additional bonds between pairs of color-anticolor charges at very close distances. Since electrons, through strong interactions, bind protons in atomic nuclei, and because it was agreed that the proton contains a white color charge; therefore, in the electron, there should be a white anticolor charge.

The potential energy of three touching different anticolor charges is zero. However, attempting to break apart an electron causes these anticolor charges to move away from each other, and the electron transitions to excited states such as muon, pion, taon, W_- boson, etc., gaining additional rest mass from the strong force potential. In this situation, **the whole menagerie of unstable subatomic particles we obtain in accelerators would be only excited states of two composite stable particles, namely: the electron and the proton, as well as their antiparticle counterparts**. And just as an excited atom has a rest mass greater than the rest mass of the atom in the ground state, excited electrons and protons have a rest mass greater than their rest mass in the ground state. The specific nature of the strong interaction makes the breaking of a proton or an electron practically impossible, at least not yet within the reach of our accelerators.

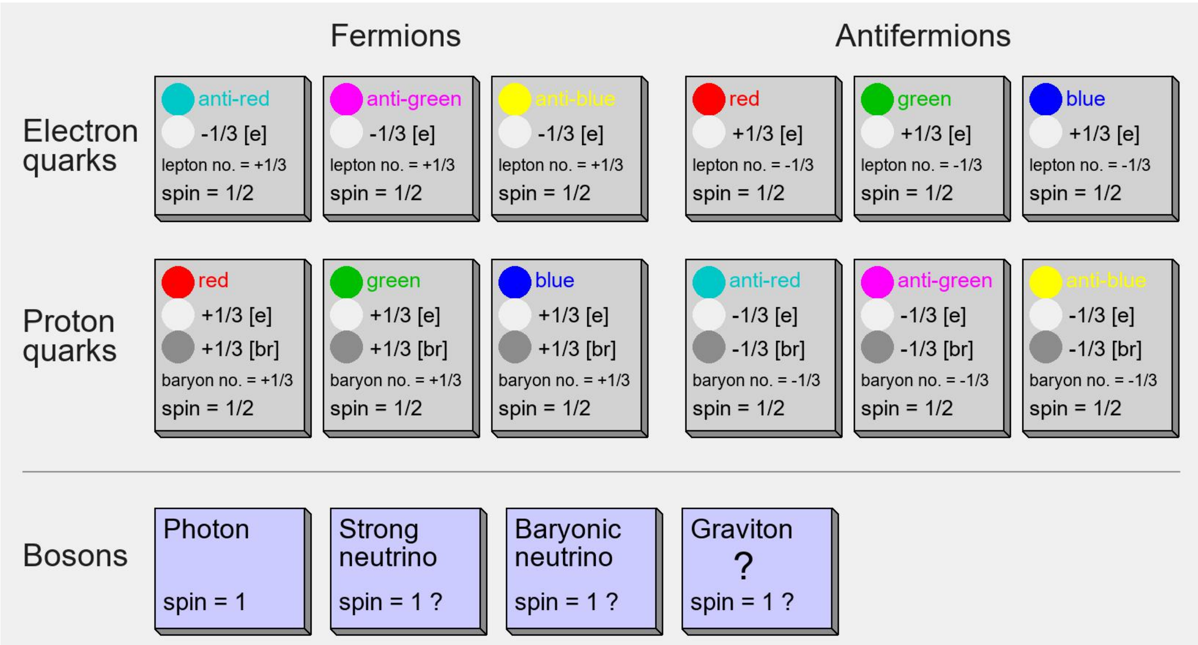
Attention! Subatomic particles with zero electric charge are newly created pairs: excited particle - excited antiparticle. These pairs have too little kinetic energy to move away from each other and after a while undergo annihilation or go down to a lower excited state or to the ground state, and then acquire the appropriate velocities allowing them to leave the creation point. For example, the neutral pion $\boldsymbol{\pi^0}$ *is a pair of excited electron and excited positron. Usually, this pair undergoes annihilation after a short time, but sometimes the excited particles transition to* *the ground state and move away from each other as an electron and a positron.*

According to this concept, the electron is composed of three elementary particles, each containing one negative elementary electric charge and one elementary strong anti-charge, each in a different color. Meanwhile, the proton is also composed of three elementary particles, each containing one elementary positive electric charge, one elementary strong charge, and one additional elementary charge of a second nuclear interaction. Let us provisionally call this short-range nuclear interaction the "barion interaction", and let us refer to the elementary charge of this interaction as the "barion charge". Let the unit of barion charge be denoted by the symbol $[\boldsymbol{br}]$ (barion), and let us assume that the elementary barion charge is equal to $\frac{1}{3}\,[\boldsymbol{br}]$. Let us denote the elementary barion charge in the proton as a plus sign, and in the antiproton as a minus sign. Thus, the proton contains $+\mathbf{1}\,[\boldsymbol{br}]$ of barion charge, while the antiproton contains $-\mathbf{1}\,[\boldsymbol{br}]$. Barion charges of the same sign repel each other, similar to electric charges.

In the barionic interaction, we have a formula similar to equation (13) for the force, with the function $\boldsymbol{f_B(r)}$ and the coefficient $\boldsymbol{k_B}$ applying here. The force of mutual repulsion between like-charged barionic charges at zero distance is greater than the force of attraction between different-colored strong charges, which is why the elementary particles of the proton in the ground state are at some distance from each other, resulting from a state of equilibrium between the strong, barionic, and electric interaction forces (the proton is not a point-like particle). Therefore, the mass of the proton is mainly composed of the potential of the strong and barionic interaction fields, and to a lesser extent, the potential of the electric field.

Nuclear interactions, similar to electric interactions, should have their energy quanta, massless bosons, similar to photons. Let us call these bosons strong neutrinos and baryonic neutrinos. They are created, just like photons, in situations where an excited electron or proton would jump to states of lower energy. We assume that the functions $\boldsymbol{f_S(r)}$ and $\boldsymbol{f_B(r)}$ can also pass through zero multiple times, just like the function $\boldsymbol{f_E(r)}$. (Neutrinos have no rest mass because it has never been observed that they move at speeds significantly lower than $\boldsymbol{c}$.)

Below is a proposal for a set of elementary particles in the revised version of the Standard Model, after applying the principle of Occam's razor. For fermions, the term "elementary particle" has been properly restored to its meaning. An elementary particle, as its name suggests, is a stable object (it does not decay, change flavor, or exchange charges with other particles) and can only be created or destroyed in pairs with its antiparticle.



Source: own elaboration

Bozons can only be created and absorbed by charges of their own interaction, which is why barion neutrinos do not interact with electrons and positrons (they do not collide with them). In the presented concept, bozons are not carriers of interactions, but rather transfer energy and momentum over a distance. We do not observe virtual bozons (photons, gravitons, W and Z bosons, pions, etc.) that transfer interactions. Essentially, virtual bozons only convey information from the past about the parameters and position of the object interacting with another object and have little in common, aside from the name, with real bozons. Moreover, the term "virtual" suggests that they are part of some informational superstructure that exists outside of spacetime.

It is hypothesized that there is a unification between all interactions, which is why we assume that the form (13) of the Coulomb formula applies to all interactions occurring in Nature. For the electric interaction, we assumed that the function $f_E(r)$ is dimensionless, so in order to meet the requirements of unification, we must assume that the functions $\boldsymbol{f(r)}$ for the other interactions are also dimensionless with the argument $\boldsymbol{r}$ given in meters.

In regards to the fact that the original function $\boldsymbol{f_G(r)}$ deviates from the $\frac{1}{r^2}$ function, many observations have been made, so treating the function $\boldsymbol{f_G(r)}$ as dimensionless gives greater freedom in explaining any anomalies observed in the Solar System and beyond. Incidentally, the problem of dark matter disappears.

One question still remains unanswered: why does the electron in a hydrogen atom stop at the lowest orbital and not fall further onto the proton, while in the case of positronium, the electron after a momentary stay in the local potential minimum falls further onto the positron and annihilates? (Positronium is a pseudoatom of hydrogen, where the proton is replaced by a positron. The average lifetime of positronium is 142 ns). The answer is simple. To make the electron fall onto the proton and form a neutron, additional energy must be supplied to it because the rest mass of a neutron is greater than the sum of the rest masses of a free proton and a free electron. Therefore, a free neutron is an unstable particle.

In order for a neutron to be formed from a proton and an electron, the electron must be excited, allowing the separated strong anti-charges of the electron to interact with the separated strong charges of the proton. In this situation, the mass of the electron increases due to the separation of the strong anti-charges, while the mass of the proton decreases due to the appearance of strong anti-charges near the proton's strong charges. The final mass balance is positive, and the free neutron is temporarily in a local potential minimum, which lies above the sum of the rest masses of the free proton and electron. Therefore, on average after 15 minutes, the neutron "spits out" an electron, emitting neutrinos and photons in the process.

A free neutron is actually an unstable composite of a proton and an electron. However, in the case of the deuteron nucleus, where two protons are bound together (by strong and electric interactions) with an excited electron between them, the mass balance is negative; therefore, the formation of the deuteron nucleus involves the emission of energy, and its nucleus is stable as a result. The nucleus of the deuteron is called a deuteron.

In some cases of atomic isotopes, the electron from the lowest orbital does indeed fall onto the atom's nucleus, leading to a nuclear transformation. However, these situations occur where the newly formed atomic nucleus has a rest mass (potential energy) lower than the starting nucleus. This process is known as electron capture, also called inverse beta decay, e.g., $^{26}\boldsymbol{Al} + \boldsymbol{e}_{-} \rightarrow\ ^{26}\boldsymbol{Mg}$.

It should be noted that, according to the presented concept, the deuteron has a half-integer spin, while neutrinos and neutrons have integer spins. Therefore, it is very easy to verify the correctness of the hypothesis presented - it is enough to measure the spin of the deuteron nucleus. Generally, all isotopes of atoms with an odd atomic number should have a half-integer spin, regardless of their mass number, and isotopes of atoms with an even atomic number should have an integer spin. At the same time, the rather strange and illogical postulate of cases of parity symmetry violation in the world of subatomic particles disappears. Why is it strange? Because cases of parity symmetry violation can be compared to the situation when, for some people standing in front of a mirror with their right hand raised, their left hand is raised in the mirror reflection.

From all the considerations presented above, a very important conclusion follows: the force acting on a massive object results directly from the maximum gradient of the total potential field, which consists of all potential fields interacting with this object. Therefore, the source of force in all interactions is the same principle:

the principle of minimum potential energy.

Or, in other words:

the principle of minimum rest mass.

This is a fundamental law of physics that governs all processes in the Universe. All forces arise from the gradient of potential fields of individual interactions, and these fields are created based on information about the distribution of interaction charges in the past. Currently, it is believed that this information is carried by virtual bosons. Virtual bosons are elements of the Standard Model that are completely different from real bosons. Above all, they cannot carry energy. Therefore, for abstract (virtual) elements carrying information about objects interacting at a distance, a more adequate name would be, for example, "interaction rays," and a light cone directed towards the future should be called "interaction cone." Potential fields are also just information, based on which interaction forces are calculated. We do not directly observe the fields of interactions; we only observe the effects of the action of these fields.

Quarks in protons and electrons, protons and electrons in atomic nuclei, electrons in atoms, atoms in chemical molecules, chemical molecules in fluids and solids, planets in the Solar System, stars in galaxies, etc., are held together by forces arising from potentials of fields, rather than virtual bosons. Since one principle governs all forces in Nature, a unified formula encompassing all interactions can be proposed.

Why hasn't the Universe reached its minimum rest mass yet? That is, zero mass, with a balance of matter and antimatter, or a minimum in the form of a single global black hole, in the absence of such equilibrium. Firstly, this is due to initial conditions, and secondly, there are numerous local minima standing in the way of the global minimum, as shown in Fig.1. It is precisely these appropriately distributed local minima, i.e. appropriately shaped functions $\boldsymbol{f_E(r)}$, $\boldsymbol{f_S(r)}$ and $\boldsymbol{f_B(r)}$, that determine the structure of the periodic table and the evolution of the Universe. They are what caused life to be imprinted on the periodic table and created conditions for the emergence of life in the Universe. Life in the Universe could be a very common phenomenon.

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