On the virtual decay of some elementary particles, on the illusion of decay, and the mass of information

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Introduction

The article examines two seemingly independent but closely related problems of field theory: the mechanisms of decay of some elementary particles and the presence of "mass" in information that exists separately from the information itself.

Objectively, there are virtual and real physical objects (usually elementary particles). These objects can be in two states: virtual and real. These two states are akin to two projections of some new quantum number. A virtual particle is characterized by almost all quantum numbers inherent in a real particle. For virtual particles, the connection between the energy E and the momentum **p** inherent in a real particle is broken: $E^2 = m^2c^4 + p^2c^2$. Unlike particles characterized by a specific quantum number and a specific projection of this number, virtual and real objects can transition from one state to another. The mechanism of such a transition is well known [1]. There are virtual and real physical processes [1]. They can proceed sequentially, alternating. Virtual particles and processes can be characterized by superluminal speed.

If a change in the projection of any quantum number leads to the appearance of a new object of the microworld, then virtual and real particles are often (but not necessarily) characterized by the same quantum numbers and projections of these numbers. For example, a change in the projection of isospin leads to quark transitions u ↔ d, a change in the projection of the isospin of a quark in a nucleon (n or p) leads to transitions n ↔ p.

The existence of virtual and real objects and processes explains the "non-standard" and unexpected mechanisms of decay of the neutral pion and W and Z bosons.

Virtual processes occur in time intervals of $\Delta t \sim 10^{-24}$ s. Such processes, due to the uncertainty relation for energy ΔE and time Δt ($\Delta E \Delta t \geq \hbar/2$), cannot be observed in principle [2]. Soviet philosopher V.S. Gott claims that virtual particles and processes are unobservable and have no physical reality [2]. In addition, virtual particles are endowed with properties that have no physical meaning, such as negative and imaginary mass [2]. The impossibility of observing virtual particles in measuring devices does not refute their objective existence [2]. There are a number of physical proofs of the objective existence of virtual particles [1, 2].

Research conducted at the University of Illinois at Urbana-Champaign, USA, allows us to "look at quantum theory in a new way and rethink the fundamental laws of physics" [3]. In quantum physics, the properties of a particle can exist separately from the particle itself. For example, the spin of a particle, i.e., its own angular momentum, can move on its own, independently of the particle [3]. "At the smallest scales, everything consists of a cloud of quantum possibilities… Quantum particles, which exist in a fuzzy cloud of possible states, give rise to the solid, well-defined world… of everything else around us" [4].

It is possible to change the mass of the information carrier when it is recorded or deleted from the carrier [5–7]. Does this mean that information is physical and has mass? This is what the authors of the works [5–7] claim. Moreover, a person produces and materializes ideal information [7]. The author of this article answers the question of the existence of mass information in the negative. Based on the logic of the article [3], it can be assumed that the mass of information, if it exists, is separate from information.

Mass and energy are equivalent. Recording or deleting information corresponds to some kind of energetic external or internal impact on the information carrier. The origin of this impact is unclear. It is not clear how "a person… materializes ideal information" [7].

In 1927, the empty four-dimensional space-time of Poincaré was replaced by the vacuum field of Dirac. Then the physical (quantum, cosmological, cosmic) vacuum was introduced into consideration. Later, the physical vacuum was replaced by the ether field [1, 8]. It was previously revealed that the ether field is a special form of existence of matter. It was shown that the ether field is more fundamental than the fields of the known four fundamental interactions, and some properties of this field were investigated [1, 8]. The ether field fills all space. Without it, wave processes are impossible. The ether field can perform the functions of the Higgs field and the function of dark energy, which accelerates the universe, and particles with negative mass can be born in it. Here it is appropriate to cite the words of A. Poincaré about the classical ether of H. Lorentz (the concept of which was abandoned at the beginning of the 20th century): "Whether the ether exists or not is of little importance; let us leave this to metaphysicians, for us it is important that everything happens as if it exists and that this hypothesis turns out to be suitable for explaining phenomena... " [9].

The ether field helps to explain a number of physical facts related to the birth, disappearance and illusion of decay of the t-quark and W and Z bosons.

The fastest decays are realized through strong interaction. Only hadrons can decay through strong interaction. The characteristic decay time (hadron time) is about $3 \cdot 10^{-24}$ s. The characteristic time of strong interaction $\tau_S \sim 10^{-23} \ldots 10^{-22}$ s. Hadrons can also decay through electromagnetic and weak interactions.

The minimum average lifetime is characteristic of the t quark (about $5 \cdot 10^{-25}$ s [10, 11]) and W and Z bosons (about $3 \cdot 10^{-25}$ s [12]). These particles are characterized by the fastest decays (the fastest processes) reliably known to modern physics. The average lifetime of the π0 meson (in relation to the decay through the main channel via electromagnetic interaction) can be estimated at $8.337 \cdot 10^{-17}$ s [13]. This is in good agreement with the time of electromagnetic interaction ($\sim 10^{-12} \ldots 10^{-20}$ s).

Materials and methods

Neutral pion. It is known that the π^0 meson decays due to electromagnetic interaction. The main decay mode is $\pi^0 \rightarrow 2\gamma$ (probability 0.98823 ± 0.00034) [12]. The average lifetime during decay by this mode is about 8.337 10^{-17} s [13]. There are decay modes with the emission of ma (with a probability of more than $\sim 10^{-2}$ %), which is typical for decays due to weak interaction. The decay $\pi^0 \rightarrow 3\gamma$ is possible (which is forbidden in electromagnetic interaction, but allowed in weak interaction) with a probability of less than $3.1 \cdot 10^{-6}$ % [12]. During decays due to weak interaction, the average lifetime of the π0 meson increases by several orders of magnitude [13]. In the decay via the $\pi^0 \rightarrow 4\gamma$ channel, the probability of which is less than $2 \cdot 10^{-6}$% [12], the average lifetime of the π^0 meson is maximum and equals $4.120 \cdot 10^{-9}$ s.

W and Z bosons. It is known that W and Z bosons participate in gravitational and weak interactions, and W bosons also participate in electromagnetic interactions. They do not participate in strong interactions. In most cases, $W^{\pm}$ and Z^0 bosons decay into hadrons with a probability close to 70% [12]. The rest energy of the W boson is 80.433 ± 0.009 GeV [14], and of the Z boson, 91.1876 ± 0.0021 GeV [12]. The average lifetime of the W and Z bosons is about $3 \cdot 10^{-25}$ s [12]. This is less than the hadron time and the characteristic time of the strong interaction.

In most cases, W and Z bosons decay into a quark and an antiquark. This results in the formation of two jets, since the current quarks produced in this process immediately acquire a multitude of "sea" quark pairs and form hadrons. The hadron streams are observed in the detectors as jets. There are several known decay channels for the W+ boson: into hadrons (probability 67.60 ± 0.27%), tauon and tauon neutrino (11.25 ± 0.20%), positron and electron neutrino (10.75 ± 0.13%), μ+ and muon neutrino (10.75 ± 0.15%), strange D+ meson and photon (less than $1.3 \cdot 10^{-3}$%), π+ meson and photon (less than $8 \cdot 10^{-5}$%), etc. [12]. The decay channels of the W^- boson are charge-conjugate [12]. The Z boson decays with a probability of 69.91% into a quark and antiquark pair, which form a meson; the total probability of decay into a lepton and antilepton (neutrino-antineutrino, e^+-e^-, μ^+-μ^-, τ^+- τ^-) is 10.10% [12].

Top quark. The mass of the t (top) quark is 173.2 ± 0.7 GeV/c^2 [10]. This is the largest mass among all known fundamental particles of the standard model. The average lifetime of the t- quark is about $5 \cdot 10^{-25}$ s [11]. This is less than the hadron time and the characteristic time of the strong interaction. The decay of the t-quark via the strong interaction is forbidden, since strong interactions (gluon exchange) can change the color of the quark but do not change its flavor.

Due to its short lifetime, the t-quark does not have time to become part of a hadron. (Virtual t quarks are present in any hadron.) There are 11 known decay channels for the t-quark [10]. The b-quark is often found among the decay products. The t-quark decays mainly through the weak interaction via the channel t → W + b. Then the W-boson decays into leptons or hadron jets. Instead of the b-quark, an s- or d-quark may appear with a probability of about 9%. The decay into a b-quark and a quark-antiquark pair b, s or d (decay products of the W-boson) is characterized by the highest probability (66.5 ± 1.4%). The decays $t \to e + \nu_e + b$ and $t \to \mu + \nu_\mu + b$ (13.4 ± 0.6)% are realized with equal probability (13.3 ± 0.6%) [10].

Results

Some facts and real events contradict known laws.

Neutral pion. The π^0 meson contains equal amounts of {d, ū} and {u, $\bar{d}$}. Electrically neutral combinations of these quarks can only exist as their superposition $(u\bar{u} - d\bar{d})/\sqrt{2}$.. The lowest energy state of this superposition is the π^0 meson, a truly neutral particle (which is its own antiparticle).

The quarks in the π0 meson decay via the weak interaction:

$$d \to u + e^- + \bar{\nu}_e;$$
$$u \to d + e^+ + \nu_e;$$
$$\bar{d} \to \bar{u} + e^+ + \nu_e;$$
$$\bar{u} \to \bar{d} + e^- + \bar{\nu}_e.$$

Considering the quark composition of the π^0 meson, the decay via weak interaction can be formally written as

$$\pi^0 \to (u + e^- + \bar{\nu}_e) + (d + e^+ + \nu_e) + (\bar{u} + e^+ + \nu_e) + (\bar{d} + e^- + \bar{\nu}_e). \quad (1)$$

This process is considered impossible, which means it can occur virtually. Virtual processes occur quickly, much faster than real ones.

Decay products can annihilate to form photons, having previously passed from a virtual to a real state. Annihilation of decay products can occur virtually; the annihilation products (photons) can pass from a virtual to a real state. Let us rewrite the relation (1) as

$$\pi^0 \to (u + \bar{u}) + (e^- + e^+) + (\nu_e + \bar{\nu}_e) + (d + \bar{d}). \quad (2)$$

The pairs of particles and antiparticles indicated in brackets annihilate. Therefore, expression (2) can be written as

$$\pi^0 \to \gamma + \gamma + \gamma + \gamma.$$

A photon (γ-quantum) is a truly neutral particle. This means that annihilation of two photons is possible, and the decay

$$\pi^0 \to \gamma + \gamma.$$

The laws of conservation of energy, momentum and angular momentum; do not prohibit three-photon and multiphoton annihilation. This means that the decay is possible

$$\pi^0 \to \gamma + \gamma + \gamma.$$

Formally,

$$\pi^0 + \pi^0 \rightarrow \gamma + \gamma;$$
$$\pi^0 + \pi^0 \rightarrow \gamma + \gamma + \gamma;$$
$$\pi^0 + \pi^0 \rightarrow \gamma + \gamma + \gamma + \gamma;$$
$$\pi^0 + \pi^0 \rightarrow \gamma + \gamma + \gamma + \gamma + \gamma$$

etc.

The resulting photons can transition from a virtual to a real state and then annihilate to form new photons. Their energy is insufficient to form pairs of massive particles. As a result, the decay of the π0 meson into two photons occurs quickly during the characteristic time of electromagnetic interaction ($8.337 \cdot 10^{-17}$ s [12]). As a result, it appears (or rather, it is an illusion) that the decay occurs due to electromagnetic interaction.

W, Z bosons and t-quark. Another interesting fact, contradicting the known laws, is related to the decay of $W^{\pm}$ and Z^0 bosons. They do not participate in strong interactions. In most cases, $W^{\pm}$ and Z^0 bosons decay into hadrons with a probability close to 70% [12]. Formally, virtual quark-antiquark pairs are born, which "accumulate" many other ("sea") quark pairs. From them, virtual hadrons are formed, which transform into real ones.

From the uncertainty relation written with respect to energy and time, it follows that the mass of the W boson with a lifetime of $3 \cdot 10^{-25}$ s should be equal to 2.175 GeV/c^2. The average lifetime of the W boson with a mass of 80.433 GeV/c^2 should be equal to $0.8 \cdot 10^{-27}$ s. This is not true [12]. This means that the W and Z bosons are real but very short-lived particles.

From the uncertainty relation written with respect to energy and time, it follows that the mass of the t-quark with a lifetime of $5 \cdot 10^{-25}$ s should be equal to 1.305 GeV/c^2, and the average lifetime with a mass of 173.2 GeV/c^2 should be equal to $3.5 \cdot 10^{-27}$ s. But this does not correspond to reality [10, 11]. This means that the t-quark can only be considered a virtual particle with a very high degree of caution. It is a real, albeit very short-lived, particle.

In proton–proton interactions observed at the Large Hadron Collider, the top quark is produced in both gluon scattering (90% of events) and quark–antiquark scattering [15]. At the LHC (CERN), gluon scattering dominates, while at the Tevatron (Fermi National Accelerator Laboratory, Illinois, USA), quark scattering predominates [15].

So, the W and Z bosons and the t quark are real, very short-lived particles that do not participate in the strong interaction. Their average lifetime is much shorter than the characteristic time of the strong interaction.

In 2014, the ATLAS detector at the LHC registered the production of pairs of W bosons of the same electric charge. (W^+-W^+ and W^--W^- [16]. In 2021, the ATLAS detector at the LHC experimentally discovered the process of simultaneous production of three W bosons in proton-proton collisions [17]. It is not yet clear whether these experimental facts mean that the W^+ boson (as well as the W^- boson) behaves simultaneously as a particle and an antiparticle.

Illusion of the decay of W, Z-bosons, and the t-quark in the ether field. The mass of unstable particles is not precisely determined. It is "smeared" over a certain interval. From the uncertainty relation written with respect to energy and time, it follows that the shorter the lifetime of a particle, the greater the uncertainty of its energy (mass). If we construct the energy (mass) distribution of the Z boson, it will have the form of a normal distribution (Gaussian distribution) [18]. The width of this resonance curve reflects the uncertainty of the Z-boson mass, which is directly related to its lifetime. The maximum of the distribution corresponds to a value of 91.188 ± 0.007 GeV/c^2, which is in good agreement with the data [12]. Thus, the mass of each individual Z boson can be precisely measured, but different Z bosons will have different masses, determined by the lifetime of each of these particles [18].

Memory in various forms and types is inherent in all higher animals [19]. But memory is also inherent in inanimate matter; for example, the shape memory effect [20]. Memory is manifested in numerous conservation laws. Any physical field, including the etheric field, is material. This means that the etheric field, like any other field, also has a certain memory [21].

Memory is a fundamental property of matter. For example, if a pair of virtual particles of high energy is born and disappears in an etheric field (in a physical vacuum), the field “remembers” the point, or rather, the region of space where this occurred. In this region of space, there was a surge of energy in the ether field, from which a particle-antiparticle pair was born. When this pair disappears, and the surge of energy is blurred in space over time: the peak of energy decreases, the width of the maximum increases. This is typical for a spherical diverging wave. Moreover, the wave front moves at the speed of light. The distribution of energy by coordinates corresponds to the Gaussian distribution. This energy can dissipate, being evenly distributed in the ether field: the maximum of the distribution decreases, and the size of the region of its localization in space increases [21].

Before the energy has had time to dissipate, a new particle-antiparticle pair can be born from it.

In essence, this is the law of conservation of energy of the ether field. One of the interpretations of the uncertainty relation for energy ΔE and time Δt states that for a short time Δt a particle with rest energy ΔE (or mass $m = \Delta E/c^2$) can be born "out of nothing", and the violation of the law of conservation of energy on ΔE is not observable in principle. Introducing the ether field into consideration, it can be stated that a particle with rest energy ΔE can be born not "out of nothing", but from the energy of this field, and the law of conservation of energy is fulfilled. This is one of the arguments in favor of the existence of particles with negative mass, which is necessary for the fulfillment of the law of conservation of energy of the ether field.

The vanished virtual pairs of W, Z bosons, and t quarks leave an energy burst at the place where they disappeared. This energy can give birth to pairs of other particles and antiparticles with a total energy not exceeding the energy of the pair of disappeared particles. The total rest energy of a pair of W bosons is about 160.9 GeV, of Z bosons — about 182.4 GeV, of t quarks — about 346.4 GeV. This means that at the "point" in space where a pair of W bosons disappeared, other particles with an energy of no more than 160.9 GeV can be born. At some distance from this point, where the energy E_0 (according to the Gaussian distribution) is less than 160.9 GeV, pairs of particles with an energy not exceeding the energy value E_0 can be born. (Due to the additional energy of the ether field, it is possible to exceed E_0. These are extremely unlikely processes. A typical example is the hypothetical positron decay of a proton into heavier particles.)

Since the rest energy of the W boson is about 80.4 GeV and the b quark is 4.7 GeV, the quark-antiquark pair $b\text{-}\bar{b}$ can be born at a fairly large distance from the point of disappearance of the pair of virtual W bosons. The more time passes after the disappearance of the pair of parent particles, the further the wave front goes, and the greater the distance from the "point" of disappearance of the pair of virtual particles to the "point" of birth of the new pair can be.

Thus, when a pair of W or Z bosons disappears in a limited region of space, for example, a quark-antiquark pair ($b\text{-}\bar{b}$) can be born. This creates the illusion of the decay of a W or Z boson into two quarks, and there is enough energy left to surround them with "sea" quarks and to create hadrons.

In the vicinity of the point of disappearance of a pair of t quarks, for example, a pair of W bosons and a pair of b quarks can be born.

In these processes, the illusion of the decay of W, Z bosons and t quarks is created, and the pairs of W, Z bosons and pairs of t quarks behave as virtual particles.

On the mass of information. In recent years, articles have appeared on the materiality, or substance, of information [5–7, 24–25]. These articles are based on Landauer's principle, formulated in 1961. The presence of material attributes in information does not exclude the existence of immaterial, i.e., ideal information. Successful attempts have been made to measure the mass-energy of information. It is different from zero.

Previously, the author attempted to investigate this problem [22]. As noted, the author of this article answers the question of the existence of mass information in the negative. If information does have mass, it is "separate" from information. A change in the mass of an information carrier when recording or deleting information may be associated with an energy effect on the information carrier of an as yet unclear nature.

Let us consider pairs of electrically charged particles and construct a graph of the dependence of the ratio of the absolute value of the Coulomb F_C and gravitational F_G forces in a vacuum on the absolute value of the specific charge (the ratio of charge q to mass m) of these particles. We find that the proton and all fundamental particles lie on the same line. The exceptions are the t-quark, maximon, and WIMP. Composite objects of the microworld (atomic nuclei containing more than one nucleon) and maximon are located above this line, and WIMP and the t-quark are below this line. The charged maximon and antimaximon would lie on this line if the mass of each of them was equal to $2.176 \cdot 10^{-18}$ kg, which is approximately 435 times less than the known mass of the t-quark, and the mass of the t-quark should be noticeably greater [22].

Let us assume that the rest energy (mass) of a particle includes the energy (mass) of information. This additional mass can be formally attributed either to the information or to its carrier. There is no doubt that a fertilized egg carries complete information about the future material development of an organism. No external factors can change the appearance of a living organism [23]. It can be assumed that the first maximon (cosmological singularity), existing in the Planck epoch, like an embryo of a living organism, should carry complete information about the subsequent development of the material universe. In this case, a certain part of the mass of the first maximon should reflect the "mass of information". As a result, the pure mass of the maximon (without the mass of the information it carries) can be noticeably less than the Planck mass, which is quite consistent with the results of the studies presented in the article [22]. In this case, the maximon will lie on a straight line in the coordinates $F_C/F_G = f\ (q/m)$, like most known fundamental particles.

Conclusion

The ether field allows us to explain the decays of some particles (π^0, W, Z). The maximon (cosmological singularity) carries additional information, and the t-quark and WIMP are exotic particles. The decay of a pair of virtual t-quarks and WIMPs is just an illusion, similar to the "decays" of W and Z bosons

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