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Direct Derivation of the Neutrino Mass

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Abstract

In this paper, the submicroscopic deterministic concept developed by the author is applied to the problem of the neutrino mass. A particle appears from space considered as a mathematical lattice of primary topological balls, and induces a deformation coat in its surrounding. The principles of the interaction of particles with space and through space between themselves are considered in detail. The approach states that real quarks possess only an integer charge ($\pm e$) and when moving they periodically change to the monopole state ($\rightleftarrows$ g) and hence, canonical particles are dynamic dyons. A neutrino emerges as a squeezed quark when it is in a monopole state, or in other words, the quark monopole state (a bubble in the tessellattice) is transferred to the appropriate lepton monopole state (a speck in the tessellattice). The self-mass (a 'rest' mass) for each neutrino flavour is calculated. The calculated value of the self-mass for the electron anti-neutrino is $1.22873978 \times 10^{-36}$ kg = 0.68927247 eV/c^2. The concept of neutrino oscillations is revised, and another postulation is proposed, namely, that the transition from lighter to heavier flavours is due to the inelastic scattering of neutrinos on oncoming scatterers. As a result, the neutrino captures the mass defect, becomes heavier, and therefore the transitions $\nu_e \to \nu_\mu$ and $\nu_\mu \to \nu_\tau$ occur; thus, the number of light neutrinos decreases in the neutrino flux studied.

Keywords

Charge, Inerton, Mass defect, Monopole, Neutrino, Space, Tessellattice

1. Introduction

Much has already been studied in neutrino physics [1]. The knowledge on neutrino masses and mixing was described in the review [2]. The main achievements of recent years were the discovery of neutrino oscillations [3] [4]. Currently researchers have been working in other large research projects, in particular the examination of the main parameters of neutrino oscillations [5], the investigation of whether a $2\nu\beta\beta$ decay of nucleus could be possible without emitting any neutrinos (the so-called $0\nu\beta\beta$

decay) [6], the exploration of the existence of a sterile neutrino [7], physics topics between neutrino and kaon experiments [8], etc. Status and perspectives of neutrino physics and possible new effects were outlined in reviews [9] [10].

Many theoreticians have been studying the origin of neutrino mass [11]–[21]. Different models have been examined, but the main features of these studies boil down to a few assumptions. The first possibility is that a neutrino is a Dirac particle, which means that the particle (neutrino) and anti-particle (anti-neutrino) are different and such particles interact, i.e. experiences the gravitational interaction, via the presence of mass. The second possibility is to consider the neutrino and the anti-neutrino as the same particle, which is interpreted as a Majorana particle. The difference is that in a Majorana's neutrino the factor of one half, which avoids double counting, should be included, because the two fields are not independent. Besides, the Dirac term of gravitational interaction can directly be generated via the Higgs mechanism and the Dirac term can be invariant under the lepton number transformations. Though in the case of the Majorana term an additional Higgs triplet is required, which brings non-renormalizable terms in the total Lagrangian and hence the lepton number transformation becomes impossible.

Furthermore, theoretical approaches to understanding neutrino masses include mixings in the framework of the see-saw mechanism, assuming three active neutrinos (electron, muon and tau neutrinos). In such models, not only the presence of mass and the difference between the masses in the neutrino flavours is important, but also the presence of the mixing angles, since they are the ones that allow neutrino oscillations to be determined. In the last of the above publications on the nature of neutrino mass [19], the researchers suggest a new particle (particles) that must contribute to neutrino masses and compare the estimated limits with an upper bound from Higgs naturalness (although science does not know for sure what the Higgs 'naturalness' is).

In paper [20], neutrino masses were calculated using the neutrino's confining potential, electrostatic energy, and its electromagnetic radius. But since these parameters have very approximate values, the obtained result $0.006\ \mathrm{eV}/c^2$ can hardly be considered true.

The researchers [21] studied neutrino mass anarchy in the Dirac neutrino, seesaw, and double-seesaw models involved, and also took the random Majorana mass matrices into consideration. In the framework of their model, they calculated probability distributions of the mass square ratios in each neutrino model.

In his review paper, de Gouvêa [18] emphasizes in summary that the neutrino mass puzzle is a central question in particle physics today. Although the mentioned studies are focused mainly on the neutrino mass and neutrino oscillations, they nevertheless do not reveal the very essence of the phenomenon, namely: what is the neutrino mass and what is its origin, how does it appear, does each flavour have its own mass value? Besides the very phenomenon of the sudden creation of a neutrino in a beta-decay reaction (or under accelerated particle beams that strike atoms) from nothing continues to be a great mystery of nature.

In the researchers' group report [22] on theory of neutrino physics, they point out that it is important to identify the different hypothetical degrees of freedom and interactions responsible for nonzero neutrino mass. However, it is also important to recognise that elementary particles are not points but spatially extended objects that must have volume and surface. In addition, a physical vacuum is not a vacuum at all, but a kind of substrate ('loka' in Vedic literature, which later in Europe began to be called an ether) from which all particles appear and then disappear into it.

Experimental studies of neutrino mass represent the pinnacle of skill of large groups of researchers, and perhaps the most important of recent achievements are the following. In paper [23] the researchers obtained a limit for the electron neutrino mass < 150 eV/c^2. Their method was based on an electron capture in ^{163}Ho, which was accompanied by complicated electron-electron scattering processes that probably affected the effective neutrino mass. A close value of the upper limit of the electron neutrino mass was obtained [24] using cyclotron radiation emission spectroscopy; in their method electrons possessed a high energy and between electrons and tritium gas molecules ^{3}H-^{3}H inelastic collisions took place. The obtained limit for the neutrino mass was < 152 eV/c^2 [24]. At last a high-precision direct measurement of the tritium β-decay spectrum using molecular tritium ($\text{T}_2 \to \text{HeT}^+ + e + \bar{\nu}_e$) demonstrated that the upper limit for the electron neutrino mass was < 0.8 eV/c^2 [25] and their method did not rely on assumptions whether the neutrino was a Dirac or Majorana particle.

Such a significant discrepancy between the experimental results above obtained using very precise sophisticated experimental methods requires clarification. However, so far we have not seen any analysis of such a striking discrepancy in the obtained results of the measured value of the neutrino mass.

In the present paper all these raised issues are highlighted, and answers are provided. Moreover, the notion of mass as such is clarified, starting from first principles. The paper proposes an approach that is based on the structure and properties of real physical space, and therefore the description and search for answers to the problems raised is different from the established abstract theoretical approaches that are typical for current particle physics.

2. Preliminary

In particle physics, it is customary to use an abstract mathematical apparatus to describe particles, their interaction, creation, and annihilation. However, although there are great advances in the study of elementary particles using tools of physical mathematics, researchers note serious problems with such an approach. Lykken and Spiropulu [26] emphasize that the failure to find superpartners is brewing a crisis in physics, forcing researchers to question assumptions from which they have been working for decades. Shifman [27] notes that the absence of superpartners to particles in experiments at the Large Hadron Collider points to a paradigm rupture in our basic grasp of quantum physics. He also points out that theorists would need to relearn (because they mainly employ mathematical methods that describe symmetry/supersymmetry and are not well equipped for alternative approaches). Comay [28] discusses a number of conceptual errors in the electromagnetic, weak and strong interactions, discloses severe errors in quantum chromodynamics (QCD) and the Standard Model in general. He notes that such a state of affairs is far from being well-known and emphasises the need to re-examine the Standard Model.

Besides, in the theoretical concepts of elementary particle physics, a particle is considered as a mathematical point, which significantly weakens the theory and indicates the need to expand views on the real situation. My paper [29] discusses the possibility of solving the crisis in particle physics associated with the collapse of supersymmetry, considering a submicroscopic approach that assumes both the structure of real physical space and the volume and surface of particles.

In the Standard Model of particle physics, precise definitions of a series of basic concepts are still lacking. In fact, all the processes of particle physics occur in physical space, but the theory only refers to a physical vacuum from which all the particles emerge. Any clear definitions of basic notions such as vacuum, particle, lepton, quark, mass, charge, and so on are absent in the reference literature.

One can say that the Higgs field is a basic field of nature, which is associated with the generation of the masses of all the massive particles. However, the Higgs field was introduced as an abstract field having two abstract scalar neutral and two abstract electrically charged components which form a complex doublet of the weak isospin SU(2) symmetry. How are these abstract notions of physical mathematics associated with real space, which is rather described by rules of pure mathematics and mathematical physics? Moreover, the Higgs formalism does not answer the simple question: What is mass itself, what is charge? It can be said that the Higgs field explains the generation of mass, and not the origin of mass itself. The generation of "quanta of mass" in complex numbers from a few abstract symbols introduced in a couple of differential equations written on a sheet of paper? The approach cannot explain in principle the concept of mass. Moreover, Comay [28] shows that the present form of the QED Lagrangian density violates parity conservation whereas electrodynamics conserves parity, and he demonstrates that the Lagrangian density $-1/4 \cdot F_{\mu\nu} F^{\mu\nu}$ is certainly an erroneous element of the present structure of QED, however, it is this term that is extremely important for Higgs' abstract paper [30]. In addition, in the framework of the Higgs formalism, there is no understanding of what real physical space is exactly. We can also quote a sensible remark [31]: "The problem is lack of parsimony: If we don't need a "permittivity particle" to describe electrical properties of the vacuum, why should we need a "mass particle" to describe the mass-giving properties of the vacuum?"

Serious conceptual problems appear also in nuclear physics. Indeed, recently it has been revealed [32] [33] that nuclear forces, including those derived within chiral effective field theory, fail to reproduce the excitation of the α-particle. Namely, a transition form factor, which provides a test of the QCD factorisation theorem, appeared to have about twice the value of the measured values in the experiments.

This underlines the fact that real nuclear forces cannot be related only to the abstract formalism of QCD theory.

Particle physics has many serious challenges because it is still resting on a knowledge base created around 90 years ago. Particle physicists still operate on the basis of abstract theoretical views, applying results obtained with the abstract tools of physical mathematics to reality. All the theories used in particle physics are based on symmetries, which is possible only in the case when particles are considered as points rather than extended objects. Of course, such approach can lead to serious mistakes in the results and particle physicists must be prepared for such a development of events. To describe reality, one needs to use mathematical physics, which operates with the parameters of real matter and real objects. The establishment of new fundamental principles is possible only on the basis of knowledge of real physical space, its structure and laws, which must then be connected with the quantum mechanical formalism. Failure to understand this will likely lead to more unexplained phenomena.

A detailed mathematical theory of real physical space was constructed by Bounias and the author [34] [35] [36] starting from set theory, topology and fractal geometry. A detailed application to physics was done in book [37] in which particle physics and nuclear physics were described in terms derived from the submicroscopic constitution of space.

In mathematics, a point can be treated as a topological ball and a set of points represents a set/network of balls. Then, in such approach, matter and distances can be derived from the same manifold.

Thus, physical space can be considered as a mathematical lattice of primary topological balls, which was named the tessellattice by Michel Bounias [34]. In the tessellattice, the size of a ball, which is a cell, can be characterised by the Planck's length $\ell_{\text{Planck}} = \sqrt{\hbar G/c^3} \approx 1.6 \times 10^{-35}$ m. From the physical point of view the tessellattice is a degenerate substrate that shares discrete and continuum properties and constitutes a substructure of a 'physical vacuum'.

In the tessellattice, local fractal deformations are associated with the local appearance of matter. In other words, fractal formations manifest the appearance of something from nothing because a local fractal deformation designates a local increase in the dimensionality of space. Hence a particle appears from a degenerate cell of the tessellattice following some fractal rules. Such an approach allows us to introduce the notion of a particle (both a lepton and quark) and the concept of mass. The existing particles can also be described using the submicroscopic concept [37].

Indeed, a lepton can easily be attributed to a fractally contracted cell because such a particle is stable as it is able to counteract the pressure from the entire substrate of the tessellation; then effective radii of known flavours (electron, muon, tau) obey the inequalities: $\ell_{\text{Planck}} > \mathbb{r}_e > \mathbb{r}_\mu > \mathbb{r}_\tau$, that is, the heavier a lepton, the smaller the size.

The mass m_A of a particled ball A is a function of the fractal-related decrease of the volume of the ball,

$$m_{A,i} = C \ \mathbb{V}^{\text{deg}} / \mathbb{V}_i^{\text{lepton}} \cdot (\mathrm{e}_{\mathbb{V}} - 1) \gg 1 \tag{1}$$

where C is the dimensionality factor; $i = 1, 2, 3$ (three leptons – electron, muon, tau); $(\mathrm{e}_{\mathbb{V}})$ is the Bouligand exponent and $(\mathrm{e}_{\mathbb{V}} - 1)$ is the gain in dimensionality given by the fractal iteration; $\mathbb{V}^{\text{deg}}$ is the volume of a degenerate ball and $\mathbb{V}^{\text{lepton}}$ is the volume of the particle produced from this ball. Fractality introduces a change in the dimension of the particulate cell (3D approaches to 4D owing to the convolution of volumetric fractals), which now distinguishes it from other degenerate cells of the tessellattice. Therefore, a dimensional increase is a necessary condition for the creation of matter.

A quark-like family has a structure opposite to the one for leptons, namely, in the case of quarks we may anticipate an inflation by means of a fractal iteration of a degenerate cell. Hence, for quarks the following relationship holds

$$m_{A,i} = C \ \mathbb{V}^{\deg} / \mathbb{V}_i^{\text{quark}} \cdot (\mathrm{e}_{\mathbb{V}} - 1) \ll 1 \tag{2}$$

where $\mathbb{V}_{i+1}^{\text{quark}} > \mathbb{V}_i^{\text{quark}}$, $i = 1, 2, \ldots 6$ (six quarks).

The inequality (2) shows that quarks do not have mass in the sense of lepton mass (1): leptons are fractal volumetrically contracted objects, but quarks are fractal volumetrically inflated objects. That is why these two classes of particles exhibit completely different mechanics in the tessellattice: leptons obey the quantum mechanical formalism (the mystery of which is revealed by deterministic submicroscopic mechanics) and quarks obey a mechanics of bubbles [37] [38].

Of course, a local fractal deformation must develop a deformation coat in the environment by analogy with what happens in solid-state physics around an electron that resides in a polar crystal; outside the deformation coat, the tessellattice is in a degenerate, undeformed state (Fig. 1).

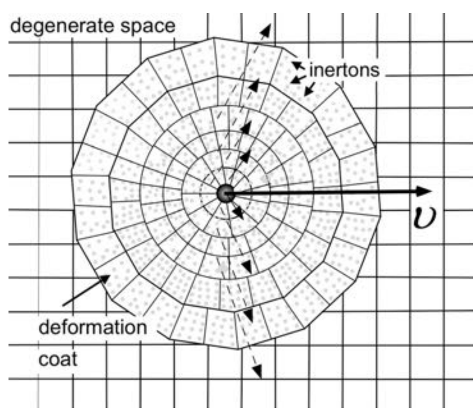

Figure 1. Moving particle in the tessellattice.

2.1. Leptons in the Tessellattice

When a particle starts moving, squeezing between tessellation cells, it collides with oncoming cells. As a result, the particle gradually loses its mass and speed, emitting spatial excitations that carry away volumetric fractals, i.e. fragments of the particle mass. These excitations migrate via the tessellattice by a relay mechanism hopping from cell to cell.

At the submicroscopic consideration, the particle's de Broglie wavelength λ actually characterises a section in the tessellattice in which the particle mass is decomposed. During the next section λ of the particle path, the tessellattice, having elastic properties, returns these massive excitations back to the particle. The excitations were named 'inertons' [37]; it follows that inertons are the essence of the force of inertia because any physical movement involves their appearance (Figure 2).

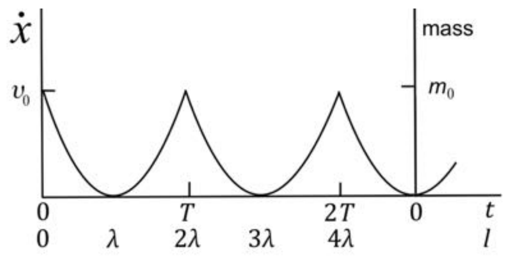

Figure 2. Oscillations of the particle velocity and mass. The particle emits fragments of its mass in odd sections $\lambda \cdot (2n-1)$ and adsorbs them in even sections $\lambda \cdot 2n$ where λ is the particle's de Broglie wavelength, and $n = 1, 2, \ldots$

The Lagrangian of a moving massive particle and its inerton cloud in the 1D consideration is

$$\mathcal{L} = \frac{1}{2} m\dot{x}^2 + \frac{1}{2}\mu\dot{\chi}^2 - \frac{1}{T}\sqrt{m\mu}\, x\dot{\chi} \quad (3)$$

where x and χ are the coordinates of the particle and its inerton cloud, respectively; m is the particle mass, μ is the inerton cloud mass, T is the scattering time (or the period of oscillation of the particle). Here $m = \mu$ because the particle and its inerton cloud exchange the same mass.

The equations of motion result in the de Broglie relationships for the particle:

$$\lambda = h/(mv) \quad \text{and} \quad E = h\nu \quad (4)$$

where $\nu = 1/T$.

The relationships (4) allow one to derive the Schrödinger equation in which the wave ψ-function is interpreted as the reduced mass density of the system {particle + inerton cloud}; it takes the form of the wave equation for sound waves. Moreover, the approach makes it possible to estimate the amplitude of the particle's inerton cloud:

$$\Lambda = \lambda\, c/v. \quad (5)$$

Λ shows how far from the particle inertons can be distanced, providing for a short range action (though quantum mechanics is a long-range theory).

The periodic particle's mass defragmentation and its restoration can be described by the following Lagrangian

$$\mathcal{L}_{\text{mas-tens}} = \frac{1}{2}\lambda^2\dot{m}^2 + \frac{1}{2}m_0^2\,\dot{\vec{\xi}}^2 + v m_0 \lambda\, \dot{m}\, \nabla\vec{\xi} \quad (6)$$

where $\vec{\xi}$ is the tension to which mass m periodically changes. The equations of motion become:

$$\ddot{m} - v^2\,\nabla^2 m = 0, \quad (7)$$

$$\ddot{\vec{\xi}} - \upsilon^2 \nabla^2 \vec{\xi} \quad = 0, \tag{8}$$

which are the wave equations for the mass m and tension $\vec{\xi}$, respectively, i.e. the periodic change of contraction and rarefaction, nodes and antinodes ($m \to |\vec{\xi}| \to m \to |\vec{\xi}| \to \ldots$). For the particle itself the transition to the tension state means that the particle is free of fractals and therefore must return to its original volume $\mathbb{V}_i^{\text{deg}}$ typical for a degenerate cell of the tessellattice, but in this situation the particled cell acquires a rigidity due to the acquired tension ξ (like a stretched string, for example).

2.2. Electrodynamics in the Tessellattice

The electric charge appears on the surface of a ball in the tessellattice as a quantum surface fractal, i.e. spikes covering the surface determine the presence of charge in the ball. The fact that the charge is a surface phenomenon is evident from the macrophysical objects of living nature [37], for example, a chestnut fruit or a hedgehog are typical charges; the male genital organ can be considered as a positive charge, and the female genital organ as negative.

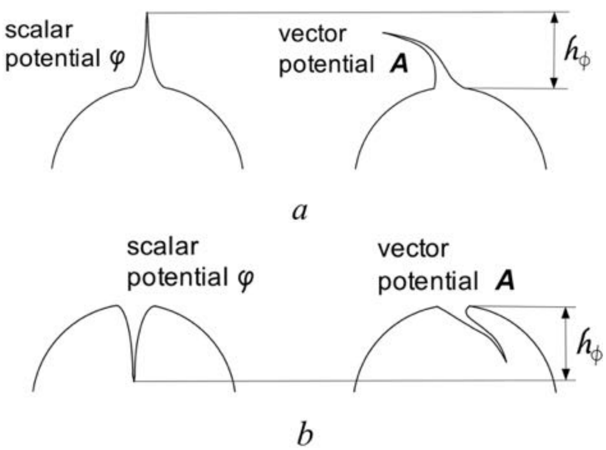

Figure 3. One spike on the surface of the ball. *a* – outward-facing spike generates a positive electrical charge; *b* – inward-facing spike generates a negative electrical charge.

Figure 3 illustrates the spike behaviour on the surface of the appropriate ball, or cell. φ is the scalar potential that forms the electric field $\vec{E} = -\vec{\nabla}\varphi$ and $\vec{A}$, which is the combed, or twisted spike, is the vector-potential that forms the magnetic field induction $\vec{B} = \vec{\nabla} \times \vec{A}$.

A photon is an excitation of the tessellattice that moves in the tessellattice like an inerton, i.e. hopping from cell to cell. A photon carries electromagnetic polarisation, that is, in the same cell, outward and inward spikes are partially present on two opposite faces of the cell [36].

The Lagrangian density of a flux of free photons that interact with a charged particle in standard symbols is [37] [39]

$$\mathcal{L}_{\text{el-magn}} = \frac{\varepsilon_0}{2c^2}\dot{\varphi}^2 + \frac{\varepsilon_0}{2}\dot{\vec{A}}^2 + \varepsilon_0 \dot{\vec{A}} \cdot \vec{\nabla}\varphi - \frac{\varepsilon_0 c^2}{2}\left(\vec{\nabla} \times \vec{A}\right)^2 - \rho \cdot (\varphi_0 - \varphi) + \vec{g} \cdot \vec{A} \quad (9)$$

where ρ is the charge density, φ_0 is the reference point of the potential φ because as in reality the difference of the potentials between two points is considered, $\vec{v}$ is the velocity of the charge, and $\vec{g}$ is the density of the magnetic monopole introduced instead of a conventional expression $\vec{j} = \rho\vec{v}$, i.e. $\vec{g} = \rho\vec{v}$. The equations of motions, i.e. the Euler-Lagrange equations for the potentials φ and $\vec{A}$ are as below

$$\frac{1}{c^2}\frac{\partial^2 \varphi}{\partial t^2} - \nabla^2\varphi = \frac{\rho}{\varepsilon_0}, \quad (10)$$

$$\frac{1}{c^2}\frac{\partial^2 \vec{A}}{\partial t^2} - \nabla^2\vec{A} = \mu_0\vec{g}. \quad (11)$$

These two equations are the d'Alambert's form of Maxwell's equations. Here, Equation (10) is the wave equation for the density of the electric charge and Equation (11) is the wave equation for the density of the magnetic monopole $\vec{g}$. The Equations (10) and (11) reveal that Maxwell's equations are symmetric in the sense that their structure is the same for both electric and magnetic potentials, and that is how it should be – the electric field has its source in an electric charge, and the magnetic field has its source in a magnetic charge, which we call a monopole. The vector $\vec{E} = -\vec{\nabla}\varphi$ is normal to the surface of the particle and the vector field $\vec{A}$ is tangential to the surface of the particle; that is, these two components are orthogonal, as they should be.

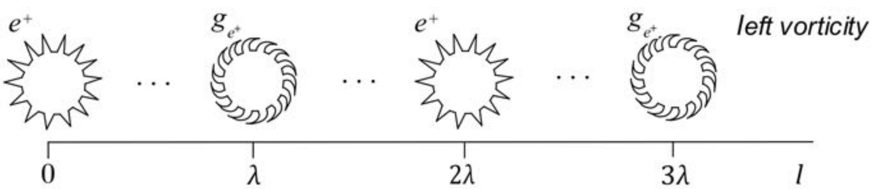

Figure 4. Principle of motion of the positively charged particle: the charge state periodically passes to the monopole state (and similarly for the right vorticity).

Figure 4 demonstrates the motion of a positively charged particle. The potentials φ and $\vec{A}$ move in antiphase. This Figure is a good supplement to Fig. 2 because it exhibits that all the characteristics of the particle under consideration periodically change along its path: mass to tension, charge to monopole, and velocity also oscillates between the initial value and zero. The spatial period for this oscillation is the particle's de Broglie wavelength λ. The inner reason for such a behaviour of these characteristics is the interaction of the particle with oncoming cells of the tessellattice, or in other words, this occurs owing to the continuous interaction of the particle with physical space (which is a substrate!).

Furthermore, the electric charge is a dyon: the state of electric charge e is periodically changed to the state of magnetic monopole g. Besides, the electric charge as a quantum of surface fractality should be the same for both leptons and quarks because they appear from the same cell, and the charge is integer.

Thus, both leptons and quarks obey the same Maxwell's equations. It should be so, because photons, as carriers of the electromagnetic field, are carriers of the electromagnetic interaction for both leptons and quarks – the spectrum of photons is continuous from about 0 Hz (very long radio waves) to the maximum reached values of about 10^{28} Hz (gamma-quanta), which corresponds to 10–100 TeV.

2.3. Quarks in the Tessellattice

The charge of a quark is not directly measurable due to quark confinement in hadrons. Nevertheless, a group of researchers united in the ATLAS collaboration [40] conducted an experiment to establish the charge of the *t*-quark, due to a correlation of its decay products with the *b*-quark and the charges of the collimated hadrons from the *b*-quark hadronization that form a *b*-jet. They concluded that the *t*-quark is characterised by charge $-2e/3$. However, their result was obtained owing to the manual introduction of the charge $Q_b = -e/3$ for the *b*-quark (see in Ref. 40 Equations (5.1) and (7.1)). Therefore, the result obtained by the ATLAS Collaboration cannot be considered as reliable.

There are also no prerequisites for the appearance of a fractional electric charge on a ball in the tessellattice, there are no arguments in favour of charges $\pm e/3$ or $\pm 2e/3$.

On the other hand, some researchers [41] [42] [43] [44] have emphasised that integer quark charge models describe experiments better than those using fractional charges. Thus, Ferreira [42] wrote that the integer charge models do a better job than the Standard Model at describing the two-photon data. LaChapelle [44] highlighted that quarks and leptons are manifestations of the same underlying field. Further evidence that quarks possess an integer charge comes directly from the *β*-decay; the emitted electron has the integer charge $-e$, which directly indicates that there were only integer charges inside the parent nuclide [37].

So, quarks can have only an integer charge. Then we can put the charge $+e$ for the *u*-quark and the charge $-e$ for the *d*-quark. This makes it possible to build the following structure of the π-mesons [37] [38]

$$\pi^0 = \mathrm{d\,u}, \quad \pi^+ = \mathrm{u\,g_d}, \quad \pi^- = \bar{\mathrm{u}}\,\mathrm{g}_{\bar{\mathrm{d}}}, \tag{12}$$

that is, the π^0-meson is a vortex in which quarks u and d rotate; the π^+-meson is a vortex of the u-quark and monopole g of the d-quark, i.e. $\mathrm{g_d}$; the π^--meson is a vortex of the $\bar{u}$-antiquark and monopole g of the $\bar{d}$-antiquark, i.e. $g_{\bar{d}}$.

The structures of the proton and neutron are, respectively

$$p = d\,u\,u, \quad p^+ = (du, u) = (\pi^0,\ u), \tag{13}$$
$$n = d\,u\,g_u, \quad n^0 = (du,\ g_u) = (\pi^0,\ g_u). \tag{14}$$

By analogy with leptons, moving quarks emit excitations that can be named 'inverse inertons', or 'quark inertons', which allows the identification with gluons of the theory of strong interaction. Hence a quark is wrapped in its own cloud of inflated spatial excitations, gluons. Considering quarks as bubbles, it is easy to show that the potential $V(r) = \sigma r$ reflects an overlapping of two bubbles and the energy of agglutination is described by the member $\Delta E_{\text{attraction}} = -\sigma r$ where r is the distance between the centres of the bubbles [37] [38]. Once again, when two bubbles overlap slightly, the quarks interact through the appropriate static bubble-bubble potential $V(r) \propto r$, and this is the reason of the phenomenon known as the quark confinement.

In a hadron, which is a merger of bubbles, a moving quark emits its quark inverse inertons, or gluons, in the form of a standing spherical wave, which provides for a short-range action between quarks. Such a standing spherical wave establishes like a static potential $V(r) \propto 1/r$ for another quark, which is known as the asymptotic freedom for quarks in the theory of strong interaction.

3. Results

As is known, initially the neutrino is not present in the nuclei and mesons from which it appears in nuclear reactions and collisions of particles. Let us consider how a neutrino is created in the framework of the submicroscopic concept.

3.1. The Nascence of the Neutrino

Currently in particle physics the weak decays of hadrons are recognised in terms of basic processes in which $W^{\pm}$ bosons are emitted or absorbed by the hadrons' constituent quarks. The decay of a neutron is described by the reaction $d \to u + W^-$, and then $W^- \to e^- + \bar{\nu}_e$. That is, the neutron emits an electron and electron anti-neutrino through the weak interaction. $W^{\pm}$ and Z^0 bosons are considered as carriers of the weak interaction, but their exact properties are not completely known. It is believed that they should not have any internal structure. On the other hand, these bosons can be combined particles and can be attributed to the family of mesons. In fact, one thing is the role ascribed to them in theories, and another is what exactly is measured in experiments, especially since the final decay products of $W^{\pm}$ and Z^0 bosons are the same elementary particles as in the case of mesons π^0, K^0, ω, J/ψ, etc., which are electrons, muons, taus and neutrinos.

In the framework of the submicroscopic concept [37] [38] the decay of a hadron occurs under an impact of spontaneous pairs of quark-antiquark, which stimulates the decay. Such spontaneous pairs arise from the tessellattice owing to the powerful impacts of the particle on the oncoming cells. The decay of the neutron (presented below as $(du + \mathrm{g_u})$, i.e., a combination of quarks d and u, and the magnetic monopole $\mathrm{g_u}$ occurs at the collision with a quark-antiquark pair $\{u^+\bar{u}^-\}$ by the following formula (Fig. 5):

$$\begin{aligned}&(d^-u^+ + \mathrm{g_u}) + \{u^+\bar{u}^-\} \rightarrow (d^-u^+ + \mathrm{g_u} + u^+ + \bar{u}^-)\\ \rightarrow\ &(d^-u^+ + u^+ + \bar{u}^-\mathrm{g_u}) \rightarrow (d^-u^+ + u^+) + (\bar{u}^-\mathrm{g_u}),\end{aligned} \tag{15}$$

or

$$n^0 \rightarrow p^+ + W^-. \tag{16}$$

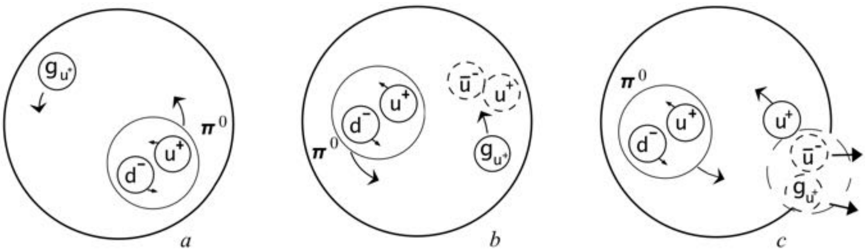

Figure 5. Decay of the neutron to proton.

So, we have disclosed that a W^- boson is a combined particle, $W^- = (\bar{u}^-\mathrm{g_u})$, which is a vortex composed of the u-antiquark and the u-quark's magnetic monopole $\mathrm{g_u}$. The W^- boson is unstable and in the decay the quark and quark monopole are separated. But a single quark and single quark monopole are unstable in the tessellattice and collapse (i.e. are squeezed by the tessellattice) to the state of the appropriate lepton. The same is true for other bosons of the weak interaction, thereby:

$$W^- \equiv (\bar{u}^-\,\mathrm{g_u}) \rightarrow (e^-,\ \bar{\nu}_e) \rightarrow e^- + \bar{\nu}_e, \tag{17}$$

$$W^+ \equiv (u^+\,\mathrm{g_{\bar{u}}}) \rightarrow (e^+,\ \nu_e) \rightarrow e^+ + \nu_e, \tag{18}$$

$$Z^0 \equiv (u^+\ \bar{u}^-) \rightarrow \begin{cases}\gamma + \gamma,\\ \mu^+ + \mu^-.\end{cases} \tag{19}$$

Pions, produced during the decay followed by the contraction of quarks, behave in a similar way:

$$\pi^0 \rightarrow (d) + (u) \rightarrow \begin{cases}\gamma + \gamma,\\ e^+ + e^- + \gamma,\end{cases} \tag{20}$$

$$\pi^+ \rightarrow (u) + (\mathrm{g_d}) \rightarrow \begin{cases}e^+ + \nu_e,\\ \mu^+ + \nu_\mu,\end{cases} \tag{21}$$

$$\pi^- \to (\bar{u}) + (g_{\bar{d}}) \to \begin{cases} e^- + \bar{\nu}_e, \\ \mu^- + \bar{\nu}_\mu. \end{cases} \tag{22}$$

The transition of the magnetic monopole from the quark state (an inflated cell) to the lepton state (a contracted cell) is demonstrated in Fig. 6.

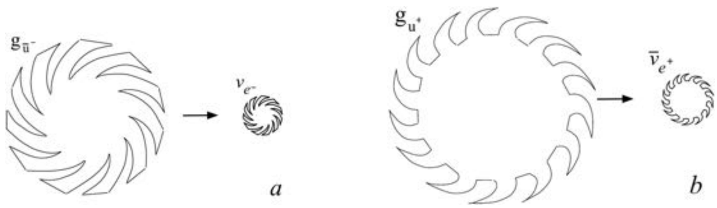

Figure 6. Transition of the monopole from the quark state to the lepton state. a is the monopole that appeared from the negative charge $(-e)$ and b is the monopole that appeared from the positive charge $(+e)$.

The tessellattice constricts a free inflated cell (a free quark) to a decreased cell (a lepton) because a small ball resists compression from the tessellattice better than a large ball. Therefore, a quark is transformed into a lepton. Although there is volumetric compression of the particle, its shape remains unchanged, i.e. the topology of the monopole state is preserved. For example, u^+ is transferred to e^+, and g_d is transferred to ν_e. That is, the magnetic monopole g_d of the d-quark becomes the electron's magnetic monopole g_e, which is associated with the neutrino ν_e.

The discussed mechanism of neutrino creation provides a very interesting opportunity to derive its mass, so to speak, from first principles.

3.2. Neutrino Mass

Expressions (3), (6)–(8) and Fig. 2 show that a particle moves in the tessellattice with a periodical decay of its mass. An electron anti-neutrino is the electron in its tension state, which is swiftly created at nonadiabatic conditions (Fig. 6). Therefore, a neutrino /anti-neutrino is a particle that should not have mass and electric charge; it is the particle that is in the state of tension, i.e., in terms of size, it can be the same as the surrounding cells of space, but unlike them, it is 'rigid'; in addition, the particle surface fractals are rolled up, or found in the combed state.

Thus, it seems the created neutrino cannot move by definition, because it is not a spatial excitation like a photon or inerton, which moves by hopping from cell to cell in the tessellattice. The neutrino is a real particle that can move only by squeezing between oncoming cells of the tessellattice, but such a motion requires mass as a consumable: the mass periodically decays passing to the tessellattice and then the latter returns the mass back, and so on.

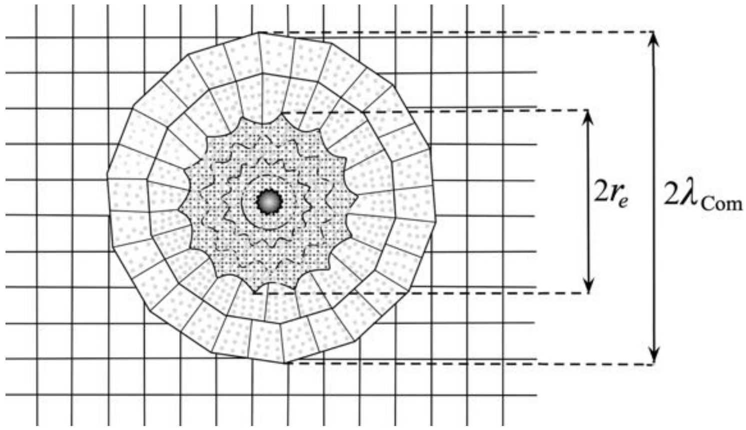

Figure 7. Deformation coat includes two substructures: massive and electrical, which are characterised by the Compton wavelength and the classical electron radius, respectively.

On the other hand, since neutrinos are found everywhere, they move, and therefore mass must be present in neutrinos. At the same time the electromagnetic state of the particle can remain frozen in the monopole state. This means that we must carefully investigate: what is the origin of the mass in the case of neutrino?

Figure 7 shows a particle, i.e. an electron, created in the tessellattice. The particle itself is small as it emerges from a cell, but it induces an extensive deformation coat in the tessellattice. The constitution of the deformation coat is quite complicated because the central contracted particled cell gives rise to a volumetric tension and electric polarisation in the coat's cells. The deformation coat moves together with the particle, which means that in each new position of the particle, the tessellattice adjusts its cells so that the deformation coat is always present around the particle.

The size of the electrically polarised deformation coat, which is known as the classical electron radius r_e, was measured by Thomson [45]. The size of the massive deformation coat, which known as the Compton wavelength of the electron λ_{Com}, was measured by Compton [46].

Submicroscopic mechanics [37] argues (Fig. 2) that the particle's mass completely disappears at the end point of each odd section λ of the particle path. Therefore, the massive coat should also disappear. However, Fig. 7 shows that the electric, or polar coat has to be preserved albeit in some altered state, owing to the fact that the monopole is able to affect the surrounding tessellattice. Indeed, the particle's surface fractals located on the surface of the particle change the dimension of the surface turning it from 2D to 3D (about the surface fractality see, e.g. Feder [47], Ch. 13). This means that the monopole must form and hold the massive deformation coat limited by the boundary of the sphere $4\pi r_e^2$. Any deformation of space induced by the electron neutrino is absent behind the radius r_e.

So, if the electron rest mass is m_e, which corresponds to the mass in the initial point of each odd section λ (Fig. 2), then in the final point of the odd section λ (which also is the initial point of the even section λ) the electron mass becomes

$$\mu = m_e \frac{4\pi r_e^2}{4\pi \lambda_{\text{Com}}^2} = m_e \cdot \left(\frac{r_e}{\lambda_{\text{Com}}}\right)^2. \tag{23}$$

For all three flavours (electron, muon and tau) the relationships below hold:

$$m_i c^2 = \frac{e^2}{4\pi\varepsilon_0 r_i}\ , \qquad \lambda_{\text{Com},i} = \frac{h}{m_i c}, \tag{24}$$

which shows that the ratio $r_i/\lambda_{\text{Com},i}$ is universal:

$$\frac{r_i}{\lambda_{\text{Com},i}} = \frac{\alpha}{2\pi} = \frac{e^2}{4\pi\varepsilon_0 ch} = 1.1614097324269 \times 10^{-3} \tag{25}$$

where r_i is the radius of electrically polarised coat of the ith neutrino flavour and α is the fine-structure constant (the definition of the α see in Ref. 37, Section 1.8.7).

Thus, the mass (23) is continuously kept in the electron and this mass matches its monopole state. It is obvious that this mass is also the anti-neutrino mass (and the neutrino mass too):

$$\mu_{\nu e} = m_e \cdot \left(\frac{\alpha}{2\pi}\right)^2 = 1.22873978 \times 10^{-36}\ \text{kg} = 0.68927247\ \text{eV}/c^2 \tag{26}$$

where the electron rest mass $m_e = 9.1093837 \times 10^{-31}$ kg. The electron anti-neutrino mass $\mu_{\nu e}$ calculated in expression (26) agrees well with the experimentally obtained inequality < 0.8 eV/c^2 [25]. A positron neutrino has the same value of mass.

Knowing the value of mass of a muon ($m_{\text{muon}} = 1.883531627 \times 10^{-28}$ kg, or 105.66 MeV/c^2) and tau ($m_{\text{tau}} = 3.16754 \times 10^{-27}$ kg, or about 1776.86 MeV/c^2), we can estimate the masses of their neutrinos by analogy with expression (26):

$$\mu_{\nu\text{muon}} = m_{\text{muon}} \cdot \left(\frac{\alpha}{2\pi}\right)^2 = 2.54062343 \times 10^{-34}\ \text{kg} \approx 142.534236\ \text{eV}/c^2, \tag{27}$$

$$\mu_{\nu\text{tau}} = m_{\text{tau}} \cdot \left(\frac{\alpha}{2\pi}\right)^2 = 4.27261 \times 10^{-33}\ \text{kg} \approx 2.39702\ \text{keV}/c^2. \tag{28}$$

Nevertheless, experimental data say that $\mu_{\nu\text{muon}} \le 0.19\ \text{MeV}/c^2$ [48] and $\mu_{\nu\text{tau}} < 18.2\ \text{MeV}/c^2$ [49]. These inequalities are significantly different from expressions (27) and (28), respectively, which may be due to the fact that the muon and tau neutrinos absorb a mass defect δm during inelastic collisions.

Let us consider the scenario according to which muon and tau neutrinos acquire a comparable significant mass. First, it is important to understand step by step how muon and tau decay occurs. In particle physics, the researchers present a typical reaction shown in Fig. 8. In this decay the creation of a W^- boson is the main point of the reaction. However, Fig. 5 and equation (17) point out that a W^- boson consists of a quark $\bar{u}$ and monopole g_u and the monopole cannot be born, only quark-antiquark pairs in a charged state can be created (the same for electron-positron pairs). A moving particle acquires its monopole state at the end of each odd section λ of its path, which is the particle's de Broglie wavelength. Therefore, muon decay is better described as follows.

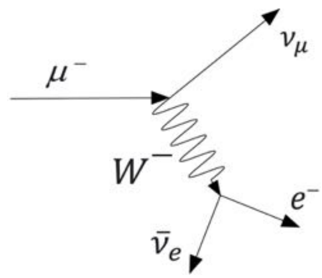

Figure 8. Muon decay, a conventional schema.

A high energetic muon meets a local obstacle like a scattering centre in which the energy becomes denser, such that the tessellattice creates a neutral perturbation there in the form of a quark-antiquark pair, $(u\,\bar{u})$. The pair can survive only if it possesses an angular momentum. Hence the quarks form a vortex and revolve around a common centre, and therefore emit and absorb quark inertons passing periodically through charge and monopole states. The muon μ^-, being in resonance with the created pair, falls into the middle of this quark pair and for that reason it passes from the state of lepton contraction to the inflated quark state, namely $\mu^- \rightarrow \bar{u}^-$. When the muon transforms into the $\bar{u}^-$quark and enters the middle of the quark pair in the state of charge, and the quarks of the pair are in monopole states ($g_u\, g_{\bar{u}}$), a rearrangement of particles occurs: formerly the muon, and now the quark $\bar{u}$, combines with a monopole g_u into a vortex, which is known as the boson $W^- = (\bar{u}^-\, g_u)$. Another monopole, namely $g_{\bar{u}}$, is released from this quark system and the tessellattice immediately contracts it to a muon neutrino μ_ν. Such a decay is demonstrated in Fig. 9.

Decomposition products of the reaction are ν_μ, e^- and $\bar{\nu}_e$. Here, the products e^- and $\bar{\nu}_e$ are generated from the W^- boson whose upper and lower energy thresholds are known. The muon neutrino ν_μ is most interesting because it carries away the energy of the original muon and also the neutrino ν_μ is able to carry additional energy that has been acquired from the scattering (Fig. 9).

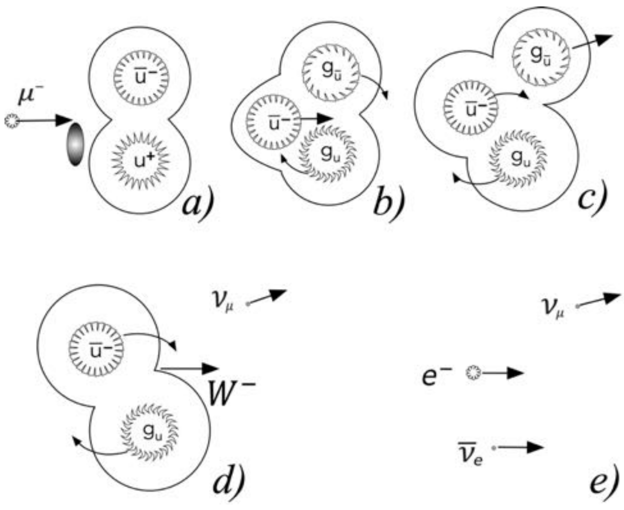

Figure 9. Stepwise muon decay.

The main branching fractions for tau decay are $\tau^- \to \nu_\tau + e^- + \bar{\nu}_e$ and $\tau^- \to \nu_\tau + \mu^- + \bar{\nu}_\mu$, which take place according to the scheme shown in Fig. 9. Namely, the tau neutrino ν_τ carries the main energetic characteristics of the history of the tau lepton.

Of course, all three leptons ν_e, ν_μ and ν_τ have the same configuration, although the radii of their kernel particled balls are different: $\mathbb{r}_e > \mathbb{r}_\mu > \mathbb{r}_\tau$, see the definition of mass (1). The three discrete states denote the three allowed states of the lepton monopole, i.e., neutrino ν_e, ν_μ and ν_τ.

During the inelastic scattering, a neutrino can be loaded with a clump of inertons, which in the form of a mass defect δm will settle on the neutrino and then the neutrino will move carrying this additional mass with it. In such a case the neutrino of a type i may further behave like a neutrino of a type $(i+1)$. In this case, if M_1 and $\vec{V}_1$ are the mass and velocity of the scatter and μ_i and $\vec{v}_1$ are the mass and velocity of the neutrino, the laws of momentum and energy conservation will be described by the following equations:

$$M_1 \vec{V}_1 + \mu_i \vec{v}_1 = (M_1 - \delta m)\vec{V}_2 + (\mu_i + \delta m)\vec{v}_2 \tag{29}$$

$$M_1 c^2 + \mu_i c^2 = \frac{(M_1 - \delta m)}{\sqrt{1 - V_2^2/c^2}} c^2 + (\mu_i + \delta m) c^2 \tag{30}$$

where $M_1 = M_0 / \sqrt{1 - V_1^2/c^2}$ and $\mu_i = \mu_{0i} / \sqrt{1 - v^2/c^2}$.

The equations (29) and (30) show that at the output of the inelastic scattering reaction, we get the neutrino that is heavier than the input neutrino: $\mu_i \to \mu_i + \delta m$. However, the initial $\mu_i \vec{v}_1$ and final $(\mu_i + \delta m)\vec{v}_2$ momenta of the neutrino can be the same or the final momentum may even exceed the initial one. Therefore, the neutrino remains the same, but we can mistakenly assume that we got a neutrino to switch from type i to $(i+1)$, for example from muon to tau.

In interesting research, we [50] observed how hydrogen atoms transformed into hydrogen atoms with a mass up to around 200 times greater than their standard mass. At a plasma discharge in a hydrogen atmosphere, a proton moving to the cathode under conditions of pulse resonance knocked out an inerton cloud from a tungsten atom. Next, the formation of a hydrogen atom from the proton and nearest electron took place in the environment of the tungsten atom's inerton cloud (but without the presence of the atom itself). As a result, the initiated hydrogen atom became 200 times heavier and consequently decreased in diameter by three orders of magnitude, i.e. its radius had to decrease from 10^{-10} to about 2.6×10^{-13} m. Also, the neutron counter measured a flow of low-energy neutrons, so, those sub particles were structurally hydrogen atoms, or rather subhydrogens.

However, in light of the topic presented in this paper, it cannot also be ruled out that during the formation of a subhydrogen [50], an electron, absorbing the inerton cloud of the tungsten atom, passed into a muon. Thus, the produced subhydrogen atoms could be really massive excited proton-muon pairs. The phenomenon is interesting because it points to the possible particle transformation occurred at an energy of a few eV only, though with the participation of the absorbed mass defect (however, the transformation of one particle into another must occur at the speed of light c or faster, but it is not known whether in a subhydrogen this condition was met).

Coming back to the neutrino mass, we can now clarify the discrepancy between the experimentally obtained upper limits on the electron anti-neutrino mass: < 150 eV/c^2 [23], < 152 eV/c^2 [24] and < 0.8 eV/c^2 [25]. The first and second values were obtained studying the systems in which an inelastic scattering of electrons took place. An anti-neutrino created at the absorption of an electron by a ^{163}Ho atom [23] could be loaded with a mass defect δm, i.e. a clump of inertons, such that its mass approached the inequality < 150 eV/c^2. A similar situation could happen in experiment [24] when electrons were inelastically scattering by a tritium atom, and with such scattering, the released neutrino picked up a mass defect δm and obtained an effective mass of about 152 eV/c^2. Those measured upper limits of the neutrino mass are around 5 to 6% larger than the calculated mass (27), which points to the fact that in the experiments [23] [24] generated neutrinos were rather muon anti-neutrinos. Indeed, the ratio $\mu_{\nu\text{muon}}/\mu_{\nu e}\approx 207$ holds (see expressions (27) and (26)), which is the same as for the muon and electron masses. Thus, the researchers [24] [25], intending to measure the mass of the electron anti-neutrino, actually measured the self-mass of the muon anti-neutrino.

On the other hand, the experiment [25] was quite mild, so that there was no inelastic electron scattering and therefore the researchers measured a true upper limit on neutrino mass, about 0.8 eV/c^2, which is only 16% larger than the calculated value (26) above.

The considered situation can also be applicable to the calculated masses of the muon (27) and tau (28) neutrino. It cannot be precluded that the reported experimental upper limits $\mu_{\nu\text{muon}} \le 0.19\ \text{MeV}/c^2$ [48] and $\mu_{\nu\text{tau}} < 18.2\ \text{MeV}/c^2$ [49] included a mass defect δm that the muon and tau neutrinos captured during decays of the W, Z bosons and/or a few other hadrons when processes of inelastic scattering took place. Moreover, the possibility that these two upper limits of neutrino masses correspond to two new unknown neutrino flavours cannot be excluded, although it seems the term ‘stable neutrino mass excitations’ is more suitable.

4. Discussion

In particle physics, elementary particles are treated as rigid point-like objects, which allows the researchers to introduce abstract mathematical techniques, such as various symmetries, non-commutative geometry, string theory, etc. In paper [51] the authors note that QCD is a theory that describes quarks and gluons, whose interactions obey a local SU(3) gauge symmetry having “colour quantum numbers”, and the goal of their review is to provide advanced Ph.D. students a comprehensive handbook, helpful for their research. They emphasise that there are many models that assume many numbers of colours in QCD, which give unique insights. Another large group of researchers [52] observes that QCD, though explaining the behaviour of quarks and gluons, remains complex and challenging; they further note that such challenges, along with the desire to understand all visible matter at the most fundamental level, position the study of QCD as a central thrust of research in nuclear science.

However, particle physics, and in particular QCD, ignores important research data obtained in the past, namely that the electron has a classical electrically polarised radius and a Compton wavelength (as do other particles). Of course, if the theory does not bear in mind important details, its assumptions and conclusions may differ significantly from the actual characteristics of real particles.

The results obtained above show the extent of the possibilities of the submicroscopic deterministic concept presented in book [37]. The deterministic concept makes it possible to build fundamental physics starting from the smallest details, which provides an opportunity to solve complex problems beyond the reach of abstract mathematics. As the result, the deterministic concept, or submicroscopic approach has defined the notions of real physical space, revealed the origins of leptons and quarks, mass, charge, photon, inerton, neutrino, the particle’s de Broglie wavelength, etc. An important feature of this concept is the continuous interaction of a particle with space. In particular, the submicroscopic approach unambiguously determines quarks as volumetric particles with an integer charge $\pm e$ and does not allow any fractional charges such as $\pm e/3$ and $\pm 2e/3$. Besides, the approach shows that any charged particle is a dynamic dyon because its scalar charge state e periodically changes to an axial monopole state $\vec{g}$. These words are also confirmed by Comay’s [28] [53] research in which he criticises QCD and indicates that in the presence of the introduction of a magnetic monopole in addition to the existing charge, the modified theoretical results significantly improve the comparison with the experimental ones.

All these findings indicate that the dominant abstract theory of QCD with its at least 16 free parameters is a misguided discipline. In fact these fittings parameters are: two fractional charges $e/3$ and $2e/3$, three colour charges, eight colour gluons, the violation of CP symmetry with its exotic particle 'axion', a crude assumption that the extended (3D+δD)-quark is replaced by a zero-dimensional mathematical point with a set of convenient symmetries, and neglecting the interaction of the particle with the surrounding tessellattice.

The term "chromo", i.e. "colour", should be rejected from QCD; the future theory that will describe the behaviour of quarks may be called Quantum Bubble Dynamics (QBD). That future theory should also include in its consideration a realistic interaction between quarks and leptons via inertons, which will also replace the current theory of weak interactions.

Earlier in this paper, we have already noted that $W^{\pm}$ and Z^0 bosons must indeed be heavy mesons made up of a pair of quarks. The same would be reasonable to assume regarding an experimentally found particle named the Higgs boson H^0, because its decays are decidedly characterised by pairs of leptons.

QCD does not know what the neutrino at all is. 50 years has not been enough for this theory to find out what kind of particle it is (a Dirac one, a Majorana one, a sterile one, etc.), how it appears from nothing, and so on. The QCD theory does not appear to be applicable to neutrino physics.

The submicroscopic concept operates with the notion of mass as a fractal local deformation of cells of space, which is periodically defragmented during movement, and this allows us to look at the problems related to neutrinos at a deeper level. Besides, the appearance of neutrinos in nuclear and particle physics cannot be explained without understanding the structure of space in the form of the tessellattice and Maxwell's equations in the symmetrical configuration that includes both a charge (10) and a monopole (11). A neutrino arises from the monopole state of a quark (an inflated particled cell) when this free particle is squeezed by the pressure of the tessellattice to the lepton state. Submicroscopic examination of particles clears the way to determine the deformation coat of the particle and finally determine the neutrino's self-mass (or 'rest' mass), expressions (26)–(28).

Considering the presented research, it is very amusing to read about the search for magnetic monopoles (abstract magnetic monopoles of the Dirac type) using neutrinos [54] [55]: 10 years of scrupulous research gave no result.

Understanding the origin of the neutrino self-mass permits us to consider the possibility of the neutrino to be a carrier of a mass defect δm that it can capture at the scattering centre or during the particle transformation reaction. Then the absorbed mass δm affects the neutrino so that its size decreases, i.e. the initial radius begins to drop from the $\mathbb{r}_{\mathrm{e}}$ to $\mathbb{r}_{\mu}$ or even $\mathbb{r}_{\tau}$.

Assuming the presence of a mass defect in neutrinos allows us to critically reconsider the concept of neutrino oscillations.

Currently the neutrino oscillation process is treated in the framework of the following model. An energy eigenvalue of a high energetic neutrino of a type k is

$$E_k = \sqrt{p^2c^2 + m_k^2c^4} - m_k c^2 \tag{31}$$

from which

$$E_k \cong E_0 + \frac{m_k^2 c^4}{2E_0} \ . \tag{32}$$

Since in the quantum mechanical formalism the motion of a particle is associated with a plane wave, the amplitude of the probability in a point A in the time t is presented as below

$$A_k(t) = C \exp\{-i\frac{E_k}{\hbar}t\}. \tag{33}$$

The transition probability for the neutrino to change from ν_k to ν_j is written in the form:

$$|A_{k\to j}(t)|^2 = C \sum_{k,j} \exp\{-i\frac{E_k - E_j}{\hbar}t\} = C \sum_{k,j} \exp\{-i\frac{\Delta m_{k,j}^2 c^4}{2E\hbar}t\}$$
$$= C \sum_{k,j} \exp\{-i\frac{\Delta m_{k,j}^2 c^3}{2E\hbar}L\}, \tag{34}$$

which is further transformed to a state suitable for use by experimenter

$$P\left(\nu_k \ \to \ \nu_{j\neq k}\right) = \sin(2\theta)\sin\frac{\Delta m^2 \ c^3}{2E\hbar}L. \tag{35}$$

In the expression (35) the fitting parameters, which are called oscillation parameters, are: θ, Δm, L and also E. The expression (35) can be complicated by the matter effect that depends on the density and composition of the medium, which includes neutrino refraction, matter potential, and evolution in matter (the MSW effect, [56]). Here, it seems the energy E of the neutrino flux is the most reliable parameter. The angle of incidence θ of the neutrino flux can also be determined more or less reliably. However, the distance L at which the oscillation occurs is an entire fitting parameter. The mass difference Δm is also quite uncertain.

In fact, what does the mass difference Δm mean? This is the difference between self-masses of two different neutrino flavours. In Sect. 3.2 it has been shown that these masses differ from each other by several orders of magnitude. Hence, if we allow that the masses change so significantly in the process of oscillation, for example 100 times, then we recognize as legitimate the violation of the laws of conservation: the mass m_i spontaneously changes to $m_j = 100\, m_i$ but the neutrino continues to move with the same velocity and the same energy. On the other hand, if the mass difference is very low $\Delta m \approx 0$, this means that the neutrino does not change the flavour; therefore, no oscillation occurs.

Thereby, the well-known theory of neutrino oscillations, which is based on the probability transition (31)–(35), cannot provide convincing evidence of the assumed changes in the reduction of light flavours and the appearance of heavy flavours. Moreover, serious problems in neutrino oscillations were pointed out earlier [57], namely, the author reasonably emphasised that, allowing neutrino oscillations, the researchers admit the possibility of violating the laws of conservation of energy and momentum.

On the other hand, the reduction of some flavours of neutrinos and the appearance of others can easily be clarified within the framework of the submicroscopic deterministic concept. The distance L is an important parameter since the longer the path, the more scattering centres the neutrino will encounter. The more such centres, the greater the probability of an inelastic collision of the neutrino with scatterers. On the collision with inelastic scatterers, the neutrino loads a mass defect δm, i.e. a clump of inertons, which automatically means that the neutrino's particled cell has shrunk a bit, and the neutrino is moving further with a higher energy. But if during such a contraction the radius of the particle reaches the threshold value (the mass defect $\delta m = m_j - m_i$), then the transition to another flavour occurs, i.e. the neutrino switches from the flavour i to j.

When passing from the lighter flavour i to the heavier j, the neutrino under consideration acquires not only a larger mass, but also continues moving with the initial value of its speed (i.e., practically the speed of light c, as shown in the conservation equations (29) and (30)).

In the course of an inelastic scattering, ν_μ and ν_τ neutrinos may also lose their mass defect, and in this case, the transition to an electron neutrino ν_e will occur.

5. Conclusion

Modern neutrino physics and particle physics in general still treat particles as points with some properties, which do not interact with the environment. However particles are volumetric objects that incessantly interact with the surrounding space.

This paper demonstrates that some already familiar things and established facts allow a completely natural rethinking and careful revision considering space as a substrate. The submicroscopic deterministic concept developed in the author's previous works, which describes Nature at a deeper level of knowledge than the quantum mechanical formalism, finds its application in the specific problem of neutrino mass. Instead of an abstract Higgs field, the main role in the theory is played by a mathematical lattice of topological balls named a tessellattice, which describes real physical space. A particle appears from a cell of the tessellattice (at the Planck's scale) at the cell's fractal deformations, and when moving, the particle constantly interacts with oncoming cells through both the volume and surface. And it is the presence of this interaction that makes quantum mechanics different from classical mechanics, even though quantum mechanics does not take this interaction into account.

Submicroscopic mechanics introduces a new physical field, which is a substructure of matter waves. This field has been named an inerton field because it can easily be associated with the field of inertia. The existence of inertons has been experimentally verified in condensed matter, biosystems, plasma physics, nuclear physics and astrophysics, and several practical applications have already been implemented (see, e.g. Ref. [37]).

The submicroscopic approach allows us to understand the origin of neutrinos, visualise their shape and physical properties, and gives an opportunity to makes these particles understandable, which, in principle, goes beyond the capabilities of current theoretical approaches used in particle physics. In particular, the concept resting on the structure of real space in the form of the tessellattice introduces only one type of neutrino, bypassing such forms as Dirac, Majorana, sterile, etc. The paper claims that the neutrino is a magnetic monopole of the corresponding leptonic particle, namely the positron, anti-muon and anti-tau; respectively, the anti-neutrino is the magnetic monopole of the electron, muon and tau.

The self-mass (a 'rest' mass) for each neutrino flavour is calculated. The calculated value $\mu_{\nu e} = 0.68927247\ \mathrm{eV}/c^2$ (26) of the self-mass for the electron anti-neutrino is entirely consistent with the upper experimental threshold [25]. The calculated self-mass of the muon neutrino $\mu_{\nu \mathrm{muon}} = 142.534236\ \ \mathrm{eV}/c^2$ (27) has been found to be in accordance with the experimental results [23] [24]; it turns out that the researchers, looking for an upper limit for the mass of the electron neutrino, have measured the upper limit for the mass of the muon neutrino.

Recognising that the neutrino is characterised by its self-mass, the rest mass, we must reject the idea of oscillations between neutrino flavours because it contradicts the fundamental physical laws of conservation. Then switching from one flavour of neutrino to another is only possible due to inelastic scattering of neutrinos by oncoming combined particles and nuclei, resulting in the neutrino being loaded with a mass defect, which is a clump of inertons. That is, after receiving additional mass during inelastic scattering, which reaches the threshold value, the neutrino immediately passes into the state of a heavier flavour, and hence the amount of the lighter flavour automatically decreases in the neutrino flux studied. Indeed, the longer the neutrino's path, the more transitions to heavier neutrino flavours are observed by experimenters. The transition from a heavier to a lighter neutrino occurs when the corresponding fragment of the mass is released, that is, when the mass defect is transferred from the neutrino to the scatterer.

Thus, this work expands the knowledge base in fundamental physics and shows the importance of using the tessellattice in all particle physics research. There is no physical vacuum, instead there is a primary substrate existing in the form of the tessellattice.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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