WEAKLY INTERACTING PARTICLES AS DIFFERENT STATES OF A STRUCTURAL MASS UNIT

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We have delivered the concept of a structural mass unit as a carrier of a special basic structure, different states of which can be compared (juxtaposed) to weakly interacting particles and antiparticles. This structure radically differs from the compound structure of atoms and nuclei as it doesn't contain the elements its mass is formed of, and its components cannot be interpreted in the concept of "particles" and removed from it. Mutual transformation of weakly interacting point particles is the result of basic structure and it is possible if every particle has an antiparticle. Mass (energy) of states of the basic structure carrier depends on the orientation of the components of this structure. Neutrino and antineutrino appear to be the states of the structural mass unit and therefore they possess mass. Antiparticles and particles are different states of the basic structure carrier, the structure components of which have opposite signs.

1 Introduction

In modern physics weakly interacting particles are considered as fundamental objects since the experiment has shown that they don't consist of any primary particles and don't have a structure [1]. Interaction of these objects is also well studied. However, the ability of these point particles for mutual transformations, regularity of these transformations and the number of the particles themselves don't result from nothing. Therefore, the Standard model mainly deals with interaction of the named particles and the pattern of mutual transformations and also the spectrum of these particles are obtained from the experiment. According to the concept considered below, transformations of weakly interacting particles follow from the fact that all the named particles and antiparticles are, in essence, different states of the carrier of a special structure that differs radically from the constituent structures of atoms and nuclei. This carrier, named by the author of this article as a structural mass unit, has a number of states which are able to transform into each other in much the same way as it happens with weakly interacting particles.

2 Concept of a structural mass unit

The concept of a structural unit is widespread in modern science. In physics, for example, a molecule can be regarded as a structural unit consisting of atoms, an atom can be regarded as a structural unit in chemical compounds, and an atomic nucleus – as a structural unit in atoms. We now introduce the concept of a structural mass unit (hereinafter abbreviated as SMU) which will be understood as a self-contained part of matter, i.e. existing separately from other similar parts, independent, its mass is not equal to zero. The main distinction of a structural mass unit from the above mentioned units is that this part of matter cannot be divided into the constituents that could exist independently. Mass of such composite structures as molecules, atoms and nuclei is made up of masses of particles they consist of, and for all that the summary mass of such structures is always a little less than the sum of masses of unbound constituent particles as a result of their interaction. But SMU doesn't contain constituent particles, and the mechanism of generating its mass is quite different and unknown for the time present. After all, mass is a carrier of energy. It has inertial and gravitational properties. But how SMU conserves energy is, in fact, a mystery.

The fundamental difference of SMU from molecules, atoms and nuclei as structural units of matter consists in that for the first one a special kind of structure is peculiar; the concept of "particles" as very small discrete formations possessing mass and moving in space is not

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applicable for interpreting the components of this structure. Therefore, for describing the structure of SMU it is not required to introduce any constituting it particles in the usual sense, and splitting this unit into structural components is no longer possible. The structure of SMU, fundamentally different from the structure of molecules, atoms and atomic nuclei, we will name as a basic structure [2, 3] since it is its basis. Thanks to its structure, SMU can be in different states which have different mass. And these states can be identified to leptons, their antiparticles, $W^{\pm}$- and Z^{0}-bozons as independent parts of matter. The analysis, presented below, confirms, according to our opinion, reality of the SMU.

3 Vector diagrams for different states of SMU

The concept of a structural mass unit of weakly interacting particles is based on the distribution law of pair values for the conserved additive quantum numbers of these particles [4]. The mentioned particles together with antiparticles have the following values of number pairs (L,Q), where L is any of lepton quantum numbers L_e, L_μ or L_τ, while Q is an electric charge of a particle in the system where the module of electron charge is assumed as equal to one: $(\pm 1,\mp 1)$ and $(\pm 1,0)$ for charged and neutral leptons of all generations, $(0,\pm 1)$ and $(0,0)$ for $W^{\pm}$- and Z^{0}-bosons respectively. Number pairs W_y and Z_y, obtained with the help of transformation

$$W_y = \tfrac{1}{2}Q,\ \ Z_y = -\tfrac{1}{2}L - \tfrac{1}{2}Q\,, \tag{1}$$

are also conserved additive quantum numbers. From (1) we get the following values of number pairs (W_y, Z_y): $(\mp\frac{1}{2},0)$, $(0,\mp\frac{1}{2})$ for charged and neutral leptons of all generations $(\pm\frac{1}{2},\mp\frac{1}{2})$ and $(0,0)$ for $W^{\pm}$- and Z^{0}-bosons respectively. The numbers W_y and Z_y admit the following nontrivial interpretation.

Let us introduce the vectors $\mathbf{W}$ and $\mathbf{Z}$ in some abstract space, the origins of these vectors coincide. The projections of these vectors $W_y = |\mathbf{W}|\cos\alpha$ and $Z_y = |\mathbf{Z}|\cos\beta$ on the distinguished direction Y in this space, set by the vector $\mathbf{Y}_w$, will be calculated by the formulae (1) for weakly interacting particles. We take the modules of the introduced vectors equal to $|\mathbf{W}| = |\mathbf{Z}| = 1/\sqrt{3}$. According to the values of the projections W_y and Z_y let us plot planar vector diagrams for each of the mentioned particles individually (Fig.1). The angles between the vectors $\mathbf{W}$ and $\mathbf{Z}$ in all the diagrams (except the last one) are equal to $2\pi/3$. At each transition from one diagram to another in the order corresponding the particles $e^{+} \to W^{+} \to \nu_e \to e^{-} \to W^{-} \to \bar{\nu}_e \to e^{+}$ a pair of vectors $\mathbf{W}$ and $\mathbf{Z}$ turns $\pi/3$ each time as a single whole relative to the vector $\mathbf{Y}_w$.

We can suppose that in these diagrams the vectors $\mathbf{W}$, $\mathbf{Z}$ and $\mathbf{Y}_w$ represent inseparable from each other components of some structure, different states of which are determined by the orientation of the vectors $\mathbf{W}$ and $\mathbf{Z}$ relative to the vector $\mathbf{Y}_w$. According to the concept under consideration such structure is peculiar to the structural mass unit, different states of which turn out to be all the weakly interacting particles. The numbers W_y and Z_y represent the states of this structure. As it can be seen from (1) the values of additive quantum numbers and a spin of weakly interacting particles can be determined by the formulae

$$L_e = -2(W_y + Z_y),\ Q = 2W_y,\ s = \hbar\left|W_y - Z_y\right|, \tag{2}$$

s is a spin of a particle; $\hbar$ is Planck's constant. The components $\mathbf{W}$ и $\mathbf{Z}$ make contribution to the spin of a particle which is proportional to the projections of these vectors on the vector $\mathbf{Y}_w$

equal to $\pm\frac{1}{2}$ or 0. It follows from the diagrams in Fig.1 that the spin of leptons is equal to $\frac{1}{2}$, $W^{\pm}$-bosons – 1, Z^0-boson – 0.

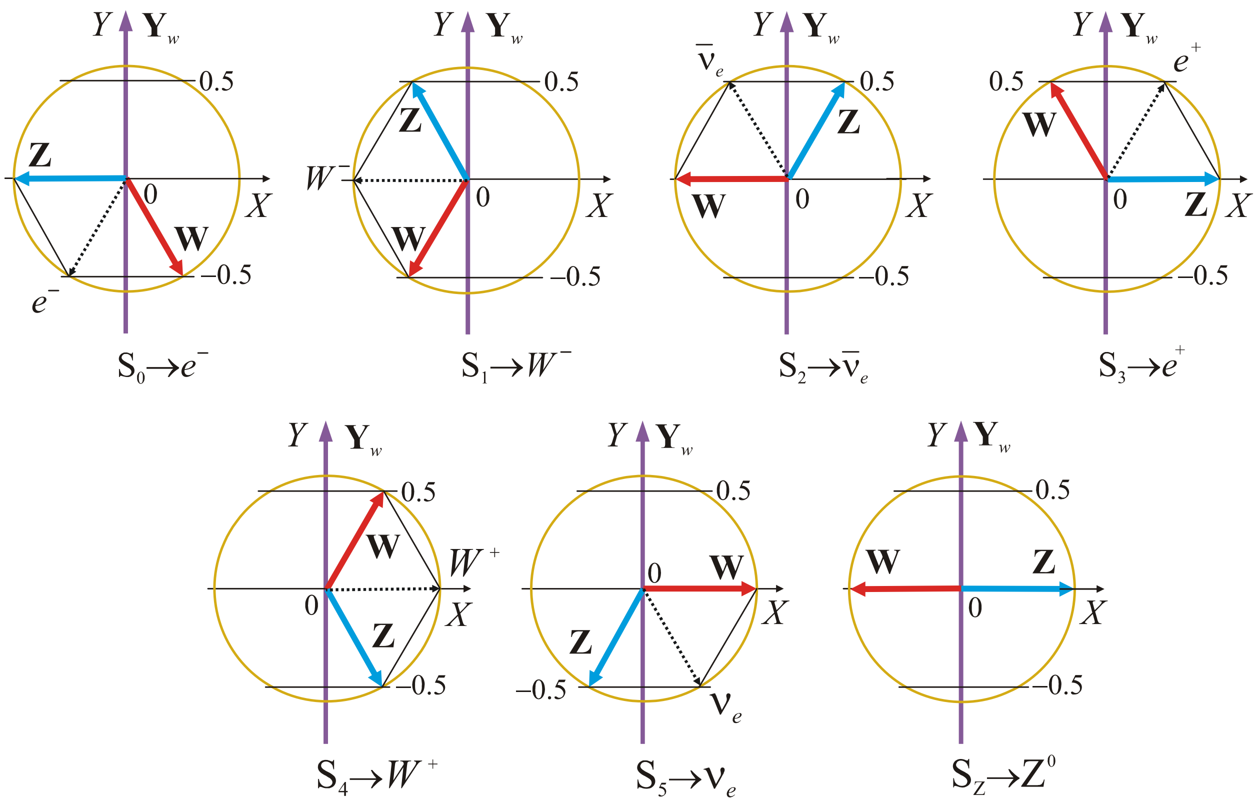

Figure 1: Vector diagrams for the states of SMU corresponding weakly interacting particles of the first generation. The dotted line shows the vectors being equal to $\mathbf{W}+\mathbf{Z}$

Connection of the vectors W and Z in the diagrams of states shown in Fig. 1 and designated as S_n consists in that

$$W_n = W_{n+1} + W_{n-1},\ Z_n = Z_{n+1} + Z_{n-1}, \tag{3}$$

where $n \neq z$. Whence it follows that any state S_n can be presented symbolically as

$$\mathrm{S}_n = \mathrm{S}_{n+1} + \mathrm{S}_{n-1}. \tag{4}$$

To describe the structure of MSU for weakly interacting particles it is not required to introduce any particles composing it. The more so as such particles are not really discovered in them [1]. Consequently, it makes no sense to interpret the components of SMU structure, represented by the vectors $\mathbf{W}$, $\mathbf{Z}$ and $\mathbf{Y}_w$, in the concept of “particles” as very small discrete formations possessing mass and moving in space.

4 Transformation of different states of SMU

Weakly interacting particles as different states of SMU can transform into each other since SMU states have this property. Let us designate SMU in the state S_n as SMU(S_n), where index n equals the number of the state in the diagram (Fig.1). Let us consider SMU transformation lying in the basis of $W^+ \to e^+ + \nu_e$ process. The vector diagram of this process is presented in Fig. 2. As follows from the diagrams in fig.2, vector equalities are satisfied in this transformation

$$\mathbf{W}_4 = \mathbf{W}_3 + \mathbf{W}_5, \quad \mathbf{Z}_4 = \mathbf{Z}_3 + \mathbf{Z}_5. \tag{5}$$

Therefore, we may write as follows

$$\mathrm{SMU}(\mathrm{S}_4) \to \mathrm{SMU}(\mathrm{S}_3) + \mathrm{SMU}(\mathrm{S}_5). \tag{6}$$

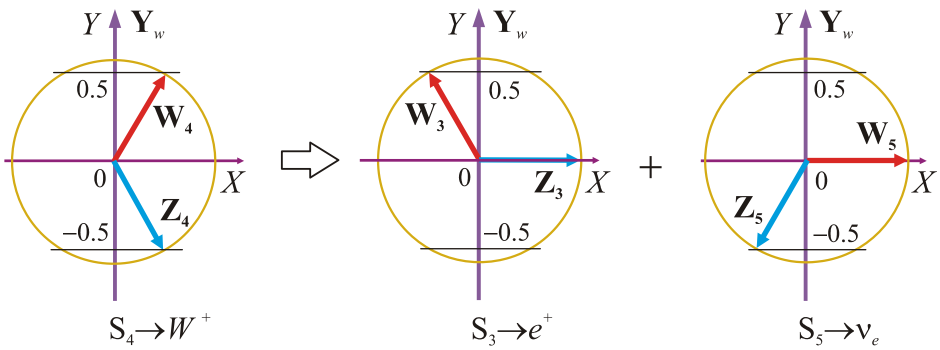

Figure 2: Transformation of SMU lying in the basis of $W^+ \to e^+ + \nu_e$ process

As evident from Fig. 2, each of W- and Z-components of the generated states S_3 and S_5 has been obtained as a result of decomposition of the vectors $\mathbf{W}_4$ and $\mathbf{Z}_4$ of the original structure into the two composing vectors $\mathbf{W}_3$ and $\mathbf{W}_5$, $\mathbf{Z}_3$ and $\mathbf{Z}_5$ respectively. The structure of the objects generated as a result of transformation of S_4 state has not become simpler than the original one. Therefore, as a result of this transformation the SMU structure is reproduced again in each of newly generated objects, and the integrity of SMU is not broken either.

The equalities (5) are equivalent to the equalities for the projections of these vectors along the axes Y and X

$$W_{y4} = W_{y3} + W_{y5}, \quad Z_{y4} = Z_{y3} + Z_{y5}. \tag{7}$$

$$W_{x4} = W_{x3} + W_{x5}, \quad Z_{x4} = Z_{x3} + Z_{x5}. \tag{8}$$

From the equalities (7) and (2) it follows that additive quantum numbers Q and L_e are conserved in the process (5) individually.

4 Transformation mechanism of SMU states

If we compare transformation of some state of SMU depicted in Fig.2 with a simplified picture which depicts a biological cell division into two analogous cells, then their superficial resemblance indicates the validity of introducing the term 'structural mass unit'. During this process one SMU(S_n) transits from the state S_n into the state S_{n-1} or S_{n+1}. From Fig. 2 we can see that this transition is accompanied by the appearance of a new SMU in the state S_{n+1} or S_{n-1} respectively. This means that one SMU transforms into two SMUs. However, it would be incorrect to consider this process as a division of SMU into two parts which it doesn't have. In fact, SMU experiences a complex transformation in which various virtual pairs of structural mass units necessarily take part. Let us illustrate it by the example of SMU(S_4) transformation shown in Fig. 2.

For the vectors W and Z from different diagrams in Fig. 1 there are equalities

$$\mathbf{W}_n + \mathbf{W}_{n+3} = 0 \quad \text{и} \quad \mathbf{Z}_n + \mathbf{Z}_{n+3} = 0 . \tag{9}$$

Therefore, we can think that in the vacuum there constantly appear virtual pairs of structural mass units in the states S_n and S_{n+3} simultaneously, their vectors satisfy the equalities (9). Let us designate these virtual pairs as $\left[\mathrm{SMU}(S_n) + \mathrm{SMU}(S_{n+3})\right]_{virt}$.

Now the equality (4) can be interpreted as follows: transition $\mathrm{SMU}(S_4) \to \mathrm{SMU}(S_5)$ appears when the original structural mass unit in the state of S_4 absorbs another virtual unit $[\mathrm{SMU}(S_0)]_{virt}$ taken from the virtual pair $\left[\mathrm{SMU}(S_0) + \mathrm{SMU}(S_3)\right]_{virt}$. In fact, from the vector diagrams in Fig 1 it follows that $\mathrm{SMU}(S_4) + [\mathrm{SMU}(S_0)]_{virt} \to \mathrm{SMU}(S_5)$. After this the second virtual structural unit $[\mathrm{SMU}(S_3)]_{virt}$ becomes real $[\mathrm{SMU}(S_3)]_{virt} \to \mathrm{SMU}(S_3)$ (Fig. 3).

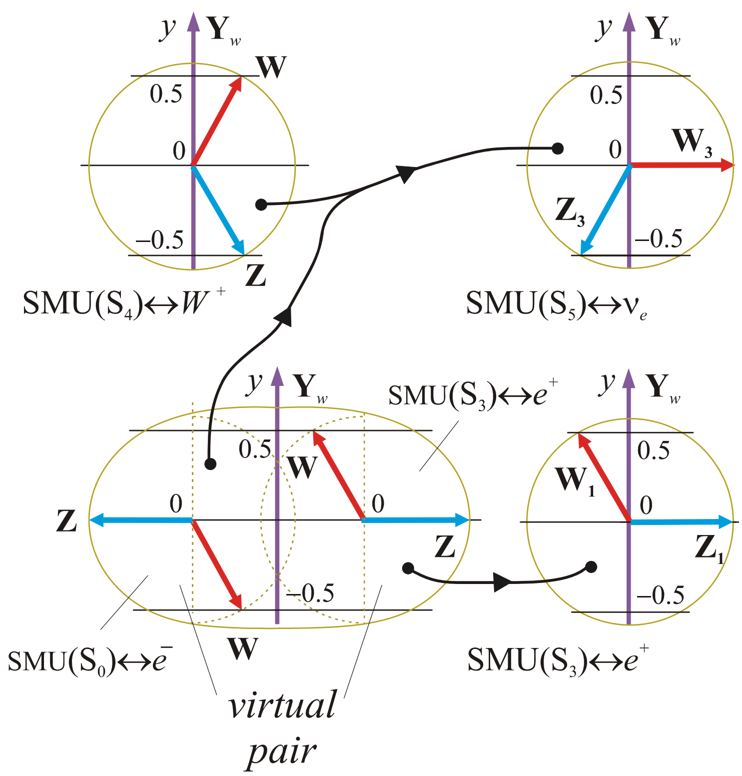

Figure 3: The diagram of transformation $\mathrm{SMU}(S_4) \to \mathrm{SMU}(S_5) + \mathrm{SMU}(S_3)$ with participation of the virtual pair $\left[\mathrm{SMU}(S_0) + \mathrm{SMU}(S_3)\right]_{virt}$

This transformation can also occur with participation of another virtual pair $\left[\mathrm{SMU}(\mathrm{S}_2)\mathrm{+SMU}(\mathrm{S}_5)\right]_{virt}$, however with the same final result (Fig. 4).

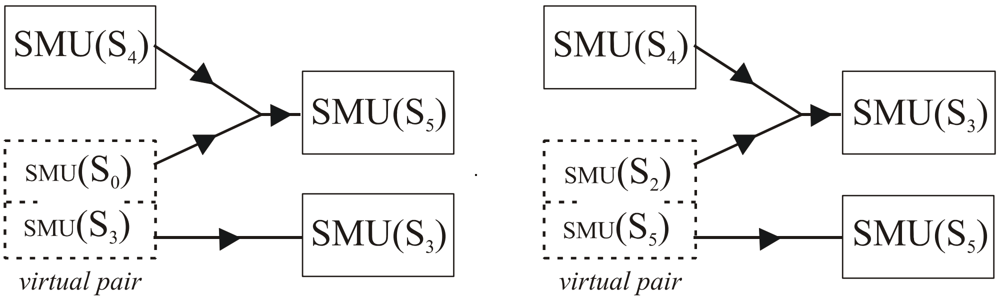

Figure 4: The diagrams of transformation $\mathrm{SMU}(\mathrm{S}_4) \to \mathrm{SMU}(\mathrm{S}_5) + \mathrm{SMU}(\mathrm{S}_3)$ and participation in this process of virtual pairs $\left[\mathrm{SMU}(\mathrm{S}_0) + \mathrm{SMU}(\mathrm{S}_3)\right]_{virt}$, or $\left[\mathrm{SMU}(\mathrm{S}_2)\mathrm{+SMU}(\mathrm{S}_5)\right]_{virt}$.

Transformations of weakly interacting particles occur in accordance with the diagrams shown in Fig. 4. In the examined process the original SMU completely absorbs virtual SMU. Such transformation corresponds the process adding SMU + SMU = SMU. The summary process of transformation is described by the formula (4). Then in each of the virtual pairs $\left[\mathrm{SMU}(\mathrm{S}_0) + \mathrm{SMU}(\mathrm{S}_3)\right]_{virt}$ or $\left[\mathrm{SMU}(\mathrm{S}_2)\mathrm{+SMU}(\mathrm{S}_5)\right]_{virt}$, as it can be seen from the diagram in Fig.1, one of the virtual structural units corresponds the particle and the other one corresponds its antiparticle. Whence it follows:

1. For the processes of transformation of the structural mass unit states it is not required at all that the mentioned unit consists of any parts or primary particles. It participates in such processes as an integral object interacting with virtual pairs of structural mass units.
2. In the presented concept mutual transformations of weakly interacting particles is possible only then when all these particles have antiparticles. Thus, the observable transformations of weakly interacting particles occur only because each of these particles has its antiparticle. If these antiparticles didn't exist, then the transformations of particles wouldn't occur. Therefore, mutual transformation of the mentioned particles is as informative property of their nature as mutual transformation of particles.

5 Transformation of SMU states compared to different generations of weakly interacting particles

Transformations of SMU lying in the basis of the processes $W^+ \to \mu^+ + \nu_\mu$ or $W^+ \to \tau^+ + \nu_\tau$, depicted with the help of diagrams, will individually have just the same form as it happens in the process of $W^+ \to e^+ + \nu_e$ (Fig. 2). However, in these transformations there appear particles and antiparticles of the second and third generations. Therefore, the components W and Z of SMU states, corresponding different generations, should be different. This can be achieved by means of conserving planar diagrams without changes for the states of SMU but arranging the diagrams' planes under different angles to each other. For that we introduce the vector $\mathbf{L}_w$

perpendicular to the vector $\mathbf{X}_{w2}$ and forming some angle with the vector $\mathbf{Y}_{w2}$. Then the transformation of SMU, corresponding the process of $W^+ \to \mu^+ + \nu_\mu$, will have the same form as it is shown in Fig. 5. As follows from the diagram in Fig. 5, in this transformation vector equalities are satisfied

$$\mathbf{W}_4 = \mathbf{W}_3 + \mathbf{W}_5, \quad \mathbf{Z}_4 = \mathbf{Z}_3 + \mathbf{Z}_5. \tag{5}$$

Let us designate the projections of the vectors **W** and **Z** along the direction $\mathbf{L}_w$ as W_L and Z_L. As it can be seen from Fig. 5, for the state of SMU(S_4) the number $W_{4L} + Z_{4L} = 0$, for SMU(S_3') $W_{3L} + Z_{3L} = W_{3L} < 0$ and for SMU(S_5') $W_{5L} + Z_{5L} = Z_{5L} > 0$. The values of these numbers normalized for the module of the vectors **W** or **Z** can be taken as the number L_μ. It turns out that for the state SMU(W^+) $L_\mu = 0$, for SMU(μ^+) $L_\mu = -1$, and for SMU(ν_μ) $L_\mu = 1$. Having constructed the similar diagrams for other transformations with the particles of the second generation we obtain $L_\mu = -1$ for SMU$(\bar{\nu}_\mu)$ and $L_\mu = 1$ for SMU(μ^-).

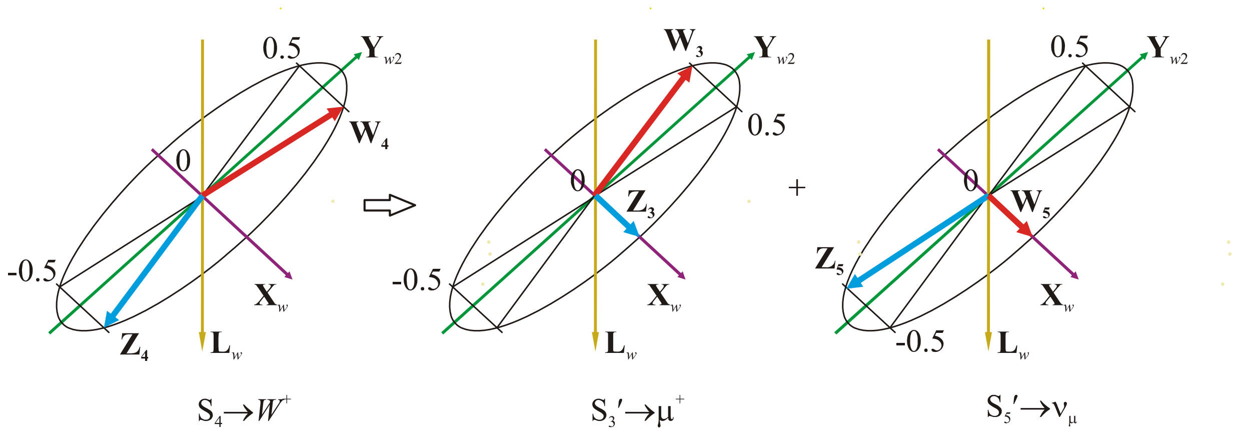

Figure 5: Transformation of the structural mass unit

lying in the basis of the process $W^+ \to \mu^+ + \nu_\mu$.

Transformation of SMU, corresponding the process of $W^+ \to \tau^+ + \nu_\tau$, will have the same form as is shown in Fig. 5, only the angle between the vectors $\mathbf{L}_w$ and $\mathbf{X}_{w3}$ will be different. The projections of the vectors $\mathbf{W}$ and $\mathbf{Z}$ along the axis $\mathbf{L}_w$ will be also different. In the same way we can introduce a lepton number L_τ which will be equal to one for τ^- and ν_τ, and equal to -1 for τ^+ and $\bar{\nu}_\tau$, and equal to zero for W^-.

The arrangement of the diagram planes for the particles of three generations is presented in Fig. 6 in which only the vectors being equal to $\mathbf{W} + \mathbf{Z}$ are shown (see Fig. 1) and the particles they correspond to are designated.

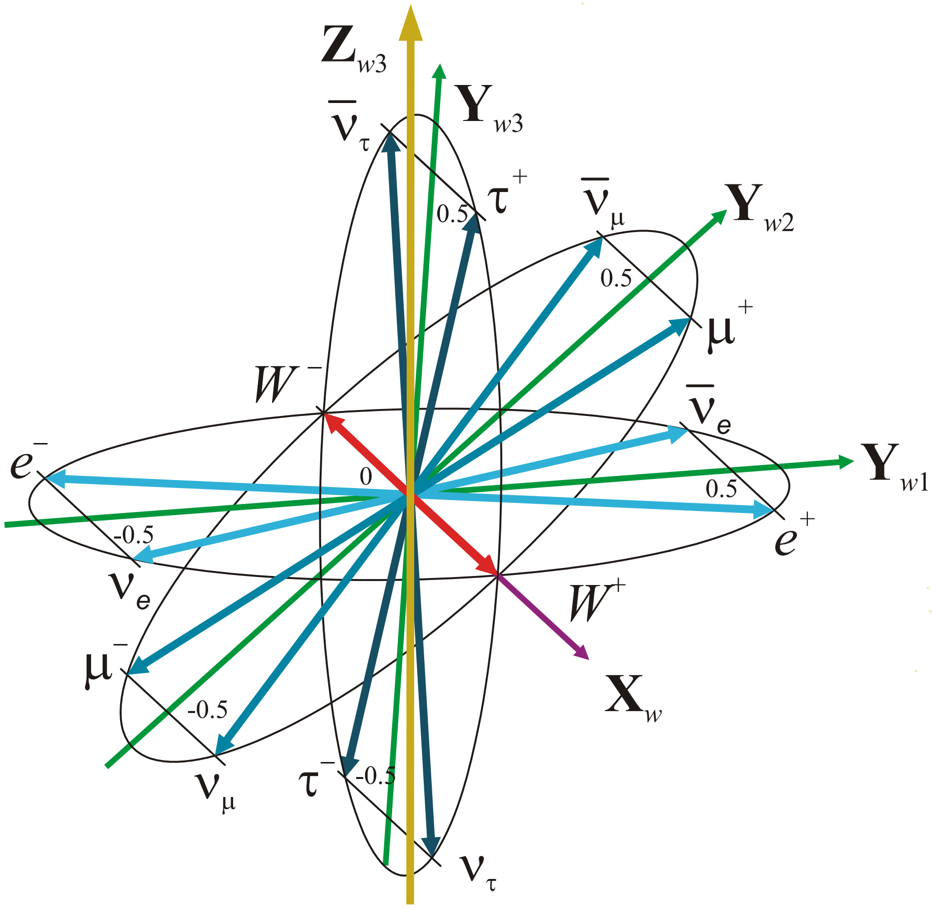

Figure 6: The planes arrangement of diagrams corresponding the leptons of different generations.

It follows from Fig. 6 that various transitions between states, corresponding different generations of particles, turn out to be possible with participating intermediate states $\mathrm{SMU}(\mathrm{S}_0)$ and $\mathrm{SMU}(\mathrm{S}_3)$, as for these states lepton numbers are always equal to zero. The examples of such transformations are

$$\mathrm{SMU}(\tau^-) \to \mathrm{SMU}(\nu_\tau) + \mathrm{SMU}(W^-)\,,$$

$$\mathrm{SMU}(\mu^-) \to \mathrm{SMU}(W^-) + \mathrm{SMU}(\nu_\mu)\,,$$

$$\mathrm{SMU}(W^-) \to \mathrm{SMU}(e^-) + \mathrm{SMU}(\bar{\nu}_e)\,.$$

The first of them takes place in the plane $(\mathbf{X}_w, \mathbf{Y}_{w3})$, the second – in the plane $(\mathbf{X}_w, \mathbf{Y}_{w2})$ and the third – in the plane $(\mathbf{X}_w, \mathbf{Y}_{w1})$.

The choice of the described above arrangement of planes of state vectors (Fig. 6) makes it possible to describe correctly the examined mutual transformations of leptons of different generations. Therefore, the state vectors SMU should be arranged in a three-dimensional abstract space.

6 Conclusion

The structural mass unit (SMU) is a mass carrier. This is a contradictory concept. On the one hand it is a unit, but such unit of the structure that can be in different states and have different values of mass and different characteristics. It is a carrier of such property of matter which is called mass. In the experiment only specific state of SMU is recognized. Its structure can be presented exceptionally in abstract form, i.e. its components cannot be expressed in the concept of "particles".

According to the examined concept the spectrum of weakly interacting particles and antiparticles is the spectrum of states of SMU, the basis of which is the basic structure. We "see" the basic structure of SMU only in some abstract space when the vectors of its states have been plotted, reasoning from the values of additive quantum numbers of weakly interacting particles. All the vectors of lepton states of the same generation lie in the same plane, and these planes for the leptons of different generations are situated under different angles.

Perhaps the basic structure of SMU will make it possible to explain the mechanism of mass accumulation of a point particle. Thus, mass always has a structure.

The structural mass unit can transform into two structural mass units, but it is not a division of the first one into its parts which it doesn't have. Therefore the concept of weakly interacting particles division into parts doesn't make sense. Two structural mass units can turn into one such unit, but meanwhile the complication of its structure doesn't happen.

The structure of SMU under consideration is formed by its components. However, they fail to be interpreted using the concept of "particles". Therefore, interconnection of the components stipulating integrity of the structural mass unit is not the result of force interaction between them.

In the delivered concept neutrino and antineutrino should have mass as it is also a state of SMU. And mass of any state of SMU is always different from zero.

Let us note some features that, in our opinion, justify introduction of the concept of the structural mass unit.

1. Leptons, $W^{\pm}$- and Z^0-bosons are integral structures. They don't disintegrate into the constituents. This property is also possessed by the structural mass unit.

2. Leptons, $W^{\pm}$- and Z^0-bosons have the property of mutual transformation. Different states of the structural mass unit also possess this property.

3. The spectrum of values for the pair conserved of the additive quantum numbers L and Q for the states of the structural mass unit precisely <u>coincides</u> with the spectrum of values for similar numbers for weakly interacting particles. There are no other values of the mentioned quantum numbers for the mentioned particles.

4. Vector diagrams of weakly interacting particles make it possible to realize that all the weakly interacting particles are different states of structural mass unit, therefore particles and antiparticles don't fundamentally differ from each other as they are also states of the structural mass unit. The same basic structure is in their basis. Therefore we can suppose that under some conditions particles can transit into antiparticles and vice versa

5. To conserve the energy of particles is the property of basic structure. In conclusion we may say that a weakly interacting particle is some state of the structural mass unit and not a quant of the field.

7 References

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