Nature Itself in a Mirror Space-Time

Rasulkhozha S. Sharafiddinov

Institute of Nuclear Physics, Uzbekistan Academy of Sciences, Tashkent, 100214 Ulugbek, Uzbekistan

Abstract

The unity of the structure of matter fields with ideas of flavor symmetry laws involves that the left-handed neutrino in the field of emission can be converted into the right-handed one and vice versa. These transitions together with classical solutions of the Dirac equation testify in favor of the unidenticality of masses, energies and momenta of neutrinos of the different components. If we recognize such a difference in masses, energies and momenta, accepting its ideas about that the left-handed neutrino and the right-handed antineutrino refer to long-lived leptons, and the right-handed neutrino and the left-handed antineutrino are of short-lived fermions, we would follow the mathematical logic of the Dirac equation in the presence of the flavor symmetrical mass, energy and momentum matrices. From their point of view, nature itself separates the Minkowski space into the left and the right spaces concerning a certain middle dynamical line. Thereby, it characterizes any Dirac particle both by left and by right space-time coordinates. It is not excluded therefore that whatever the main purposes each of earlier experiments about right-handed neutrinos may serve as the source of facts confirming the existence of a mirror Minkowski space-time.

1. Introduction

A notion about neutrinos introduced by Pauli may be based logically on the availability in nature of an unbroken flavor symmetry [1]. From its point of view, each type \( l = e, \mu, \tau, \ldots \) of charged lepton has his own \( (\nu_l = \nu_e, \nu_\mu, \nu_\tau, \ldots) \) neutrino. Such pairs are united in families of a definite [2,3] flavor

\[
L_l = \begin{cases} +1 & \text{for } l_L, l_R, \nu_L, \nu_R, \\ -1 & \text{for } \bar{\nu}_R, \bar{\nu}_L, \nu_R, \nu_L, \\ 0 & \text{for remaining particles,} \\
\end{cases}
\]  

confirming that nature itself testifies in favor of a flavor symmetrical connection between the structural particles in dfermions

\[
(l_L, \bar{l}_R), \quad (l_R, \bar{l}_L), \\
(\nu_L, \bar{\nu}_R), \quad (\nu_R, \bar{\nu}_L).
\]  

This in turn implies that the left-handed neutrino in the field of emission similarly to a kind of charged lepton [4] can be converted into the right-handed one and vice versa [5]. Such transitions, however, encounter many problems which reflect so far unobserved characteristic features of a latent structure of mass, energy, momentum and thereby require in principle to fundamentally change our presentations about neutrinos.

Therefore, we consider in a given work the question as to whether there exists any mass dependence of spin nature and, if so, what the expected connection says about the dynamical origination of spontaneous mirror symmetry violation.
2. Helicity Criterion for the Dirac Equation

To express the idea more clearly, it is desirable to use the Dirac equation which for the four-component wave function $\psi(t, x)$ may be written as

$$i \partial_t \psi = \hat{H} \psi,$$

(4)

where it has been accepted that

$$\hat{H} = \alpha \cdot \hat{p} + \beta m.$$

(5)

Here $\hbar = c = 1$, $E = i \partial_t$ and $p = -i \partial_x$, the matrices $\alpha = \gamma_5 \sigma$, $\beta$ and $\gamma_5$ in the form as were suggested by Dirac [6] have the following structure

$$\alpha = \begin{pmatrix} 0 & \sigma \\ \sigma & 0 \end{pmatrix}, \quad \beta = \begin{pmatrix} I & 0 \\ 0 & -I \end{pmatrix}, \quad \gamma_5 = \begin{pmatrix} 0 & I \\ I & 0 \end{pmatrix}.$$  

(6)

Among them $I$ is a unity $2 \times 2$ matrix, and $\sigma$ are the Pauli spin matrices.

Such a choice is based historically on the fact [6] that $\alpha$ and $\beta$ give the possibility to directly pass from (5) to the relationship involving the mass, energy and momentum

$$E^2 = p^2 + m^2.$$  

(7)

Furthermore, if neutrinos are of free particles with an energy $E > 0$ then

$$\psi = u(p, \sigma) e^{-ip \cdot x}.$$  

(8)

With these conditions, $\alpha$ and $\beta$ separate the four-component spinor $u$ into the two two-component spinors. We must, therefore, replace it with

$$u = u^{(r)} = \begin{pmatrix} \chi^{(r)} \\ u_a^{(r)} \end{pmatrix},$$  

(9)

where $a$ and $r = 1, 2$ distinguish each of $u$, $u^{(r)}$ and $u_a^{(r)}$ from one another.

The two-component spinors $\chi^{(r)}$ and $u_a^{(r)}$ reflect just a regularity that (4) constitutes the two most diverse equations:

$$E \chi^{(r)} = (\sigma p) u_a^{(r)} + m \chi^{(r)},$$

(10)

$$E u_a^{(r)} = (\sigma p) \chi^{(r)} - m u_a^{(r)}.$$  

(11)

This united system in turn establishes two more highly important connections

$$u_a^{(r)} = \frac{(\sigma p)}{E + m} \chi^{(r)}, \quad \chi^{(r)} = \frac{(\sigma p)}{E - m} u_a^{(r)}$$  

(12)

and thereby describes a situation in which the availability of any of the two classical solutions of the Dirac equation equal to

$$u^{(r)} = \sqrt{E + m} \left( \frac{\sigma p}{E + m} \chi^{(r)} \right),$$  

(13)

says in favor of an explicit mass dependence of spin nature. It is fully possible therefore that mirror symmetry may be violated at the expense of a mass of a particle [7] itself.

Many authors state that there is no connection between the mass of the neutrino and its spin nature. The existence of the latter would seem to contradict our observation that the upper (lower) sign of the helicity operator $\sigma p = \pm |p|$ corresponds to the right (left)-handed neutrino...
At the definite choice of spin and momentum directions. But, as stated in (4), this implication follows from the fact that in the form as it was accepted, the compound structure of the Dirac equation depending on the mass, energy and momentum is not in state to give a categorical answer to the question of what of the two four-component spinors (13) together with

\[ \chi^{(1)} = \begin{pmatrix} 1 \\ 0 \end{pmatrix}, \quad \chi^{(2)} = \begin{pmatrix} 0 \\ 1 \end{pmatrix} \] (14)

describes the same left or right spin state of the fermion.

It is also relevant to include in the discussion the free antiparticle with

\[ \psi = v(p, \sigma)e^{-ipx}. \] (15)

If choose its spinor

\[ v = v^{(r)} = \begin{pmatrix} v^{(r)}_a \\ \chi^{(r)} \end{pmatrix}, \] (16)
at which \( a \) and \( r \) are responsible for separation of any spinor of \( v, v^{(r)} \) and \( v^{(r)}_a \) among all the remaining ones, for the case \( E < 0 \) when (4) is reduced to the equations

\[ |E|v^{(r)}_a = -(\sigma p)\chi^{(r)} - mv^{(r)}_a, \] (17)
\[ |E|\chi^{(r)} = -(\sigma p)v^{(r)}_a + m\chi^{(r)}, \] (18)

one can find that

\[ v^{(r)} = \sqrt{|E| + m} \left( \frac{-\sigma p}{|E| + m} \chi^{(r)} \right). \] (19)

Comparison of (19) with (13) at \( r = 1, 2 \) leads us to the choice once more of the sign of the helicity operator, confirming that we cannot establish the spin nature of elementary particles until an equation (4) itself is able to separate their by the mirror symmetry laws.

3. Mass, Energy and Momentum Matrices

The above circumstance seems to indicate that each of transitions

\[ \nu_L \leftrightarrow \nu_R, \quad \bar{\nu}_L \leftrightarrow \bar{\nu}_R \] (20)

may serve as the group of arguments in favor of the unidenticality of masses, energies and momenta of neutrinos of the different components. If we recognize this difference in masses, energies and momenta, accepting its ideas about that the left-handed neutrino and the right-handed antineutrino refer to long-lived leptons, and the right-handed neutrino and the left-handed antineutrino are of short-lived fermions, we would follow the mathematical logic of the Dirac equation from the point of view of the flavor symmetrical mass, energy and momentum matrices

\[ m_s = \begin{pmatrix} m_V & 0 \\ 0 & m_V \end{pmatrix}, \quad E_s = \begin{pmatrix} E_V & 0 \\ 0 & E_V \end{pmatrix}, \quad p_s = \begin{pmatrix} p_V & 0 \\ 0 & p_V \end{pmatrix}, \] (21)
\[ m_V = \begin{pmatrix} m_L & 0 \\ 0 & m_R \end{pmatrix}, \quad E_V = \begin{pmatrix} E_L & 0 \\ 0 & E_R \end{pmatrix}, \quad p_V = \begin{pmatrix} p_L & 0 \\ 0 & p_R \end{pmatrix}, \] (22)

where \( V \) must be considered as an index of a distinction.
In their presence, the structure of the Dirac equation becomes fully definite and behaves as follows
\[ i \frac{\partial}{\partial t_s} \psi_s = \hat{H}_s \psi_s, \]  
(23)
in which
\[ \hat{H}_s = \alpha \cdot \hat{p}_s + \beta m_s, \]  
(24)
and \( E_s \) and \( p_s \) correspond to quantum energy and momentum operators
\[ E_s = i \frac{\partial}{\partial t_s}, \quad p_s = -i \frac{\partial}{\partial x_s}. \]  
(25)

As well as in (21), the index \( s \) here expresses, as we shall see below, the unidenticality of space-time coordinates \( [(t_s, x_s)] \) of the left- and right-handed particles. Then it is possible, for example, to describe the field of the free neutrino in a latent united form:
\[ \psi_s = u_s(p_s, \sigma)e^{-ip_s \cdot x_s}, \quad E_s > 0. \]  
(26)

Because of (6), (21) and (22), the four-component wave function \( \psi_s(t_s, x_s) \) is reduced at first to the two two-component wave functions and, next, the latters separate it into the four possible parts. Formulating more concretely, one can write the field \( u_s \) in a general form:
\[ u_s = u^{(r)} = \begin{pmatrix} \chi^{(r)} \\ u^{(r)}_a \end{pmatrix}. \]  
(27)

So, we must recognize that (23) together with (6), (21), (26) and (27) constitutes the naturally united system of Dirac equations:
\[ E_V \chi^{(r)} = (\sigma p_V)u^{(r)}_a + m_V \chi^{(r)}, \]  
(28)
\[ E_V u^{(r)}_a = (\sigma p_V)\chi^{(r)} - m_V u^{(r)}_a. \]  
(29)

Their two-component spinors \( u^{(r)}_a \) correspond to the fact that in them, \( m_V, E_V \) and \( p_V \) are the flavor symmetrical \( 2 \times 2 \) matrices which are absent in a classical system of Dirac equations. Instead they include the usual mass, energy and momentum.

It is not surprising therefore that at the availability of a connection
\[ u^{(r)}_a = \frac{(\sigma p_V)}{E_V + m_V} \chi^{(r)}, \quad \chi^{(r)} = \frac{(\sigma p_V)}{E_V - m_V} u^{(r)}_a, \]  
(30)
any of the two new solutions of the Dirac equation equal to
\[ u^{(r)} = \sqrt{E_V + m_V} \begin{pmatrix} \chi^{(r)} \\ (\sigma p_V) \chi^{(r)} \end{pmatrix} \]  
(31)
responds to the same left- or right-handed neutrino.

To investigate further, we present these solutions in an explicit form
\[ u^{(1)} = \sqrt{E_L + m_L} \begin{pmatrix} 1 \\ 0 \end{pmatrix}, \]  
(32)
\[ u^{(2)} = \sqrt{E_R + m_R} \begin{pmatrix} 0 \\ 1 \\ 0 \\ \frac{(\sigma p_R)}{E_R + m_R} \end{pmatrix}. \]  

(33)

So it is seen that \( u^{(1)} \), \( \chi^{(1)} \) and \( u^{(1)}_a \) characterize the left-handed neutrino, and \( u^{(2)} \), \( \chi^{(2)} \) and \( u^{(2)}_a \) describe the right-handed neutrino.

For completeness we include in the discussion the free antineutrino with

\[ \psi_s = v_s(p_s, \sigma)e^{-ip_s \cdot x_s}, \quad E_s < 0. \]  

(34)

At the same time, it is clear that (6) and (21) replace the spinor \( v_s \) for

\[ v_s = v^{(r)} = \begin{pmatrix} v^{(r)}_a \\ \chi^{(r)} \end{pmatrix} \]  

(35)

and thereby transform the Dirac equation (23) into the two new equations

\[
|E_V|v^{(r)}_a = -(\sigma p_V)\chi^{(r)} - m_V v^{(r)}_a, \\
|E_V|\chi^{(r)} = -(\sigma p_V)v^{(r)}_a + m_V \chi^{(r)}.
\]  

(36, 37)

By following the same arguments that led to solution (19), but having in view of the equality

\[ v^{(r)} = \sqrt{|E_V| + m_V} \begin{pmatrix} \frac{-\sigma p_L}{E_L + m_L} \\ \chi^{(r)} \end{pmatrix}, \]  

one can also make a conclusion that

\[
v^{(1)} = \sqrt{|E_L| + m_L} \begin{pmatrix} \frac{-\sigma p_L}{E_L + m_L} \\ E_L + m_L \\ 0 \\ 1 \\ 0 \end{pmatrix}, \\
v^{(2)} = \sqrt{|E_R| + m_R} \begin{pmatrix} 0 \\ \frac{-\sigma p_R}{E_R + m_R} \\ E_R + m_R \\ 0 \\ 1 \end{pmatrix}.
\]  

(39, 40)

They show that \( v^{(1)} \), \( \chi^{(1)} \) and \( u^{(1)}_a \) correspond to the right-handed antineutrino, and \( v^{(2)} \), \( \chi^{(2)} \) and \( u^{(2)}_a \) respond to the left-handed antineutrino.

Thus, we have established the full spin structure of the Dirac equation in which it is definitely stated that

\[ \sigma p_L = -|p_L|, \quad \sigma p_R = |p_R|. \]  

(41)

Simultaneously, as is easy to see, the neutrino \( \nu_L \) and the antineutrino \( \bar{\nu}_R \) are the left-polarized leptons, and the neutrino \( \nu_R \) and the antineutrino \( \bar{\nu}_L \) refer to the right-polarized fermions.

In these circumstances, it seems possible to use \( \psi_s \) in the form

\[ \psi_s = \begin{pmatrix} \psi \\ \phi \end{pmatrix}, \quad \psi = \begin{pmatrix} \psi_L \\ \psi_R \end{pmatrix}, \quad \phi = \begin{pmatrix} \phi_L \\ \phi_R \end{pmatrix}. \]  

(42)

Uniting (12) with (23) and solving the finding equations concerning \( \psi_{L,R} \) and \( \phi_{L,R} \), it can also be verified that

\[ E_{L,R}^2 = p_{L,R}^2 + m_{L,R}^2. \]  

(43)
The difference in lifetimes of neutrinos of the different components can explain the spontaneous mirror symmetry violation, at which they have the unidentical masses, energies and momenta. The account of this leads us to the conclusion that

\[ E_L = i \frac{\partial}{\partial t_L}, \quad E_R = i \frac{\partial}{\partial t_R}, \tag{44} \]

\[ p_L = -i \frac{\partial}{\partial x_L}, \quad p_R = -i \frac{\partial}{\partial x_R}. \tag{45} \]

Insofar as the mass is concerned, we start from the special comparison theorem [8] for the Dirac equation that \( m_s \) similarly to all \( E_s \) and \( p_s \) must be quantum operators such as

\[ m_L = -i \frac{\partial}{\partial \tau_L}, \quad m_R = -i \frac{\partial}{\partial \tau_R}, \tag{46} \]

where \( \tau_L \) and \( \tau_R \) are the lifetimes of the left- and right-handed particles.

Furthermore, if these situations are of fundamental principles of quantum mechanics, our reasonings refer to all fermions interacting according to the Dirac equation.

Such a connection arises as a consequence of the ideas of corresponding mechanism laws responsible for the dynamical origination of spontaneous mirror symmetry violation. From their point of view, nature itself separates the Minkowski space into the left and the right spaces concerning a certain middle dynamical line. Thereby, it characterizes any Dirac particle both by left \([ (t_L, x_L) ] \) and by right \([ (t_R, x_R) ] \) space-time coordinates. In this it is additionally assumed that \( \tau_L \) and \( \tau_R \) correspond in (46) to the lifetimes of a particle in the left and right Minkowski spaces. It is not excluded therefore that whatever the main purposes the recent experiments [9] about right-handed neutrinos may serve as the first confirmation of the existence of a mirror Minkowski space-time.

4. Conclusion

There exists of course a range of old phenomena in which appears a part of the dynamical origination of spontaneous mirror symmetry violation. A beautiful example is solar neutrino problem [10].

At first sight, an active left-handed neutrino passing through the medium from the Sun to detector on the Earth can be converted into the sterile right-handed neutrino [11] not interacting with the field of emission. For example, in the reactions \( \nu_{eL,R} + Cl^{37} \rightarrow e_{L,R} + Ar^{37} \) as well as in other phenomena with neutrinos. Therefore, it seems that an observed flux of neutrinos will twice as smaller than of a starting one. However, as we shall see, this is not quite so. The point is that the left-handed long-lived neutrino at the interaction with matter will be converted into the right-handed short-lived neutrino. The right-handed neutrino in turn interacts with the field of emission until it will not virtually decay forming the real left-handed neutrino. Under such circumstances, a flux of solar neutrinos does not suffer a decreasing in his quantity.

In the standard electroweak model [12-14], it has been usually assumed that in nature the right-handed neutrino is absent. This is of course intimately connected with the prediction of a two component theory [15] of the neutrino expressing the idea of parity nonconservation in the weak interactions [16]. According to one of its aspects, the matrix \( \gamma_5 \) in the chiral presentation of the Weyl [17] constitutes the projection operator \( (1 - \gamma_5)/2 \) allowing one to choose only the left components of the four-component spinor.
Such a procedure, however, redoubles the results of theoretical calculations in all flavor symmetrical processes with weak charged currents even in the presence of a normalized multiplier. Insofar as the weak neutral currents are concerned, the terms with $\gamma_5$ appear in them as the axial-vector components of these currents. The number of solar neutrinos and the structural phenomena originating in the detectors on the Earth coincide, as follows from considerations of flavor symmetry. This conformity requires the comparison with experiment of any of the two equal parts of a theoretical estimate of a flux of solar neutrinos.

Finally, insofar as the Dirac Lagrangian and its structural components are concerned, all they together with some above unnoted aspects of spontaneous mirror symmetry violation will be presented in the separate work.

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