On a Mirror Structure of Matter Fields

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Abstract

Spontaneous mirror symmetry violation is carried out in nature as the transition between the usual left (right)-handed and the mirror right (left)-handed spaces, where the same particle has the different lifetimes. As a consequence, all the equations of motion for the unified field theory of elementary particles include the mass, energy and momentum as the matrices expressing the ideas of the left- and right-handed neutrinos are of long- and short-lived objects, respectively. These ideas require in principle to go away from the chiral definitions of the structure of matter fields taking into account that the Dirac matrices come forward in the Weyl presentation as the matrices having an exact mathematical formulation but not allowing to follow the logic of a true nature of mirror symmetry including the dynamical origination of its spontaneous violation. Therefore, from the point of view of the mass, energy and momentum matrices, each of the structural contradictions between the spontaneous mirror symmetry violation and the chiral presentation of the Weyl must be interpreted as an indication to the absence in nature of a place for chirality.

1. Introduction

One of the set of the innate properties of matter, the idea of which was not disclosed before the creation of the first-initial unified field theory, is spontaneous mirror symmetry violation. It is not surprising therefore that in the form as it was accepted, not one of all the quantum mechanical equations of motion depending on the mass, energy and momentum is not in a force to describe the elementary objects by the mirror symmetry laws.

At the same time, nature itself relates the same left or right spin state of a particle even, in the case of the neutrino ($\nu_l = \nu_e,\, \nu_\mu,\, \nu_\tau, ...$), to corresponding component of its antiparticle. It constitutes herewith an individual paraneutrino [1] confirming the availability in it of the transitions between the left and the right.

However, as was accepted in the standard electroweak model [2-4], their existence contradicts one of its postulates that in nature the right-handed neutrinos are absent. Instead it includes the right components of leptons ($l = e,\, \mu,\, \tau, ...$) as the usual singlets.

But if we take into account that the mass, energy and momentum of any of elementary particles unite all symmetry laws in a unified whole, then to any type of lepton corresponds in their spectra [5] a kind of neutrino [6]. Thereby, they describe a situation when mirror symmetry violation spontaneously originates in any [1,7] of interconversions

$$l_L \leftrightarrow l_R, \quad \bar{l}_R \leftrightarrow \bar{l}_L, \tag{1}$$

$$\nu_{lL} \leftrightarrow \nu_{lR}, \quad \bar{\nu}_{lR} \leftrightarrow \bar{\nu}_{lL} \tag{2}$$

by the same mechanism. Such a mechanism can, for example, be simultaneous change of the mass, energy and momentum of a particle at its transition from one spin state into another.

It reflects the availability of the usual left (right)-handed and the mirror right (left)-handed Minkowski space-times. Therefore, to understand the nature of elementary particles at a new dynamical level, one must use each interconversion of (1) and (2) as the transition between the usual and the mirror spaces [8], where the same particle has the different masses, energies and momenta. This connection expresses, in the case of the C-invariant Dirac neutrino, the idea about that the left-handed neutrino and the right-handed antineutrino are of long-lived leptons of C-invariance, and the right-handed neutrino and the left-handed antineutrino refer to short-lived C-even fermions.

The unidenticality of lifetimes τ_s and space-time coordinates $(t_s, \mathbf{x}_s)$ of left $(s = L = -1)$ and right $(s = R = +1)$ types of elementary objects of C-parity establishes in addition the full spin structure of all the equations of motion for the unified field theory of particles with a nonzero spin in which the mass, energy and momentum are predicted as the matrices

$$m_s = \begin{pmatrix} m_V & 0 \\ 0 & m_V \end{pmatrix}, \quad E_s = \begin{pmatrix} E_V & 0 \\ 0 & E_V \end{pmatrix}, \quad \mathbf{p}_s = \begin{pmatrix} \mathbf{p}_V & 0 \\ 0 & \mathbf{p}_V \end{pmatrix}, \tag{3}$$

$$m_V = \begin{pmatrix} m_L & 0 \\ 0 & m_R \end{pmatrix}, \quad E_V = \begin{pmatrix} E_L & 0 \\ 0 & E_R \end{pmatrix}, \quad \mathbf{p}_V = \begin{pmatrix} \mathbf{p}_L & 0 \\ 0 & \mathbf{p}_R \end{pmatrix}. \tag{4}$$

Such a presentation of m_s, E_s and $\mathbf{p}_s$ is of course intimately connected with the character of their compound structure depending on a vector (V) nature [8] of the same space-time, where there exist C-invariant particles.

However, among the set of C-even objects there are no C-odd particles. Their mass, energy and momentum do not coincide with (3) and (4), since in them appears an axial-vector (A) nature [9] of the same space-time, where there exist C-noninvariant particles. They can therefore be expressed in the form

$$m_s = \begin{pmatrix} 0 & m_A \\ m_A & 0 \end{pmatrix}, \quad E_s = \begin{pmatrix} 0 & E_A \\ E_A & 0 \end{pmatrix}, \quad \mathbf{p}_s = \begin{pmatrix} 0 & \mathbf{p}_A \\ \mathbf{p}_A & 0 \end{pmatrix}, \tag{5}$$

$$m_A = \begin{pmatrix} m_L & 0 \\ 0 & m_R \end{pmatrix}, \quad E_A = \begin{pmatrix} E_L & 0 \\ 0 & E_R \end{pmatrix}, \quad \mathbf{p}_A = \begin{pmatrix} \mathbf{p}_L & 0 \\ 0 & \mathbf{p}_R \end{pmatrix}. \tag{6}$$

This difference corresponds in nature to separation of elementary currents with respect to C-operation, because it admits the existence of C-even and C-odd types of particles of vector (V) and axial-vector (A) masses, energies and momenta.

It is also relevant to use [8,9] their sizes as the quantum operators

$$m_s = -i\frac{\partial}{\partial \tau_s}, \quad E_s = i\frac{\partial}{\partial t_s}, \quad \mathbf{p}_s = -i\frac{\partial}{\partial \mathbf{x}_s}. \tag{7}$$

Furthermore, if the investigated and the used objects are simultaneously both C-even and C-odd neutrinos, a motion of all types of particles with the spin 1/2 and the four-component wave function $\psi_s(t_s, \mathbf{x}_s)$ may in a mirror world [8,9] be described by a latent united equation

$$i\frac{\partial}{\partial t_s}\psi_s = \hat{H}_s\psi_s, \tag{8}$$

which states that

$$\hat{H}_s = \alpha \cdot \hat{\mathbf{p_s}} + \beta m_s. \tag{9}$$

However, as is now well seen, the sizes of m_s, E_s and $\mathbf{p}_s$ are 4×4 matrices, which are absent in all the classical equations of motion for particles, and therefore, there arises a question about the structure of matrices $\alpha = \gamma_5 \sigma$ and β about which there is no unified sight in a mirror behavior dependence of matter fields.

Using a unity I matrix, the Pauli spin σ matrices and taking into account the standard presentation of the Dirac [11], for α, β and γ_5, we have

$$\alpha = \begin{pmatrix} 0 & \sigma \\ \sigma & 0 \end{pmatrix}, \quad \beta = \begin{pmatrix} I & 0 \\ 0 & -I \end{pmatrix}, \quad \gamma_5 = \begin{pmatrix} 0 & I \\ I & 0 \end{pmatrix}. \tag{10}$$

At a choice of the above matrices, the solutions of an equation (8) reflect, in the case of both vector [8] and axial-vector [9] types of fermions, the same characteristic features of quantum mechanical helicity operator $\sigma \mathbf{p}_s = s|\mathbf{p}_s|$, which indicate to a unified principle that

$$\sigma \mathbf{p_L} = -|\mathbf{p}_L|, \quad \sigma \mathbf{p_R} = |\mathbf{p}_R|. \tag{11}$$

But for α, β and γ_5, the definition (10) is not singular. They can in the chiral presentation of the Weyl [12] have the following form:

$$\alpha = \begin{pmatrix} \sigma & 0 \\ 0 & -\sigma \end{pmatrix}, \quad \beta = \begin{pmatrix} 0 & I \\ I & 0 \end{pmatrix}, \quad \gamma_5 = \begin{pmatrix} I & 0 \\ 0 & -I \end{pmatrix}. \tag{12}$$

In both presentations (10) and (12), as we can expect from simple reasoning, an equation (8) cannot change his mirror structure, so that there exists so far unobserved relation between the solutions.

Our purpose in a given work is to follow the logic of an equation (8) in the presence of (12) both from the point of view of vector C-invariant particles and on the basis of C-noninvariance of axial-vector types of neutrinos. This does not exclude simultaneously from the discussion the ideas of chiral invariance in the dynamical nature dependence of spontaneous mirror symmetry violation.

2. Chirality of Neutrinos of a Vector Nature

A notion about chiral symmetry introduced by Weyl is based factually on the presentation (12), according to which, the matrix γ_5 becomes chirality operator having the same self-values as the helicity operator. In this case, it is expected that the solutions of an equation (8) including (3) and (4) correspond in presentations (10) and (12) to the most diverse forms of the same regularity of a C-invariant nature of vector (V) types of neutrinos.

To express the idea more clearly, we use a free particle with

$$\psi_s = u_s(\mathbf{p}_s, \sigma) e^{-ip_s \cdot x_s}, \quad E_s > 0. \tag{13}$$

One can define the four-component spinor u_s in the form

$$u_s = u^{(r)} = \begin{bmatrix} \chi^{(r)} \\ u_a^{(r)} \end{bmatrix}, \tag{14}$$

in which

$$\chi^{(1)} = \begin{pmatrix} 1 \\ 0 \end{pmatrix}, \quad \chi^{(2)} = \begin{pmatrix} 0 \\ 1 \end{pmatrix}, \tag{15}$$

and the presence of an index a in one of $u^{(r)}$ and $u_a^{(r)}$ is responsible for their distinction.

So, it is seen that (13) together with (3) and (12) separates (8) into

$$E_V \chi^{(r)} = (\sigma \mathbf{p}_V) \chi^{(r)} + m_V u_a^{(r)}, \tag{16}$$

$$E_V u_a^{(r)} = -(\sigma \mathbf{p}_V) u_a^{(r)} + m_V \chi^{(r)}. \tag{17}$$

Solving a given system concerning $\chi^{(r)}$ and $u_a^{(r)}$, but having in view (14), it can also be verified that (4) and (15) lead us from

$$u^{(r)} = \sqrt{E_V + (\sigma \mathbf{p}_V)} \begin{bmatrix} \chi^{(r)} \\ \frac{m_V}{E_V + (\sigma \mathbf{p}_V)} \chi^{(r)} \end{bmatrix} \tag{18}$$

to their explicit form

$$u^{(1)} = \sqrt{E_L + (\sigma \mathbf{p}_L)} \begin{bmatrix} 1 \\ 0 \\ \frac{m_L}{E_L + (\sigma \mathbf{p}_L)} \\ 0 \end{bmatrix}, \tag{19}$$

$$u^{(2)} = \sqrt{E_R + (\sigma \mathbf{p}_R)} \begin{bmatrix} 0 \\ 1 \\ 0 \\ \frac{m_R}{E_R + (\sigma \mathbf{p}_R)} \end{bmatrix}. \tag{20}$$

At the same choice of a free particle and its four-component wave function, the solutions of an equation (8) depending on (3) and (4) have in the standard presentation (10) the following structure:

$$u^{(1)} = \sqrt{E_L + m_L} \begin{bmatrix} 1 \\ 0 \\ \frac{(\sigma \mathbf{p}_L)}{E_L + m_L} \\ 0 \end{bmatrix}, \tag{21}$$

$$u^{(2)} = \sqrt{E_R + m_R} \begin{bmatrix} 0 \\ 1 \\ 0 \\ \frac{(\sigma \mathbf{p}_R)}{E_R + m_R} \end{bmatrix}. \tag{22}$$

From their point of view, the chiral presentation (12) leading to (19) and (20) replaces the mass of a C-invariant particle by the operator of its helicity and vice versa. In other words, it requires one to make the replacements

$$m_{L,R} \rightarrow \sigma \mathbf{p}_{\mathbf{L},\mathbf{R}}, \quad \sigma \mathbf{p}_{\mathbf{L},\mathbf{R}} \rightarrow m_{L,R}. \tag{23}$$

In the same way one can solve the equation (8) for the free antiparticle with

$$\psi_s = \nu_s(\mathbf{p}_s, \sigma) e^{-ip_s \cdot x_s} \quad E_s < 0. \tag{24}$$

Its four-component spinor ν_s must have the form

$$\nu_s = \nu^{(r)} = \begin{bmatrix} \nu_a^{(r)} \\ \chi^{(r)} \end{bmatrix}. \tag{25}$$

The availability of an index a in one of $\nu^{(r)}$ and $\nu_a^{(r)}$ implies their difference. We see in addition that jointly with (3) and (12), the four-component wave function (24) constitutes from (8) the system of the two other equations

$$|E_V| \nu_a^{(r)} = -(\sigma \mathbf{p}_V) \nu_a^{(r)} - m_V \chi^{(r)}, \tag{26}$$

$$|E_V|\chi^{(r)} = (\sigma \mathbf{p}_V)\chi^{(r)} - m_V \nu_a^{(r)}. \tag{27}$$

Inserting the second of its solutions

$$\chi^{(r)} = \frac{-m_V}{|E_V| - (\sigma \mathbf{p}_V)} \nu_a^{(r)}, \quad \nu_a^{(r)} = \frac{-m_V}{|E_V| + (\sigma \mathbf{p}_V)} \chi^{(r)}. \tag{28}$$

in (25) and uniting the finding equality with (4) and (15), it is not difficult to show that

$$\nu^{(1)} = \sqrt{|E_L| + (\sigma \mathbf{p}_L)} \begin{bmatrix} \frac{-m_L}{|E_L|+(\sigma \mathbf{p}_L)} \\ 0 \\ 1 \\ 0 \end{bmatrix}, \tag{29}$$

$$\nu^{(2)} = \sqrt{|E_R| + (\sigma \mathbf{p}_R)} \begin{bmatrix} 0 \\ \frac{-m_R}{|E_R|+(\sigma \mathbf{p}_R)} \\ 0 \\ 1 \end{bmatrix}. \tag{30}$$

If choose the standard presentation (10), at which the matrix γ_5 is not chirality operator, then for the same case of a free antiparticle when (3), (4) and (24) refer to it, one can establish the compound structure of both types of solutions of an equation (8) in the disclosed form [8] by the following manner:

$$\nu^{(1)} = \sqrt{|E_L| + m_L} \begin{bmatrix} \frac{-(\sigma \mathbf{p}_L)}{|E_L|+m_L} \\ 0 \\ 1 \\ 0 \end{bmatrix}, \tag{31}$$

$$\nu^{(2)} = \sqrt{|E_R| + m_R} \begin{bmatrix} 0 \\ \frac{-(\sigma \mathbf{p}_R)}{|E_R|+m_R} \\ 0 \\ 1 \end{bmatrix}. \tag{32}$$

Their comparison with (29) and (30) convinces us in the validity of (23) once more, confirming that the chiral presentation (12) replaces the helicity operator of a C-invariant antiparticle by its mass and vice versa.

3. Chirality of Neutrinos of True Neutrality

Between the vector and the axial-vector spaces [13] there exists a range of fundamental differences, which require the unification of elementary particles with respect to C-operation. However, nature, by itself, does not separate [8,9] each of these forms of Minkowski spaces into left and right spaces, and the transitions between the different spin states are carried out in it spontaneously by a mirror symmetry violation. It chooses herewith the mass, energy and momentum matrices so that to the case of C-even [14] or C-odd [15] types of particles corresponds in their unified field theory a kind of equation of motion.

Therefore, from its point of view, it should be expected that an equation (8) including (5) and (6) describe in presentations (10) and (12) the most diverse forms of the same regularity of a C-noninvariant nature of axial-vector (A) types of neutrinos.

To elucidate these ideas, we use (13)-(15) for the free particles of C-oddity. Then it is possible, for example, (13) in the presence of (5) and (12) transforms (8) into the system

$$E_A u_a^{(r)} = (\sigma \mathbf{p}_A) u_a^{(r)} + m_A \chi^{(r)}, \tag{33}$$

$$E_A \chi^{(r)} = -(\sigma \mathbf{p}_A) \chi^{(r)} + m_A u_a^{(r)}. \tag{34}$$

It establishes the corresponding connections

$$u_a^{(r)} = \frac{m_A}{E_A - (\sigma \mathbf{p}_A)} \chi^{(r)}, \quad \chi^{(r)} = \frac{m_A}{E_A + (\sigma \mathbf{p}_A)} u_a^{(r)}. \tag{35}$$

The first of them together with (15) gives the right to define the four-component spinors $u^{(r)}$ for C-odd types of neutrinos

$$u^{(1)} = \sqrt{E_L - (\sigma \mathbf{p}_L)} \begin{bmatrix} 1 \\ 0 \\ \frac{m_L}{E_L - (\sigma \mathbf{p}_L)} \\ 0 \end{bmatrix}, \tag{36}$$

$$u^{(2)} = \sqrt{E_R - (\sigma \mathbf{p}_R)} \begin{bmatrix} 0 \\ 1 \\ 0 \\ \frac{m_R}{E_R - (\sigma \mathbf{p}_R)} \end{bmatrix}. \tag{37}$$

However, in a C-noninvariant case of a free particle, an equation (8) depending on (5) and (6) can in the standard presentation (10) have [9] the following solutions:

$$u^{(1)} = \sqrt{E_L - m_L} \begin{bmatrix} 1 \\ 0 \\ \frac{(\sigma \mathbf{p}_L)}{E_L - m_L} \\ 0 \end{bmatrix}, \tag{38}$$

$$u^{(2)} = \sqrt{E_R - m_R} \begin{bmatrix} 0 \\ 1 \\ 0 \\ \frac{(\sigma \mathbf{p}_R)}{E_R - m_R} \end{bmatrix}. \tag{39}$$

As we see, the chiral presentation (12) establishing (36) and (37) replaces the mass of a C-noninvariant particle by the operator of its helicity and vice versa.

Unification of (8) with (5) and (12) at the inclusion in the discussion of a C-odd antiparticle described by (24) suggests a system

$$|E_A| \chi^{(r)} = -(\sigma \mathbf{p}_A) \chi^{(r)} - m_A \nu_a^{(r)}, \tag{40}$$

$$|E_A| \nu_a^{(r)} = (\sigma \mathbf{p}_A) \nu_a^{(r)} - m_A \chi^{(r)}. \tag{41}$$

Insertion of the first of its solutions $\nu_a^{(r)}$ and $\chi^{(r)}$ in (25) allows one to conclude that

$$\nu^{(r)} = \sqrt{|E_A| - (\sigma \mathbf{p}_A)} \begin{bmatrix} \frac{-m_A}{|E_A| - (\sigma \mathbf{p}_A)} \chi^{(r)} \\ \chi^{(r)} \end{bmatrix}. \tag{42}$$

Because of (6) and (15), a latent structure of $\nu^{(r)}$ is disclosed in the following its sizes:

$$\nu^{(1)} = \sqrt{|E_L| - (\sigma \mathbf{p}_L)} \begin{bmatrix} \frac{-m_L}{|E_L|-(\sigma \mathbf{p}_L)} \\ 0 \\ 1 \\ 0 \end{bmatrix}, \tag{43}$$

$$\nu^{(2)} = \sqrt{|E_R| - (\sigma \mathbf{p}_R)} \begin{bmatrix} 0 \\ \frac{-m_R}{|E_R|-(\sigma \mathbf{p}_R)} \\ 0 \\ 1 \end{bmatrix}. \tag{44}$$

But in the standard presentation (10), an equation (8) for the same C-odd antiparticle with (5), (6) and (24) establishes [9] the two other spinors

$$\nu^{(1)} = \sqrt{|E_L| - m_L} \begin{bmatrix} \frac{-(\sigma \mathbf{p}_L)}{|E_L|-m_L} \\ 0 \\ 1 \\ 0 \end{bmatrix}, \tag{45}$$

$$\nu^{(2)} = \sqrt{|E_R| - m_R} \begin{bmatrix} 0 \\ \frac{-(\sigma \mathbf{p}_R)}{|E_R|-m_R} \\ 0 \\ 1 \end{bmatrix}. \tag{46}$$

At the action of (23) they coincide with the corresponding values from (43), (44) and that, consequently, the behavior of the chiral presentation (12) is not changed even at a choice of a C-noninvariant antiparticle.

4. Conclusion

Turning again to the structure and the component of the finding wave functions, we remark that the sign in front of a size of $m_{L,R}$ in $u_a^{(1)}$, $u_a^{(2)}$, $\nu_a^{(1)}$ and $\nu_a^{(2)}$ for C-even and C-odd particles does not coincide. This, however, does not exclude [8,9] of that $u^{(1)}$, $\chi^{(1)}$ and $u_a^{(1)}$ describe the left-handed neutrino, and $u^{(2)}$, $\chi^{(2)}$ and $u_a^{(2)}$ characterize the right-handed neutrino. At the same time, $\nu^{(1)}$, $\chi^{(1)}$ and $\nu_a^{(1)}$ respond to the right-handed antineutrino, and $\nu^{(2)}$, $\chi^{(2)}$ and $\nu_a^{(2)}$ correspond to the left-handed antineutrino.

It is already clear from the foregoing that the neutrino ν_{lL} and the antineutrino $\bar{\nu}_{lR}$ refer to the left-polarized fermions, and the neutrino ν_{lR} and the antineutrino $\bar{\nu}_{lL}$ are of the right-polarized leptons.

Such a full spin picture corresponding in an equation (8) to the matrices (3)-(6) and (10) can be established by another way starting from (12) if its prediction (23) is carried out in nature.

At first sight, this says in favor of the compatibility of all the requirements of a chiral invariance with the implications of the helicity operator itself. On the other hand, such a unification of (11) and (23) shows that

$$m_L = -|\mathbf{p}_L|, \quad m_R = |\mathbf{p}_R|, \tag{47}$$

and consequently, (12) is of those presentations about the matrices α, β and γ_5 in which ν_{lR} and $\bar{\nu}_{lL}$ come forward as the particles, and ν_{lL} and $\bar{\nu}_{lR}$ are predicted as the antiparticles.

The difference in masses, energies and momenta of a particle and an antiparticle violates, in the case of C-even types of leptons, their CPT-symmetry expressing the idea of a Lorentz invariance [16]. At the same time, a C-noninvariant neutrino itself regardless of whether or not an unbroken Lorentz symmetry exists in its nature, is strictly CPT-odd [10]. This does not imply of course that the same neutrino or antineutrino must be either fermion or antifermion.

By following the structure of the matrices (3)-(6), (9) and (10), it is easy to see that

$$[(\alpha\mathbf{p_s} + \beta m_s), \quad \sigma\mathbf{p}_s] = [\sigma\mathbf{p}_s, \quad (\alpha\mathbf{p_s} + \beta m_s)], \tag{48}$$

$$[(\alpha\mathbf{p_s} + \beta m_s), \quad \gamma_5] \neq [\gamma_5, \quad (\alpha\mathbf{p_s} - \beta m_s)], \tag{49}$$

which characterize the behavior of the standard presentation (10) both from the point of view of a C-even and from the point of view of a C-odd particles.

To the same relationships (48) and (49) one can also lead by another way using (3), (4), (9) and (12), but the latter together with (5), (6) and (9) satisfies the inequalities

$$[(\alpha\mathbf{p_s} + \beta m_s), \quad \sigma\mathbf{p}_s] \neq [\sigma\mathbf{p}_s, \quad (-\alpha\mathbf{p_s} + \beta m_s)], \tag{50}$$

$$[(\alpha\mathbf{p_s} + \beta m_s), \quad \gamma_5] \neq [\gamma_5, \quad (-\alpha\mathbf{p_s} + \beta m_s)]. \tag{51}$$

This would seem to say that either unification [10,13] of elementary objects in families of a different C-parity is incompatible with the chiral presentation (12) or $\sigma\mathbf{p}_s$ is not helicity operator of a C-odd particle. On the other hand, as follows from symmetry laws, any C-invariant or C-noninvariant neutrino cannot simultaneously have both CPT-even vector and CPT-odd axial-vector nature. Such a circumstance becomes more interesting if we take into account that the existence of vector [17] and axial-vector [18,19] mirror Minkowski space-times are by no means excluded [8,9] experimentally.

Thus, it follows that between the spontaneous mirror symmetry violation and the chiral presentation (12) there exists a range of the structural contradictions, which expresses the ideas of the left- and right-handed neutrinos referring to long- and short-lived objects, respectively. These ideas require in principle to go away from the chiral definitions of the structure of matter fields taking into account that α, β and γ_5 come forward in (12) as the matrices having an exact mathematical formulation but not allowing to follow the logic of a true nature of mirror symmetry including the dynamical origination of its spontaneous violation. Therefore, from the point of view of the mass, energy and momentum matrices, each of (47), (50) and (51) must be interpreted as an indication to the absence in nature of a place for chirality.

But here, on the basis of (7), we can relate the mass to a momentum of any particle as a consequence of the ideas of mirror symmetry laws:

$$m_L^2 = \mathbf{p}_L^2, \quad m_R^2 = \mathbf{p}_R^2, \tag{52}$$

$$\partial_\tau^L = \partial_\mathbf{x}^L, \quad \partial_\tau^R = \partial_\mathbf{x}^R. \tag{53}$$

This picture in turn has important consequences for the space-time structure of elementary objects and call for special illumination.

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