Space-time inversion and its consequences

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Abstract. The article discusses some new aspects of both the inversion of space and the inversion of time. It is shown that behind the mirror is not symmetric to in front of the mirror. It, in its turn, leads to nonconservation of spatial parity. The same situation takes place in the combined CP-parity. Further, the article shows that from the point of view of different reference systems of the Universe (from the point of view of different galaxies or accumulation of galaxies) time flows not just differently, and, in some cases, in the opposite directions. It leads to major changes in the picture of the Universe. In particular, the concept of the age of the Universe loses its meaning, serious doubts about the idea of the Big Bang and so on.

Keywords: mirror symmetry, true vectors, pseudovector, weak interaction, inversion, spatial parity, the Universe, events, time chaos.

1. Spatial inversion

Mirror symmetry refers to discrete symmetries and, as it is known, it is the basis of the law of conservation of P-parity – spatial parity. The point of view was considered and remained obvious until 1956. In the year of 1956 T.Lee and C.Yang in their famous article [1] carried out a systematic analysis of the law of conservation of P-parity in the processes with elementary particles and stated nonconservation of parity in the process caused by the weak interaction.

In 1957 group of physicists (Ambler, Hayward, Hopps and Hudson) under the leadership of C.Wu carried out a brilliant experiment [2] which showed that P-parity is not conserved in the β - decay of cobalt $^{60}\text{Co}$ caused by the weak interaction.

For the explanation of this phenomenon two hypotheses were suggested: the hypothesis of mirror asymmetry of the three-dimensional Euclidean space, and the hypothesis of the combined CP-parity in which the particles of the ordinary world are replaced by antiparticles behind the mirror. The second hypothesis was proposed by Wigner, Lee, Yang and Landau [3, 4].

The first hypothesis was not developed and it was almost forgotten. But the second hypothesis received the right for existence. But, firstly, it is just a hypothesis that can not be tested directly, as it is hardly possible to imagine how to detect antiparticles behind the mirror. This hypothesis seems to be initially confirmed, but only as it saves mirror symmetry.

Secondly, even the salvation proved to be illusory and of short duration, as 7 years later, in 1964, the experiment of Christensen and his colleagues [5] discovered nonconservation of CP-parity in the decays of kaons. The problem has been discussed and is being discussed in many sources (see, for examples, [6-10]), but no satisfactory conventional solution has been found up till now.

Now let us turn to our point of view. We show that the usual three-dimensional space, in general, does not possess mirror symmetry with respect to the conversion, and this very fact explains the nonconservation of spatial parity.

Generally, when considering the mathematical formalism which is associated with the concept of parity the mirror symmetry is mentioned in passing, and we go straight to the spatial inversion, which is equivalent to the reflection in three mutually perpendicular mirrors (see, for
examples, [11, 12]). Thus, in our opinion some essential points are lost. We will discuss the mirror reflection in one mirror in more detail. We will call it a single mirror transformation.

First of all, let us discuss the mirror transformation component of true (polar) and pseudovectors (axial vector) which are perpendicular and parallel to the surface of the mirror. We mark true vector as $A$, pseudovector as $B$, the point of application of the vectors $A$ and $B$ as $O_A$ and $O_B$. Strokes will be used to mark the same values after the mirror transformation.

The pseudovector which is perpendicular to the surface of the mirror, in the mirror transformation does not change the direction. The pseudovector which is parallel to the surface of the mirror changes its direction for the reversed in the mirror transformation. For the true vector the situation is reversed. Let us mark the component of the vector which is parallel to the surface of the mirror as index 1 and the perpendicular component is index 2. Thus, we have the following laws of the mirror transformation:

\[ A'_1 = A_1 ; A'_2 = -A_2 ; B'_1 = -B_1 ; B'_2 = B_2. \]

As we can see, in terms of the mirror transformation both true vectors and pseudovectors possess equal rights in case we swap their perpendicular and parallel components (Fig. 1).

![Figure 1. Mirror transformation of the parallel and perpendicular components of the true vector and pseudovector](image)

If we consider the transformation of the perpendicular and parallel components of the true vector and the pseudovector and then add them up, we get the following picture (Fig. 2).
Thus, if the real experimental situation is depicted by a set of true vectors and pseudovectors thus the mirror transformation of the whole picture is not symmetric.

Now let us consider the operation of space inversion: $x \rightarrow -x$, $y \rightarrow -y$, $z \rightarrow -z$. Otherwise it can be interpreted as mirror reflection in the three mutually perpendicular mirrors (the order of such reflections is not important, all the options lead to the same result). The transformation of true vectors and pseudovectors under spatial inversion is shown in Fig. 3.

Figure 2. Mirror transformation of the true vector and pseudovector

Figure 3. Spatial inversion of the true vector and pseudovector
Here are some explanations. The lower left part of the figure is our usual space, in which there is a true vector and pseudovector. The bottom right of the figure is the picture after the first mirror transformation. The upper right part of the figure is the picture after the second mirror transformation in the mirror, which is perpendicular to the first one.

In this part the dotted line depicts the third mirror, which is perpendicular to the first two mirrors. This mirror is parallel to the plane of the figure, but it lies under this plane.

In the upper left part of the figure shows the picture after the third mirror transformation in dotted mirror. This picture is also parallel to the figure plane, but lies below it, i.e. under the third mirror.

As we see, if the real experimental situation described by a set of true vectors and pseudovectors, then the initial and the final picture are not symmetric with respect to each other.

Thus, both single mirror transformation and spatial inversion in the presence of a set of true vectors and pseudovectors don’t possess any symmetry.

Thus, the question «Why is P-parity conserved in a particular process?» is more essential than the question «Why is not P-parity conserved?». From this point of view the search for the nonconservation of P-parity in the process with strong and electromagnetic interactions makes sense. By the way, if the weak and electromagnetic interactions have already been combined into the electroweak, then why does not the nonconservation of P-parity in the electromagnetic interaction take place, if it exists in the weak one?

By the way, the introduction of combined CP-parity from the point of view of the considered picture does not help the situation and, as we know, CP-parity is not conserved in the decay of kaons.

2. Inversion of time

We now proceed to the consideration of the inversion of time. Until now it was considered that we can speak of the single direction of time in the Universe on the whole – from the past to the future. At present, it is well known that in the frame of the special theory of relativity (STR) time has different «speed» in different inertial reference systems (IRS) and can even «move» in opposite directions, and in the framework of the general theory of relativity, time slows down near gravitating bodies.

However, it did not prevent us from considering the flow of time on the whole, for example, the lifetime of the Universe since the Big Bang is estimated at 13 billion years. Being entirely consistent and while analyzing the time in the framework of SRT, our idea of the single direction of time in the Universe loses its sense as, for example, the idea of the absolute simultaneity.

Besides it turns out that the known operation of inversion (both spatial and inversion of time) under some conditions equivalent to the operation of the transition from one IRS to another within SRT.

We introduce the following reasonable, in our view, definition of different direction of time:

Suppose that in some IRS K the event 2 occurs after the event 1, and IRS K’ event 1 occurs after event 2. So we can say that in these two IRS time flows in the opposite directions.

In both of these systems, time flows from the past to the future, but what is the future for IRS K turns out to be the past for IRS K’, and the past for IRS K appears to be the future for IRS K’.

Suppose there are two events: Event 1 and Event 2 (or 3). Let us consider them from the point of view of IRS K and IRS K’ (Fig. 4). Reference system K’ moves relative to the reference
system K along coincident axes x and x' to the right with velocity V, or, what is the same, the reference system K moves relative to the reference system K' to the left with velocity -V.

**Figure 4.** Two inertial reference systems in SRT

As it is known [13, 14], in the SRT have the following formulas of transformation of periods of time.

Transition IRS K' → IRS K:

\[ c\Delta t = c(t_2 - t_1) = \gamma[c(t_2' - t_1') + \beta(x_2' - x_1')]. \]  \hspace{1cm} (1)

Transition IRS K → IRS K':

\[ c\Delta t' = c(t_2' - t_1') = \gamma[c(t_2 - t_1) - \beta(x_2 - x_1)]. \]  \hspace{1cm} (2)

Here we introduce the usual symbols:

- \( c \) – velocity of light;
- \( \beta = \frac{V}{c} \);
- \( \gamma = \frac{1}{\sqrt{1 - \beta^2}} \).

Primed quantities refer to the IRS K' and the unprimed ones – to IRS K.

We begin with the formula (1). Let in IRS K' event 2 occurent 1, so \( t_2' > t_1' \) or \( t_2' - t_1' > 0 \). Then for the inversion of time it is necessary that \( t_2 - t_1 < 0 \), and then the second component of sum of the right-hand part of the formula (1) must be negative, so \( x_2' - x_1' < 0 \) and, in addition, the inequality must be carried out:

\[ \beta(x_1' - x_2') > c(t_2' - t_1'). \]  \hspace{1cm} (3)

Let us consider the value \( v \) with the dimension of velocity:

\[ v = \frac{x_2' - x_1'}{t_2' - t_1'} > \frac{c}{\beta}. \]  \hspace{1cm} (4)

As you can see, this value must be greater than the velocity of light, which is impossible, and therefore inversion of time is only possible for the two events which are not connected by the cause-and-effect relation (the interval between these two events is space-like).

Now let us take formula (2). Let in IRS K event 2 occurs after event 1, so \( t_2 > t_1 \) or \( t_2 - t_1 > 0 \). Then the inversion of time is necessary \( t_2' - t_1' < 0 \), and the second component of sum of formula (2) must be negative, so \( x_2 - x_1 > 0 \) and, moreover, the inequality must be carried out:

\[ \beta(x_2 - x_1) > c(t_2 - t_1). \]  \hspace{1cm} (5)

Let as consider, as the previous case, the value \( v \) with the dimension of speed:

\[ v = \frac{x_2 - x_1}{t_2 - t_1} > \frac{c}{\beta}. \]  \hspace{1cm} (6)
This value is again greater than the speed of light, and therefore the inversion of time is only possible for the two events which are not connected by the cause-and-effect relation (the interval between these two events is space-like).

Let us give the geometric interpretation of the phenomena from the point of view of Minkowski world. Let us consider the transition IRS $K' \rightarrow IRS$ $K$ (Fig. 5). In the initial IRS $K'$ first event 1 occurs and then – event 2 (or 3) occurs. The case where the inequality (3) is not satisfied, corresponds to the point 2. Here and in IRS $K$, as in the original IRS $K'$ event 2 occurs after the event 1, i.e. no inversion of time.

![Figure 5](image.png)

**Figure 5.** The picture of inversion of time in Minkowski world.
The transition from IRS $K'$ to IRS $K$

The case when the inequality (3) is satisfied corresponds to point 3. Here in IRS $K$ event 3 occurs, as opposed to the IRS $K'$, before event 1, so the inversion of time occurs. (Or if the inequality (3) becomes the equality, the event 3 occurs simultaneously with event 1).

Now let us consider the transition IRS $K \rightarrow IRS$ $K'$ (Fig. 6). In the initial IRS $K$ event 1 occurs first, and then event 2 (or 3) occurs. The case, when the inequality (5) is not satisfied, corresponds to the point 2. Here in IRS $K'$, as in the initial IRS $K$ event 2 occurs after event 1, so there is no inversion of time.
The case, when the inequality (5) is satisfied, corresponds to the point 3. Here, in IRS K' event 3 occurs, unlike IRS K, before the event 1, i.e. there is the inversion of time. (Or, if inequality (5) becomes equation, the event 3 occurs simultaneously with event 1).

Thus, the conditions under which there is the inversion of time, or, in other words, mutually opposite directions of the flow of time for the two of IRS are connected with the following three factors:
1. Relative velocity of IRS.
2. Spatial distance between two points.
3. Period of time.

Let us consider all possible pairs of the IRS connected with real bodies of the Universe. In some of these pairs (and in some pairs of points) time flows in the same direction, and in some of them time flows in the opposite direction. Thus, the idea of the single direction of time in the Universe loses its sense. Past and future are relative. In the Universe temporal chaos reigns. The question of the age of the Universe loses sense too.

3. Evaluation of the order of values and experimental scheme

Now let us estimate the order values describing different directions of time in the Universe. We use formula (3) in this case. The typical distance beginning from which the Universe can be considered homogeneous, and from which Friedman dynamic solution considered true about 100 Mps. Let us take 100 Mps as the distance between two points in which two events occur. Let us the relative velocity of the two reference systems (for example, of two galaxies) be 0.1 light speed.

Then, for the inversion of time the interval between the two events in one reference system must not exceed 30 million years. Thus, from the point of view of the reference system which is connected with one of the galaxies, event 1 occurs 30 million years earlier than event 2, then from point of view of the reference system which is connected with the other galaxy, event 1 occurs 30 million years later then event 2. Thus, we cannot speak of any arrow of time.
It is not difficult to select such parameters in the Universe under which inversion time difference exceeds the age of the Universe (13 billion years).

As it is known, the radius of the Universe is about 12000 Mps. Let us take 10000 Mps as the distance between the two points and relative velocity of the reference systems (in which the two events occur) about the velocity of light. Then the difference of time is equal to 30 billion years. This value proves that the notion of the age of the Universe loses its sense. We would like to stress that the given here calculations of the inversion of time are based on the special theory of relativity, and therefore they are obvious. Nevertheless, carrying out of an experiment confirming the inversion of time may be of some interest to us. The scheme of such an experiment could be next.

Let the primed IRS $K'$ is connected with the Earth, and the unprimed IRS $K$ - with two satellites, which have the zero velocity relative to each other and they are at some distance from each other. The clocks on these satellites are synchronized. Signals are sent from the satellites – at first from the one and then – from the other one. On Earth, these signals are received in reverse order.

Let us calculate the parameters of such an experiment. In order to get the inversion of time the second member of sum in equation (2) must be negative and grater in module than the first member of sum.

Take the velocity of the satellites relative to the Earth $V = 10$ Km/s $= 10^4$ m/s $\Delta x = x_2 - x_1 = 10^3$ Km $= 10^6$ m – about 2,5% of the length Earth's equator.

Then the formula (5):

$$\Delta t = t_2 - t_1 < \frac{\beta}{c} (x_2 - x_1) \approx 10^{-7} \text{s} = 100 \text{ ns}.$$  

Take $\Delta t = 0,3 \cdot 10^{-7} \text{s} = 30 \text{ ns}$. Then the interval of time between the signals recorded on the Earth, is calculated by the formula (2) and its numerical value is $\Delta t' = 0,8 \cdot 10^{-7} \text{s} = 80 \text{ ns}$. The experiment seems to be feasible under these parameters nowadays.

4. Picture of the Universe

Let us connect each galaxy (or galaxy cluster) with their inertial reference system (IRS). Thus, let us imagine the whole Universe as the combination of such IRS. However, the question if the system is inertial or not, arises. However, taking into account the gravitational interaction, there are no inertial systems in the real Universe. Thus, we can introduce some instantly accompanying system of reference. What is considered to be an inertial standard system in which the acceleration is zero?

Apparently, two variants can be offered. Firstly, this is the reference system with regard to which cosmic microwave background radiation is strictly isotropic. Secondly, this is the reference system with regard to which dark matter generally rests. Are such systems identical to each other? Apparently, this question has no answer.

As we have already seen, the theory of relativity implies that the time in different inertial reference systems flows differently, including possibly in opposite directions. In that case the concept of the age of the Universe as a whole has no sense. This concept is only maintained for each IRS separately. How can such a Universe be described? It is pertinent here to draw analogy with the concept of temperature. As you know, temperature makes sense only for equilibrium systems, and it loses its sense for uneven-equilibrium systems.

The description of the uneven-equilibrium systems is associated with different distribution functions, which are more diverse and complex for them than for the equilibrium ones. Apparently, the Universe, in which from the point of view of different IRS, time flows
differently, should be described with the help of using some distribution functions which have to be introduced.

Now the question is if this or that event and, in particular, the Big Bang took place in the Universe. In the light of the said above, it seems to us that there may be at least four possible answers to this question. Let us consider them.

1. Yes, this event (we will speak, for definiteness, of the Big Bang) took place. At present it is a generally accepted answer.
2. No, there wasn't.
3. The question does not make sense, since the concept of the age of the Universe makes no sense.
4. From the point of view of some IRS – there were, from the point of view of some others – there were not.

Thus, from the point of view of the second group of IRS two more subvariants are possible. The first subvariant: the Big Bang in the second group of IRS will take place in the future, the second subvariant: the Big Bang will never take place. By the way, from the point of view of those IRSs, in which the Big Bang took place, it happened 13-14 billion years ago, as it is generally accepted, but it took place at different time in different IRSs. So, the main conclusion derived from these arguments in the following: the Universe looks much different from the point of view of different reference systems.

Thus, if the Big Bang did not take place, or the question does not make sense (the second and third versions of the answer), then all known fundamental phenomena (expansion of the Universe, the cosmic microwave background radiation, etc.) should be interpreted in a new way. Remember, that this situation is not unique, it has already taken place many times in the history of physics. For example, in the late nineteenth century, many phenomena were interpreted within the concept of the ether. Then the concept vanished, and all the phenomena remained, of course, but they began to be interpreted differently. If the fourth answer is true, then the situation becomes even more curious. From the point of view of the IRS in which we exist, the Big Bang probably took place. A large number of experimental facts fit into this scheme.

In general all of IRS (galaxies or their clusters) are divided into two groups. From the point of view of one of them the Big Bang took place, from the point of view of another – it didn't. The description of this strange Universe – is the goal for the future.

5. Conclusions
The main conclusions of this work are the following:
1. The inversion of time and spatial inversion (mirror reflection) to certain extent are equivalent to the transition from one IRS to another. Thus, it is possible to some extent to simulate inversion of time and mirror transformation.
2. Behind the mirror is not symmetric to in front of the mirror. It, in its turn, leads to nonconservation of spatial parity and CP-parity.
3. In the Universe in General there is no single direction of time. Call it a temporary chaos of the Universe. In connection with this question of the Big Bang remains open.
4. In the Universe on the whole is no single direction of time. Let us call it the chaos of time of Universe.

We believe this work can be developed further in the following directions:
1. The experimental search of the non-conservation parity in the processes caused by strong and electromagnetic interactions.
2. Development of methods for describing properties and behavior of big system (the Universe) in which time is chaotic but not dynamic.
3. Coordination of the introduced here concepts with the aggregate of all known in cosmology experimental data.
4. Analysis of real scheme of the possible experiment (and its setting), which confirms the introduced here concepts.

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References
[1] Lee T D and Yang C N 1956 Proposals to test spatial parity conservation in weak interactions. The Physical Review 104 no. 1 pp 254-258
[2] Wu C S, Ambler E, Hayward R W 1957 Experimental test of parity conservation in beta decay. The Physical Review 105 pp 1413-1415
[3] Wigner E P 1970 Symmetries and Reflections Scientific essays (Cambridge, Mass.: M.I.T. Press)
[4] Lee T D and Yang C N 1957 New symmetry properties of elementary particles (Moscow : World))
[5] Christensen J H and Cronin J W 1964 Evidence for the 2 pi decay of the K20 Meson. Phys. Rev. Lett. 13 pp 138-140
[6] Gibson W M and Pollard B R 1979 Symmetry Principles in Elementary Particle Physics ( Cambridge, London, New York, Melbourne : Cambridge University Press) p 344
[7] Okun L B 1990 Leptons and Quarks (Moscow : Science) p 352
[8] Kane G 1987 Modern Elementary Particle Physics (Michigan : Addison-Wesley Publishing Company) p 360
[9] Chelnokov M B 2010 On Spin of Fundamental Particles. Herald of BMSTU. Natural Science 3 (38) pp 22-34
[10] Chelnokov M B 2010 On Spin Projection of Fundamental Particles and Problem of Non-Conservation of CP-Parity. Herald of BMSTU. Natural Science 4 (39) pp 73-85
[11] Bogolyubov N N and Shirkov D V 1980 Kvantovie polya. [Quantum Fields] (Moscow : Nauka) p 320
[12] Bogolyubov N N and Shirkov D V 1984 Vvedenie v teoryu kvantovih poley [Introduction in Theory of Quantum Fields] (Moscow : Nauka) p 600
[13] Ugarov V A 1997 The special theory of relativity (Moscow : Nauka) p 384
[14] Fok V A 1955 The theory of space, time and gravity (Moscow : USSR) p 504
[15] Chelnokov M B 2015 Asymmetry through the looking glass. Chebyshev collection 16 no. 1 pp 281-290