FUNDAMENTAL INTERACTIONS AND FOUR SYMMETRY RULES

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1. Four symmetry rules

As is known, all phenomena of Nature can be reduced to four fundamental interactions: strong, weak, electromagnetic and gravitational. We will show that from the symmetry position each of them corresponds to one of the four symmetry *rules*: the scale rule, the corkscrew rule, the right (left)-hand rule and the gyroscope rule [1].

We will proceed from that each combination of forces acting at some point of homogeneous and isotropic medium, can be reduced to the force (the main(polar) vector), to a pair of forces (the main moment, axial vector), to omnilateral extension (compression) described by a scalar and to omnilateral "screwing in" (the "right-hand" and "left-hand" pseudoscalar). The above six quantities represent in geometrical representation the space and time symmetry of our reality [2].

To describe the space and time symmetry one may use the PT-4 group which contains the following operations: 1 – identification, $\overline{1} = C$ (C is the inversion center) – inversion at a point, $\underline{\overline{1}} = \underline{C}$ ($\underline{C}$ is the inversion anticenter) – antiiversion at a point, $\underline{1}$ – antiidentification. The character of transformations of the given scalar and vector quantities affected by these operations is seen from figure 1. The operation $\overline{1} = C$ "inverses" (changes the sign) time, the operation $\underline{\overline{1}}$ – space and operation $\underline{1} = \overline{1} \cdot \underline{\overline{1}}$ both space and time.

The physical phenomena of our reality satisfy the requirement of the operation $\overline{1} = C = T$, i.e. of time *inversion*, it is centrosymmetrical. This is provided by that the space in it is centrosymmetrical by itself and has only one "sign", while time is presented by two signs on equal rights. The simplest relations describing such phenomena are combinations of "interac-

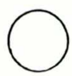
Basis invariants				Representations	Operations and characters			
polar vector	axial vector	scalar	pseudo-scalar		1	$\bar{1}$ T	$\bar{1}$ P	$\underline{1}$
–	–	–	–	A	1	1	1	1
				B	1	1	–1	–1
				C	1	–1	1	–1
				D	1	–1	–1	1

Fig. 1. The characters of irreducible representations and bases of PT-4 group.

tions" of vector and scalar quantities. There are altogether six such relations which are described by the polar and axial tensors*).

Two phenomena are described by the *even* rank polar tensors. In scalar variant (being written via zero-rank tensors) they are of the form

$$\underset{T-}{P} = a\underset{+-}{Q} \qquad (1)$$

$$\underset{T+}{H} = a\underset{++}{S} \qquad (2)$$

The relation corresponding to the odd (the first) rank polar tensor, the vector product, has the form

$$\underset{T+}{H} = [N\underset{++}{S}] \qquad (3)$$

Three axial tensors of the even and odd rank, have, respectively, the form

*) Polar tensors result from interaction either of the two polar or two axial vectors, while the axial ones from interaction of the polar and axial vectors.

$$\begin{array}{lcc} & H = & AP \\ T & + & -\,- \end{array} \qquad (4)$$

$$\begin{array}{lcc} & Q = & AS \\ T & - & -\,+ \end{array} \qquad (5)$$

$$\begin{array}{lcc} & H = & [FP] \\ T & + & -\,- \end{array} \qquad (6)$$

In these relations a is a scalar, A is a pseudoscalar, P,Q,F are polar vectors, H,S,N are axial vectors. The relations (1)-(6) are graphically shown in figure 2.

The relations (1)-(6) exhaust all possible combinations of interactions of vectors and scalars satisfying time inversion operation $T = \bar{1}$*). At the same time the same relations exhaust also all their possible combinations at all**). Thus, relations (1) and (2) connect similar vectors through scalar, relations (4) and (5) connect different vectors through pseudoscalar. These are the so-called longitudinal effects. Relation (3) describes the interaction of the two similar normally oriented "boundary" axial vectors through the axial vector too and relation (4) the interaction of the two different "boundary" vectors through the polar vector. The two latter relations describe "transverse" effects.

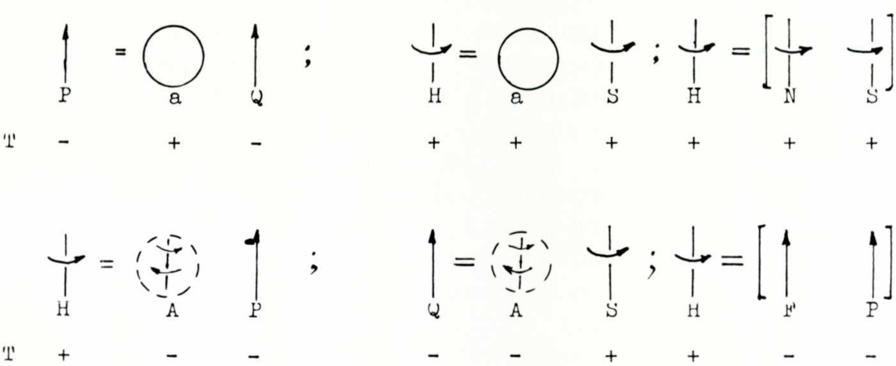


Fig. 2. Graphical interpretation of the simplest relations describing real phenomena which satisfy the time inversion requirements, $T = \bar{1} = C$.

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*) If some quantity "changes the sign" or "is reoriented" under the action of the operation $\bar{1} = T$, then the sign minus (–) is put under it, if it conserves the sign – the sign plus (+). To have after the action of the operation T the similar signs (+=–·–;–=+·– etc.) in the right-hand and left-hand parts of relations (1)-(6) implies to satisfy the operation T.

**) We do not present here purely "scalar" combinations but in the symmetry aspect they give nothing new (two scalars and two pseudoscalars are connected through scalar, while scalar and pseudoscalar, through pseudoscalar).

The six presented relations illustrate various physical phenomena which obey the four macroscopic symmetry rules. Relations (1) and (2) illustrate the *scale* rule: one vector (describing some physical quantity) is converted to another, the same, not differing from the first one in its direction but differing in its absolute value, "in modulus". Relation (3) illustrates the gyroscope rule: a spinning gyroscope at rotation about the axis normal to rotation axis acquires one more rotation about the third axis normal to both of them*).

Relations (4) and (5) illustrate the *corkscrew* rule: rotation of the right(left) screw leads to its forward (backward) motion. Relation (6) illustrates the *right (left) hand* rule, for instance, the Magnus effect: bending of the flight path of a rotating cylinder.

The quantities determining the relationship between "extreme" vectors in relations (4)-(6) are realized through anticentrosymmetrical quantities (pseudoscalar and polar vector).

2. Fundamental interactions and symmetry rules

A scalar, an axial vector, a pseudoscalar and a polar vector describe all the four simplest interactions. It can be easily seen that these interactions correspond to four fundamental interactions of Nature.

A carrier of electromagnetic interaction is a photon (relation (6)) which has the polar vector symmetry [3] the symmetry group $\infty/\underline{m}$ mm**). A carrier of gravitational interaction is a graviton (relation (3)) which has the axial vector symmetry (the group ∞/m $\underline{m}$ $\underline{m}$). Electromagnetic and gravitational interactions are long-ranged and well illustrated by such phenomena as propagation of electromagnetic and gravitational waves. They correspond to the right (left) hand rule and gyroscope rule, respectively.

Weak interactions considered in microcosm are not considered in macrocosm, though, as appears, there are many such interactions here (operation of a propeller, of a fan, of a corkscrew etc.) Weak interactions are described in symmetry (relations (4) and (5)) by a pseudoscalar (the symmetry group $\infty/\infty/\underline{m}$ $\underline{m}$ $\underline{m}$ – a sphere with twisted diameters). In symmetry they correspond to the corkscrew rule. These are "longitudinal" interactions of polar and axial vectors analogous to the symmetry configuration of neutri-

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*) "Addition" of the two latter rotations leads to gyroscope precession.

**) ∞ is the infinite order symmetry axis, $\underline{m}$ is the symmetry antiplane converting "black" into "white", "left" into "left" (or "right" into "right"). m is the symmetry plane. The next after the symbol ∞ declined line implies that the symmetry element after it is normal to the axis ∞. The rest "symmetry planes" are parallel to the axis ∞.

no (see figure 1, representation D). They are centrosymmetrical and in this sense are "close" to electromagnetic interactions. In macrocosm the carriers of weak interaction must be pseudoscalar neutrino. A very short interaction range is specific of them.

Strong interaction corresponds to the scale rule (relations (1) and (2)), it is described (in symmetry) by a scalar, group $\infty/\infty/m\, m\, m$. Of macrophenomena this interaction may be shown through the accelerated straight-line motion of a material point. Strong interaction, just as gravitational one, is centrosymmetrical and in this sense they are "parented". In high energy physics this short-range interaction of "nuclear forces" must be centrosymmetrical" and gluons may be adopted as its carriers.

It is interesting that Nature conserves for macrocosm an analog of short-range weak and strong interactions which in this case are rather not "interactions" but "phenomena". It is worth paying attention to the fact that comparison of fundamental interactions (including those on micro-level) with the symmetry rules of macrocosm reveals the symmetry of the first ones. Evidently, real interactions of elementary particles in microcosm are more complicated than the simplest ones, given in figure 2, but their symmetry groups are either centrosymmetrical (strong interaction and gravitation) or anticentrosymmetrical (weak and electromagnetic interactions).

3. Interactions and matter. Unification problem

Apart from the four fundamental interactions described by a scalar (strong), by a polar vector (electromagnetic), by a pseudoscalar (weak) and by an axial vector (gravitational), one may also consider the relationship between these interactions. Already one of them, electromagnetic one, is, in essence, not simple, but is a relationship between "electricity" and "magnetism" (relation (6)). Of other combinations one should distinguish the predicted and recently investigated electroweak interaction. This is the relationship between two anticentrosymmetrical interactions. From the formal viewpoint, according to relation (4), it must be described by the axial vector, that makes it to be close in symmetry with the gravitational interaction. The combination of strong and weak interactions must be again "closed" (in symmetry) on the weak one etc.

In the last 15 years attempts were made to unify electroweak interaction with a strong one. This leads to development of various theories of Grand Unification (GUT). It is assumed that a combination of GUT with gravitation theory will result in the establishment of a unified "superforce" responsible for creation of Universe and in the complete understanding of the "mechanism" of its creation.

The symmetry methods are widely used when developing the given unifications (gauge symmetry, supersymmetry etc.). After all, the problem is here reduced to prediction (and the finding) of carriers connecting different interactions.

It can be thought that understanding of Universe should be searched for on the other path as well. Indeed, for such an understanding one should after all establish a symmetry of "initial state" from which Universe appeared and the character of a change of this symmetry at Grand Explosion. This means that the problem is reduced to establishing the fact which symmetry must belong to this state in order to obtain just the four known fundamental interactions and particles.

Up to now, in our literature an understanding predominates that at Grand Explosion there appeared together with Universe an Anti-Universe and that annihilation of particles of these Universes occured in a way that due to their "inequal rights" the matter became essentially predominant over antimatter.

A more careful symmetryconsideration allows, however, to point out another "mechanism" of Grand Explosion according to which this explosion involves production of two "subrealities": spatial (our) and time-subreality which are not "antisubrealities". The first of them is (in space and time) as a whole centrosymmetrical (has one "sign" of a scalar and axial-vector space and two "signs" of a pseudoscalar and polar-vector time, see figure 1). And the second is anticentrosymmetrical (has one "sign" of a pseudoscalar and polar-vector time and two "signs" of a scalar and axial-vector space).

For time subreality, the requirements of operation $\underline{\bar{1}}$ (anticenter of inversion $\underline{C}$) are satisfied, not the requirements of operation $\bar{1} = T$ (see Fig. 2 and eqs. (1)-(6)). One subreality converts into the other by the operation $| 1 |$. Geometrically, this corresponds to transformation of scalars into pseudoscalars and of polar vectors into axial ones (and vice versa). Such a treatment of two subrealities is a consequence of peculiar equal rights of space and time.

From the symmetry considerations, a combination of particles from two subrealities (emerging at Grand Explosion) cannot completely annihilate and that results in creation of matter due to stable particles which agree in the symmetry with the space and time symmetry of our subreality. The decay of such particles (in particular, of a proton) is impossible.

Thus, the "initial state" is neither centrosymmetrical nor anticentrosymmetrical, is "nothing", i.e. does not contain anything which can be featured by symmetry in our notions. It is the combination of the two produced states (centrosymmetrical and anticentrosymmetrical) which corresponds to the "symmetry" of the given "initial state". From the considerations we develop here that the initial "bricks" of matter of each subreality are "elementary fluctuations of vacuum" [3], and have the space and time symmetry. These are (in the symmetry) polar and axial vectors, scalars and pseudoscalars. They just determine the four types of fundamental interactions considered in Section 2.

The problem of unification of interactions in such considerations has the sense only with respect to unifying strong and gravitational interactions. The theory of such unification will be fit to describe electroweak interaction in the time-subreality while already developed theory of electroweak interaction in the space-subreality will be fit to describe the interaction relating (in the time-subreality) strong and gravitational interactionr. Further unification of interactions will be in the essence reduced to describing interactions between elementary particles but not between interactions. Practically, already electroweak and electromagnetic interactions are interactions between particles.

The combination of relations (1)-(6) and of analogous relations of the time-subreality completely describes the mechanism of creation of the Universe, all the features of its development and all interactions.

The simplest fluctuations may produce in homogeneous and isotropic medium eleven symmetrically-different combinations, eleven groups of *complete**) symmetry [4]. Two of them (the group of a scalar and the group of a pseudoscalar) were presented above. The presented above "vector" groups reflect the degenerate state symmetry, in isotropic and homogeneous medium vector states are transformed into "limiting isotropic", cubic ones. Double combinations of elementary fluctuations lead to six groups while all the triple and fourfold combinations lead to one and the same group. It is interesting that the number of these groups (eleven) coincides with the number of measurements of space and time in supergravitation which unifies the description of interaction and matter.

4. Conclusion

Space and time are modelled by geometrical images correctly mapping their symmetry: by a scalar and axial vector for space, pseudoscalar and polar vector for time. Our reality is centrosymmetrical, satisfies the requirement of the time inversion $T=\bar{1}=C$ corresponding to inversion at a point.

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*) The complete symmetry, in addition to the usual one, considers two new types of equality: anticompatible and antimirror. In the first of them geometrical images (scalars and pseudoscalars) are compared which have both different scalar signs (+ and –) and different enantiomorphism signs (of "rightness" and "leftness"). This is operation $\underline{1}$. At antimirror comparison, the images with different scalar signs and with equal pseudoscalar signs (operation $\underline{\bar{1}}$) are believed to be equal.

There are six simplest relations connecting "space" and "time" and satisfying this requirement. Three of them are described by polar tensors and three by axial ones. They correspond to four rules of macroscopic symmetry: the scale rule, the corkscrew rule, the gyroscope rule and the right (left)-hand rule.

These four symmetry rulels are compared with fundamental interactions of Nature: strong, weak, gravitational and electromagnetic. It is shown that strong interaction corresponds to the scale rule. In relations describing this rule, two polar and two axial vectors are connected through a scalar. The connection between the polar and axial vectors is realized through a pseudoscalar and corresponds to weak interaction. Gravitational interaction is described by the vector product where axial vector "tights" two other axial vectors. Electomagnetic interactions are described by the vector product in which the polar and axial vectors are connected through the polar vector.

The Universe creation model is discussed, the "initial state" of which is neither centrosymmetrical not anticentrosymmetrical. At Grand Explosion two subrealities are created simultaneously (begin to create): spatial (our) and time ones*). The first of them is centrosymmetrical while the second is anticentrosymmerical. From symmetry considerations, the appearing elementary particles of both subrealities cannot fully annihilate and a part of them, which agrees in symmetry with the symmetry of our subreality, creates matter.

The model consistently explains the "mechanism" of Grand Explosion, of the rise of Universe, creation of matter and four fundamental interactions. Unification of interactions is treated as a tend to establish the relationship between elementary particles.

ABSTRACT

It is shown that four fundamental interactions (strong, weak, gravitational and electromagnetic) correspond to four macroscopic symmetry rules (scale rule, corkscrew rule, gyroscope rule and right (left)-hand rule). A model of the Universe creation is discussed according to which the Grand Explosion involves production of two su-

*) It can be also assumed that the "spatial" and "time" subrealities, in a restricted understanding of these words, prior to Grand Explosion, have existed "always" and "everywhere" (the matter is eternal!). In such a "spatial" subreality space is described by a scalar and time is described by a polar vector, while in such a "time" subreality space is described by an axial vector, and time by a pseudoscalar. Such "subrealities" are symmetrically incompatible. Grand Explosion in this model is a consequence of a "combinatioin" of two "subrealities", as a result of which two mixed subrealities are created and one of which is our, spatial one.

brealities: spatial (centrosymmetrical) and time (anticentrosymmetrical). From symmetry consideration, the interaction of elementary particles of both subrealities does not result in their full annihilation and a part of them which agrees in symmetry with the symmetry of our (spatial) subreality, produces matter. The model consistently explains the "mechanism" of Grand Explosion, the production of matter and of four fundamental interactions.

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