Review Article

Reflection on Relativity of Space-Time-Symmetry

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The integrity of the universe thesis is the most generalized form of relativity principle.

It agrees with the biological principle that no part of the human body is unrelated to the integrity of the organism's function.

The advances in modern science confirm the widely accepted assumption that space-time symmetry and relativity (STSR) are the common fundamental attributes (forms of existence) of elementary particles, galaxies, and biological objects. Symmetry is movement, dimension, and scale-dependent, i.e., not an absolute entity.

Our consideration focuses on the impact of universal space-time handedness (time arrow, chirality, or mirror reflection asymmetry) and chirality transfer observed within the physical and biological matter.

Symmetry perturbations are about how space and time are related. The integrity of the universe, meaning that every part of Nature exists only in relation to the rest of the world, refers to the most generalized form of relativity principle (RP). Galileo Galilei was the first among scientists to capture the phenomenon of relativity. However, his intuition did not explicitly associate the notion of symmetry with RP.

A modern interpretation of RP links space-time symmetry and relativity with quantum physics and biology. The limitations of intuitive understanding of the external world are gradually conquered by advances in the language of space-time geometry and the integration of human and artificial intelligence (AI).

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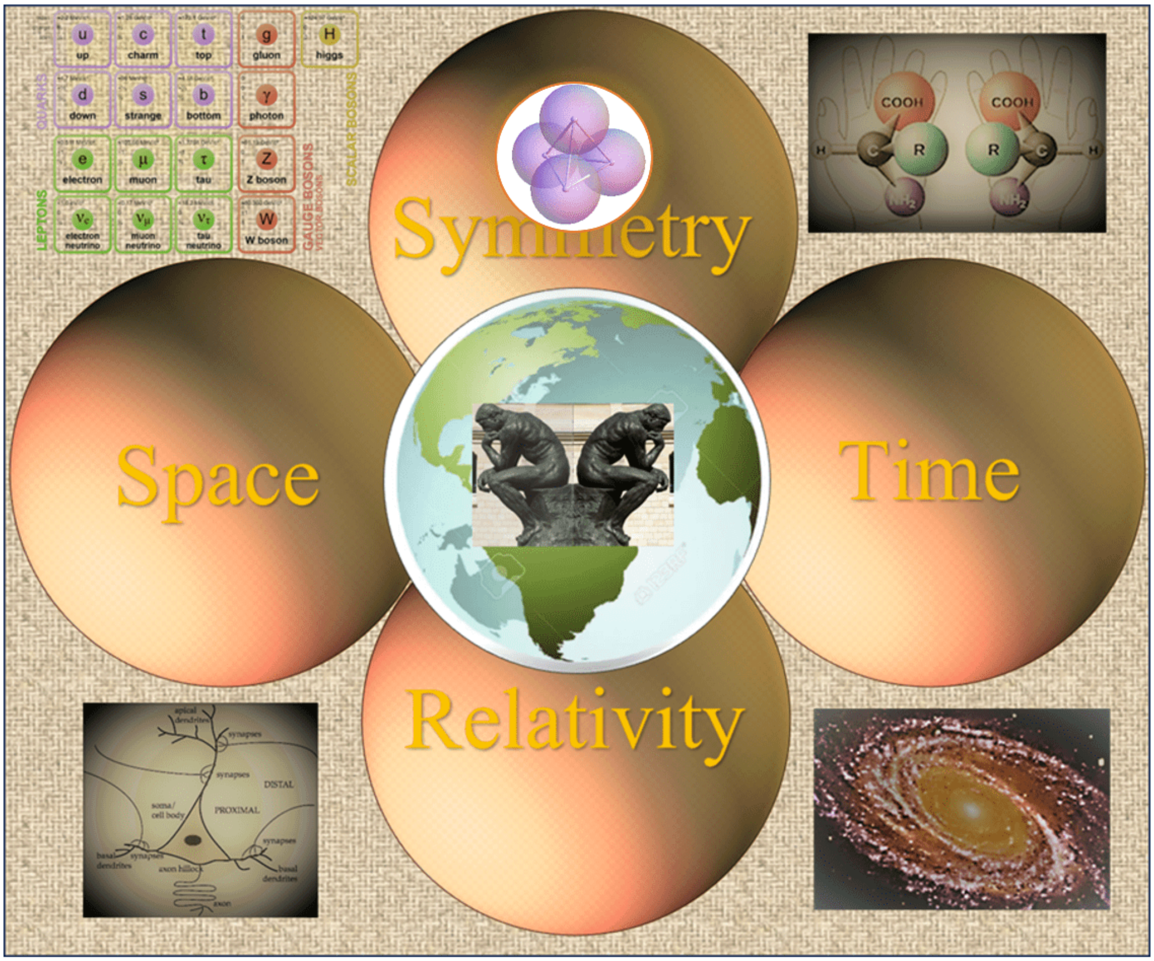

Figure 1. *The integrity of the universe thesis is the most generalized form of relativity principle.*

Abbreviations

Amino acids (AAs); Elementary particles (EPs); Artificial intelligence (AI); Left-right asymmetry (LRA); Perceptual Constancy (PC); Relativity Principle (RP); Phase Transitions (PhTrs); Relativity of symmetry (RS); Space-time symmetry (STS); Space-time symmetry and relativity (STR); Spontaneous symmetry breaking (SSB); Standard Model (SM); String theory (StT); Special theory of relativity (STR); General theory of relativity (GTR); Congruent theory of relativity (CTR); Weak interaction (WI).

Introduction

Ancient Grekc were first depicting handedness (chirality) reflecting difference between similarity and symmetry. Galileo Galilei was the first among scientists to capture the phenomenon of relativity. However, his intuition did not explicitly associate the notion of symmetry with RP. He associated the relativity principle (RP) with the inertia force. He had an opportunity to associate the relativity principle (RP) with the symmetry (equivalence of reference frames) and the gravity force, but he did not. He, obviously, did not have an opportunity to associate RP with quantum mechanics. In post-Newtonian times, in the face of experimental and theoretical advances, a new generation of scientists (including Michelson, Minkowski, Lorentz, Poincare, Einstein, Noether, and many others) were motivated to work on transforming the Galileo-Newton formulation of PR. In this pathway, the SRT and GRT were significant initial steps providing an opportunity to grasp the fundamental role of symmetry in RP in understanding the physics of non-gravitational, quantized forces. Noether articulated the first mathematical formulation connecting RP with Lorentz-Poincare symmetry transformation. GRT has been a triumph of theoretical physics, having passed numerous observational tests. However, "there are strong theoretical reasons - which relate to the origin of the Universe and physics beyond the Standard Model - to suspect that a deeper theory will emerge upon closer scrutiny" [1]. The attention of forerunners becomes aggregated around the diversity of symmetry forms [2], focusing on provocative questions in left-right asymmetry [3][4].

We will analyze the fundamental basis of the above-mentioned theoretical reasons associated with space-time symmetry. The exploration of the fundamental basis of the abovementioned reasons associated with space-time symmetry occurs right now, as evident in the flow of multidisciplinary scientific publications. Some of them you will find below. Time Arrow, evident in the chain of physical events, is associated with some hidden asymmetry [3][4]. According to the Sakharov hypothesis, it is linked with the several conditions of the universe, two of which are the non-equilibrium state (deviation from equilibrium is the form of asymmetry) and the fact that contents of matter are significantly more than antimatter. Space-time symmetry (STS) is the most fundamental and manifold feature of the universe. We will focus below preferentially on the space symmetry. More precisely on the mirror reflection asymmetry/asymmetry associated with the geometrical concept of chirality and chain of chirality transfer (ChChrTr) across the entire range of space domain. Symmetry of the objects in mathematics is characterized by the presence or void of the symmetry elements. The mirror reflection is the most intriguing symmetry element (symmetry operation). Chiral Objects a not identical (not congruent). The specific class of objects that do not have any elements of symmetry is named chiral. The distinct property of chiral objects is that they do not possess (not exhibit, not preserve) the mirror reflection symmetry but instead mirror reflection asymmetry. In other words, the operation of mirror reflection divides (discriminates) all existing objects into two distinct classes: chiral and achiral. Depending on the attributed symmetry elements, threedimensional (3-D) bilateral objects can be chiral or achiral. Chirality refers to the property of an object that is not identical to its mirror image. Chiral objects do not have an internal plane of symmetry. An example of 3D-bilateral chiral objects is the human body, in which the left and right half are not equivalent, despite the high degree of similarity in shape. This similarity is the source of confusion when the animal body is characterized as bilateral symmetry, while it is, in fact, an incident of bilateral asymmetry. Two fundamental transformations of STS (preservation and breaking) are simultaneously the critical determinants of the physical world, shaping the branching of evolutionary trees (Fig. 1).

Platform of Contemporary Physics

The observable spacetime geometry is intimately related to the spatial distribution of matter associated with the fundamental forces, including gravitational and electromagnetic fields [5]. The symmetry of position, inertial motion (translation), rotation, and acceleration of objects reflected in the physical laws guides our understanding of the relativity of the *evolution of the universe and* relevant reference frames [6]. Considering global scenario based on inherent dynamics of the symmetry/asymmetry transformations in a non-stationary (out of equilibrium) universe is frequently lacking {with rare exceptions [6]. Indeed, all known mirror reflection symmetry-asymmetry transformations are associated with the relative motion of the objects covering the entire (total) diapason of the spatial domain from the elementary particles (EPc) to astronomical scales [7][8]. Some theories treated spontaneous symmetry breaking (SSB) as a phenomenon that arises from properties of an asymmetric quantum mechanical vacuum state. In particular, the non-invariance of the vacuum state concerning symmetry leads to (SSB) [9]. *The* complexity of the Electroweak Theory and Standard Model (SM) is reflected in the many specific interactions of EPs involving the breaking and restoration of chiral symmetry. The discovery of breaking several kinds of symmetry (including matter-antimatter asymmetry) by weak interaction (WI) becomes the most convincing evidence that symmetry is not absolute but one of the previously known space-time-associated relative categories of being.[I] Translate all universal-chirality-associated knowledge to biological science has a long way to go [10]. Biochirality has become the most prominent trend in modern biology. Progress in quantum physics inevitably leads to emergence of quantum biology [11][12][13]. Indeed, Pauli exclusion principle and uncertainty principle become foundational postulates of both quantum mechanics and quantum biology [14][15][16] (Fig. 2 a,b). Mathematical exploration of generalized symmetry in quantum field theory suggests that General Theory of Relativity (GTR) is not general enough to describe the behavior of currently known sEPs [17]. The conclusion resulting profound effects on the physics and biology. We will explore how it is reflected in the spectrum of current publication in related fields. Notable that molecular dynamics in general, including biological chemistry, cannot be properly understood without principles of quantum mechanics. Indeed, spatial orientation (distribution) of the spins obeying the Pauli exclusion principle, is directly linked to molecular symmetry and is a critical determinant of molecular chirality and biochirality in general. The special and general relativity theories (STR and GTR) are based on the specific geometry of space, time, and mass [18][19][20]. Spacetime symmetries refer to transformations of space and time, which can be applied individually or together. Some properties of the system assumed do not change under symmetry transformations. In other words, we can say that the system is symmetric in terms of preserving some quantity of the system (object or event). See Fig. 2.

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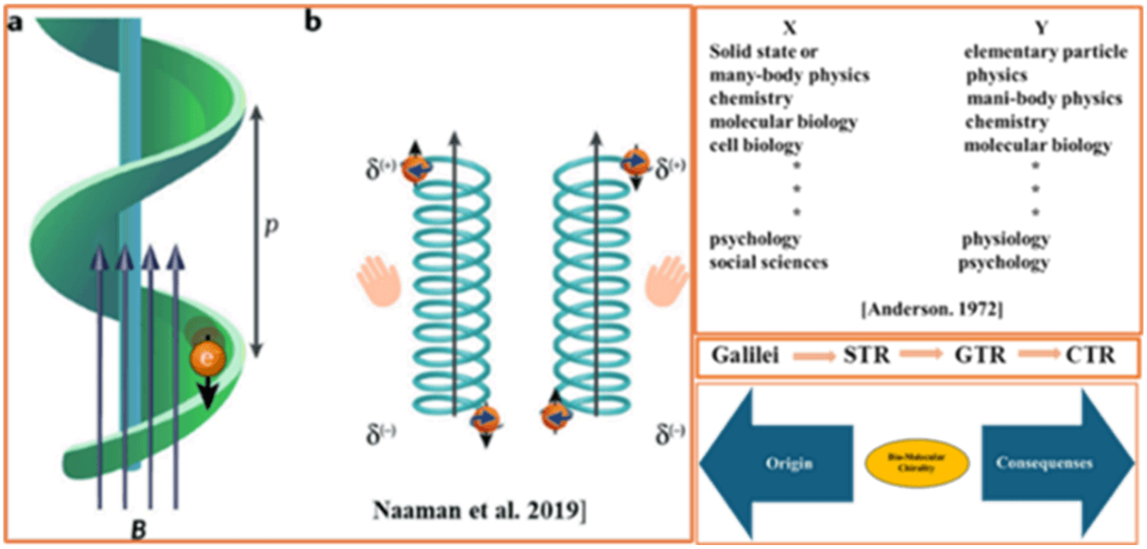

Figure 2. *Chiral induced spin selectivity (CISS) illustrating the physical effects accompanied by the transfer of charged particles through the ion channels of the cell membrane. (a,b) A scheme describing the electron-transmission through a chiral geometry of pitch. The electron is depicted as a sphere and the arrow indicates its spin. The electron moves within the potential, while a constant force, which is like the classical centripetal force (F centripetal), acts on it in the direction perpendicular to its velocity. This force is like a Lorentz force (FB) that results from a magnetic field, $B^{\rightarrow}$, along the axis of the molecule. The effective spin–orbit coupling is then given by $\mu^{\rightarrow} \cdot B^{\rightarrow}$, with $\mu^{\rightarrow}$ being the magnetic moment of the spin. B) A scheme describing the charge and spin polarization in chiral molecules, when the molecules are exposed to an electric field acting along their axis (black arrows). The electric field induces a spinselective electron displacement that results in a transient spin polarization at the electric poles (at the end helixes). Which spin is associated with which pole depends on the handedness of the molecule. Adopted from [19].* ***(c)*** *(Top) "All the animate or inanimate matters of which we have any detailed knowledge (X) are assumed to be controlled by the same set of fundamental laws (Y)" [19]. (Middle) Evolution in interpretation of relativity principle. Molecular chirality is a central feature in the evolution and development of biological systems. Two principal questions associated with bio-molecular chirality are regarding origin (X) and consequences (Y).*

The discovery of a quantum world existing beyond this geometry, brings two essential understanding. First, all fundamental determinants of nature, such as space, time, and symmetry, are not absolute but relative characteristics of physical events. Second, RP itself requires further generalization. The relativity of space and time is permanently and widely explored. But the relativity of the symmetry (invariants), in a broad sense, remains in shadow. The relative meaning of symmetry, as well as asymmetry (chirality), is most apparent in the example of our hands. Left and right hands exhibit a relative degree of similarity (associated with symmetry) and chirality (associated with asymmetry). Indeed, the mirror reflection of

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the left hand is different (not identical to) from the right one due to the difference in many specific details. Our consideration covers mostly the interrelated instances of symmetry: geometrical (symmetry of shapes/configurations) and algebraic (symmetry of equations). The terms "symmetry," chirality," and "equation" are inherently liked in mathematics. Indeed, any mathematical equation is the search for symmetry (quality =identity= parity = equilibrium = homology = equivalence = uniformity = likeness) [20][21][22][23][24]. Scientific clarification of such "self-evident" notions takes a long time (from Galileo's formulation of the RP to present interpretation). It is essential to note that the systems of linear and non-linear differential equations, being the powerful methods for describing many forms of physical motion, exhibit different types of symmetry (relative to space/time variables), which are not always equivalent to the symmetry of solution and observed physical effect [24]. Our concern is focused on seemingly unrelated issues - the evolution of view on the relativity principle in association with the STS and the mechanisms underlying the psychology of adaptation and laws of the external world. Intuitive feeling tells us that there is some analogy in the symmetry of physical objects associated with the fundamental conservation laws and genetic inheritance exhibiting some mode of preservation (symmetry). In support of intuition, current scientific evidence shows that "standard genetic code is found to exhibit an exact symmetry under a finite group of order four known in mathematics as the Klein group" [25]. The genetic code symmetries observed in all branches of the evolutionary trees have remained unchanged throughout evolution and are considered to have the power of natural law [26][27]. Based on this knowledge, symmetry may be recognized as a meta-principle that pervades all the branches of physics and all levels of biological organization. In biology, a meta-principle of symmetry exhibits validity from molecular chirality at the bottom to the laterality of cognitive function at the top of the evolutionary tree [28].

Relativity Principle and Concept of Symmetry

The basic mathematical equations reflecting the observed physical world are Lagrangian [29], Hamiltonian [30], and Schrodinger equation [31]. All three allow us to describe deviation from the exact symmetry - (phenomenon of quasi-symmetry). This fact suggests the appearance of the relativity of the symmetry determinant in many natural phenomena, including living matter [32].

At the intuitive level, the concepts of probability and relativity exhibit certain 'hidden' similarities. The mathematical formulation of this similarity, At present it is a multiple-branching field of science that considers diverse families of symmetry groups (finite vs. infinite, affine vs. not affine). Each of these groups of symmetry has a specificity in the application of any symmetry operations, including mirror reflection. Implementing all mathematically possible options (of transformations) on physical objects is not a trivial task; it goes far beyond the capacity of intuitive imagination. Unfortunately, applying the powerful tool of Group Theory in biology is practically absent [28].

Consequently, formulating the relativity principle and requirements for the frame of reference will not preserve the structure across all options. This situation is the land of scientific activity for the nearest and long-term future [33][34]. The relativity of geometrical symmetry associated with atomic and chemical structures, transferred to microscopic and macroscopic objects, is rooted in the inherent characteristics of EPs. Indeed, experimental observation of EP's behavior reveals far-reaching relationships between symmetry transformation and the fundamental concept in quantum mechanics. A convincing illustration is Heisenberg's uncertainty principle associated with quantum fluctuations [35][36]. The most straight-forward conclusion is that the uncertainty in spatial positions of particles brings uncertainty (relativity) to the geometrical symmetry of the system. The symmetry of geometrical shapes rely on the definite spatial coordinates of elements. Uncertainty of coordinate value inevitably introduces uncertainty to the symmetry of the objects. Adding or deleting some elements will also chainage the overall symmetry (in general) or chirality (specifically). The uncertainty (relativity) of quantum objects' symmetry (Lorentz and Poincare) is currently being explored theoretically [37][38]. However, all consequences of the symmetry uncertainty related to the Heisenberg principle remain to be studied. The above arguments shed light on the history of discovery and understanding of relativity principles. The view on the not trivial relations between symmetry (referred also as equivalence and invariance), movement, and relativity have a tale from the time of Ptolemy (AD 85 AD 165) and Copernic (1473-1543). Copernicus first disproved Ptolemy's claim regarding (the absolute reference frame for studying movement. Aristotle (384 B.C.E. - 322 B.C.E.) thought that under the impact of the gravity force, heavy objects would fall faster than light ones. Galilei (1564-1642), decided to test this assumption experimentally and found that it was incorrect. Reflecting on the laws of movement, Galileo assumes that the speed of light is high (in comparison with the speed of observable objects) but limited.

Analyzing the conclusions of Aristotle and Copernicus, Galileo generated several hypotheses, many of which he evaluated experimentally. Among them are the principle of inertia and low of constant acceleration induced by constant force (independent of the body mass) finalized by the relativity principle. His objective was to formulate the laws of movement in the most general form, resulting in the first the RP potentially covering relations between space, time, and the concept of symmetry. Galileo, his contemporaries, and several generations of scientists did not realize that they had caught the tail of the most powerful law of Nature. Yes, yet not in its most adequate form, but from now on, it has become just a question of time. At the time of the Galilei, ancient intuitions regarding space, time, and symmetry were transformed into the principle of equivalence of all inertial reference frames. Notably, Galileo (as well as Newton and Einstein) did not comment on the fundamental association of relativity-symmetry explicitly. Only much later, with advances in particle physics, it is becoming apparent that Galley's and Nuton's assumptions about isotropy of physical space and the uniformity of time were, in fact, silent intuitive) recognition (declaration) of the (STS with alternative vocabulary [39][40][41][42]. At present it is common agreement that Newton's laws describe the symmetry of the laws of physics in inertial frames of reference. The evolution of the relativity principle, in conjunction with the notion of symmetry, gradually became the routine subject of scientific discourse [43]. It was recognized that mathematical development and proper understanding of Particle Physics would not be possible without reviling the multi-modal link between the principles of relativity and symmetry. Newton's conclusion (1643 - 1727) regarding homogeneity and isotropy (continuity and symmetry) of space was derived from the mathematical formulation of mechanical law in conditions when his ability to observe the "large- scale" (cosmological) and "small-scale" (particles quantum mechanics) space-time event was limited. However, for an experimentally accessible world, it was the legitimate approximation of reality [18]. Kant (1724-1804) condensed the unity of the universe hypothesis into an analytical statement that time and space are the most fundamental forms of existence. Most present-day scientists assume that physical and biological entities obey Nature's universal laws (see Fig. 3(c). The widespread assumption is that life is the most fascinating among the derivative forms of existence. Ther is also an opposing hypothesize. The idea, first formulated by Leibniz [II] (1646-1716) [35]), explicitly articulated by the philosopher Berkeley (1685-1753), analyzed by Kant (1724 - 1804), and clarified by Mach (1838 -1916), was recognized by many physicists (including Einstein) as Mach's Principle [44][45][46][47].

Berkeley-Leibniz-Kant-Mach principle of relativity has not been developed as a quantitative physical theory, but, nevertheless, it frames the generalized view of the physical world. According to Galilei, all motion linked to the gravitational force and mass is considered in relation to some frame of reference (FR). The concept of mechanical FR is associated with several common- sense intuitive expectations. One is that the set of FR's comprising points should be stationary relative to each other (the condition assuming the conservation of the symmetry for the duration of the experiment). Second, presumably, it should be related to the unknown fundamental character (or characters) of the Universe. Partition of this universal impact can include the Solar system and Galaxy system. Newton, trying to distinguish inertial and accelerating FRs, assumed that such fundamental characters are absolute space and time (it was an acceptable approximation for observable range of mechanical events). Mach, in contrast, believed that movement relative to the "rest of the world" (universal distribution of mass) is a more reasonable idea. Maxwell and Lorents contribute to the idea that photon (characterized by absolute /limited speed and chirality) could be a one of fundamental messengers from the rest of the world. The complex of these ideas inspired Einstein to create the hypotheses of STR and GTR incorporating part of existing suggestions. The rest of them were transferred as challenges for the next generations. The term universal-distribution-of-the mass is silently (intuitively) PRE-SEPPOSE two opposing outcomes: time-independence (1) or time-dependence, and, consequently, symmetry preservation or breaking. Max was the first to pay attention to the symmetry of RF associated with the shape of the human body[III]. The association of the relativity principle with the symmetries of objects and FR in the mathematical language comes to appreciation later particularly in the form, of the Norther's theorems.

Einstein made famous attempts at mathematical formulation of the relativity principle in his STR and GTR. From this perspective, unsurprisingly, the most fundamental forms of existence become the primary objects of the asymmetry were not the subject of his philosophical consideration [48]. On the development of Galilean intuition, the classical mechanics hold two opposing views on space-animal sensory system and human cognitive function. Kant was not remote from recognition of symmetry as attribute of space and time, but bilaterality of organism and mirror reflection symmetry and time associated with the name of Newton (absolutist) and Leibniz (relationist) [46]. With the name of Newton (absolutist) and Leibniz (relationist) [49]. Nevertheless, the intuitive silent assumption that symmetry is an absolute category independent from motion parameters remains alive for a long time. The intimate connection between concepts of symmetry and relativity remains under-appreciated. Progress in understanding such intimacy was impossible without a mathematical approach. *However, even* after dramatic advances in theoretical modeling, we surprisingly found that after all sophisticated mathematical modifications, many intuitive statements remain valid for quantum systems [50]. Newton (1643-1727), Leibniz (1646-1716), Minkowski (1859-1909), Poincare (1854-912), Einstein (1879-1955), and many others promoted the concepts of the space, time, and relativity to the form of mathematical equations [51][52], bringing an opportunity to analyze space-time-related variables in a more flexible and general sense. Reflecting on Galileo's findings, Einstein concludes that gravity, interpreted as a force, may also be viewed as a property of space-time — the fabric of the universe, common for all objects of different masses. In this model, "Space-time tells matter how to move and matter tells space-time how to curve." [53]. Spacetime curvature induced by gravitational or electromagnetic fields is traditionally interpreted in theoretical physics as symmetry breaking [53][54][55][56][57][58][59].

Evolution of Relativity Principle

> *"There is something attractive in presenting the evolution of a sequence of ideas"* [60].

The statement above is relevant to the field of geometry, holding the link between space-time symmetry and principle of relativity. Space-time symmetry, related to the distribution (degree of condensation) and motion of physical objects within it, is one of nature's most fundamental properties, reviling enormous degree of freedom. Constant speed of light and photon helicity are impressive manifestations of space-time symmetry. Einstein field equations EFE of the GTR was written in the assumption of continuous symmetry transformations. The phenomena of space/time exchange, parity, time reversal invariant actions, and corresponding equations consider discrete symmetry. Continuous transformation involves a smooth (continuous) change, while a discrete transformation involves a finite, jump-like change, like a reflection in a mirror. The exact solution of EFE and other equations of motion can only be found by choosing a specific group of transformations. The possibility of selecting refers to an inherent degree of freedom, allowing the differentiation of a distinct physical background. An illustrative example is discrimination of cosmological and elementary particles spatial scales. The Noether theorems (relating continuous symmetries to conservation laws) mathematically proved the significance of continuous space-time symmetry. Discrete symmetry is a necessary mathematical concept in quantum and cosmological physics developments. The simplest intuitive geometrical ideas"plane," "point," "straight line," and 'plane" are the ground for more complex concepts such as point symmetry, axis of symmetry, or plane of symmetry. As the products of abstract thinking, they become the ground for formulating axioms and principles such as the principle of relativity. From the time of Galilei, the fundamental determinants of physical objects, space, time, symmetry, and relativity, constantly acquire a broader spectrum of meaning. The correspondence of products of intuition and abstract thinking to objects in nature (the exclusive cause and evolution of those ideas) is always relative and permanently modified by the growth of our experience. The historical examples are modifications of the Galilean relativity principle to (STR), which later was substituted by GTR. The best introduction to this fundamental development is reading the works of immediate participants [59][60][61]. The relativity of space and time intervals and invariance of space-time intervals disclosed by Minkowski and exhibiting an agreement with the mathematical form of Maxwell equations and Lorentz transformations (reflecting the symmetry of Maxwell equations!) become

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Einstein's main postulates of STR [62][59][60][61][63][64][65][66][67][68][69][70]. The transition from STR to GTR, initiated under the pressure of new experimental facts and theoretical models, including the constancy of the speed of life, signifies a new advance in the successful interpretation of physical reality. However, along with the obvious success and enthusiasm, it brings a problem that no one could resolve. The invisible barrier was created by not enough attention to the space-time symmetry. While energy conservation laws were appropriately held in a flat space- time of STR, those same laws exhibit break-down in the curved space-time of GTR. At the most dramatic time of this brainstorm two supporters of GTR, mathematicians Hilbert and Klein attracted Emmy Noether's (1882–1935) attention to this contradiction. On July 23, 1918, two of Noether's theorems designed to sort out the problem of GTR were presented to the scientific community. The contribution to the development of the relativity concept by cohort famous scientists {including Maxwell (1831 - 1879), Hertz (1857- 1894), Minkowski (1864 - 1909), Lorentz (1873 -1928 and Einstein (1879-1955)} provide solid ground for understanding the fundamental link between relativity and space-time-symmetry [59]. The cohort of great physicists, Schrodinger (1877-1961), Born (1882 - 1970), Curie (1895-1906), and Heisenberg (1901-1976), developed the ground for the next step of generalization of GTR. Analyzing the mathematical and physical consequences of Schrödinger's wave equation version of quantum mechanics (QM), Born discovered a new form of previously unknown symmetry (gauge invariance) applicable to quantum physics. Born's interpretation of the wave function as a probability amplitude was accompanied by Heisenberg's uncertainty principle. The marriage of novel gauge theory with quantum field theory culminated in the Standard Model (SM) of particle physics [70]. The significance and power of thesymmetry arguments are appreciated in the SM, which assumes that SSB of gauge symmetry causes gauge fields to gain mass [71][72][73][74][75][76] (Appendix III). The ideas of modern physics are moving even further, exploring the possibility of EOs internal structure (and, therefore, symmetry) [75]. The physics of EPs, spinning black hole (BH), and Gauge theories of spacetime reveal the world beyond predictive power of GTR [70][71]. The impressive and sometimes unexpected result of these advances was that all of them, directly or indirectly, confirm the significance and relativity of symmetry (RS) [72][73][74][75]. Such a radical development brings significant changes in the formulation and interpretation of the relativity principles from the STR and GTR to a more symmetry-associated variants, reflecting our advance in understanding the integrity of the universe. The pilot's name of new principle could be a congruent theory of relativity (CTR) (see Fig. 2). However, it is reasonable to preserve the right to introduce the more relevant term to theoretical physicists, which can step beyond speculative analysis to precise mathematical formulation. The parade of Galilean, STR, and GTR theories was signified by the consecutive transfer of some specific symmetry transformation from the category of an absolute to the relative. The search for the appropriate space-time symmetry underlies all currently running theories (including the quantum theory of gravitation, the SM of particles, and string theories (StT) [76]) without a visible tendency to change the patterns [77][78] The conservation of this tendency supports the hypothesis that in addition to space and time, the symmetry itself possesses fundamental relativity. Such re-evaluation of symmetry, based on the advances in-depth knowledge of the physics of phase transitions (PhTrs) [79] brings understanding the prevalent handedness (chirality or mirror asymmetry) biological world [79][80][81].

Chirality as Widespread Properties in Nature

Now we can trace how evolution of view on relativity principle allows to cognize the essence of biological chirality (or biochirality [82]. Indeed, saying that chirality (i.e., asymmetry) is the most widespread property in nature [83][84]) assumes that the relativity of the symmetry determinants should be apparent in biological and non-biological matters. At the time of classical mechanics, Galilean invariance, considering space and time as a completely separable absolute quantity, silently assuming that corresponding symmetries are absolute. However, the breaking of Galilean invariance in ion lattice disregard/dismissed the concept of absolute symmetry for many physical appearances, including mirror symmetry associated with the effect of chirality (handedness) [85]. At different times and in separate scientific communities, chirality was characterized as the most influential force in biology [86] or in physics [49] until, finally, everyone came to agree that "Chirality is one of the most widespread properties in nature" [86][87][88][89]. The remarkable property of chiral symmetry is that chirality transfer occurs across all known space and energy scales, including diapason of life existence [90] - the facts supporting the thesis that space-time-symmetry and relativity are the fundamental determinants common for abiotic and biotic existence. A prominent example is the chirality transfers from fermions (quantum scale) to the chiral anomaly of the cosmological magnetic field (astronomic scale). Present-day scientists, familiar with a complex of advanced theories of the universe, observing (even without a telescope) surrounding galaxies rotating in some harmony, and reading the articles regarding biological chirality, accept the violation of the parity principle as corresponding to all known forms of objective reality [87][88][89][90]. However, until 1956, mirror reflection symmetry (known as the parity principle) was assumed absolute, and the discovery of parity violation was shocking [91]. Even professionals working with the

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effect of chiral dichroism (discovered by Kelvin) do not foresee the universal significance of mirror symmetry. At the time following Einstein and Noether interpretation of the RP principle, was mathematically analyzed in the symmetry terms. Corresponding experimental results reveal that notion of chirality emerges in vast areas of natural science, concerning the movement of the objects under impact of forces. In non-Euclidean geometry (such as Riemannian geometry), chirality (of space-time or physical object) appears in the less intuitively perceptible forms described by more complex mathematical formalism [92]. The movement under gravitational or magnetic forces of the massive or magnetic objects declines from the straight line, and the description of this movement requires different mathematical tools. The spatial and temporal domains reveal the chirality, from the dimensions of EPc to the galaxy scales [9][10][93][94][95][96]. The integrated complex of experimental observations and theoretical advances have led the scientific community to conclude that spiral galaxies are enantiomers with prevalent 2-D chirality.

Relativity and Symmetry

> *"The Theory of Relativity confers an absolute meaning on a magnitude which in classical theory has only a relative significance: the velocity of light. The velocity of light is to the Theory of Relativity as the elementary quantum of action is to the Quantum Theory: it is its absolute core"*[97].

From ancient times to the present, everything perceived by man tends to be characterized as absolute or relative [98]. It is meaningful that symmetry has many synonyms reflecting different degrees of correspondence or congruence, from resemblance and similarity to equality. Everyone shares the intuitive meaning of symmetry (term) as a form of similarity, accompanied by the impression derived from real-life experience that this similarity is practically never absolute. Our consideration of this assumption is focused on two questions: "Is symmetry an absolute or relative characteristic of the physical object? What historical transformation does this question undergo, from silencing uncertainty through intuitive feeling to scientific resolution? Symmetry is the relative (mutual) spatial localization/position of the elements (parts constituents or internal elements) of any object. The movement of elements relative to each other or external objects will change the characteristics parameters of symmetry, and this alteration will be movement dependent. The motion-dependent character (i.e., motion-dependent relativity) is inherent for all forms of symmetry and asymmetry, including chirality. Chirality in Nature is attributed to stationary and dynamic {translational (including acceleration and rotational movement} objects. The dependence of chirality on the movement parameters brings foundational relativity to the concept of chirality [99][100]. In various situations, the object′s movement may influence its symmetry and asymmetry. One of the simplest is the following: Two vertically oriented stationary (not rotating) spinning tops (being unstable) are identical (achiral pair). If we spin them in different directions (left and right) they become nonidentical (chiral pair). The logical conclusion is that the symmetry characteristics of the objects are relative, not absolute. If it is valid for symmetry in general, it should be true for specific forms of symmetry, including chirality (asymmetry). Therefore, symmetry is a movement-dependent (i.e., space- and time-dependent) characteristic. In the math sciences (such as abstract algebra and geometry), symmetry was traditionally treated as an absolute. The symmetry as the absolute identity (singularity, singleness, coherence, oneness) in the pair of related objects was widely employed. The physical world, by contrast, constantly exhibits not absolute, varied, or broken symmetry. Vector velocity-dependent symmetry parameters are observed in various objects, from mechanical, electronic, and optical devices to EPs and biological matter [101][102][103][104][105][106] suggesting fundamental significance phenomena. The interactive behavior of massive and massless fermions reviling the symmetry patterns dependence from relative velocity value and orientation) of the particle and observer provide convincing evidence of symmetry relativity [107][108][109]. Despite this controversy, vocabulary such as relative symmetr*y* was practically absolutely avoided in physics. We will track the progress of this discourse regarding the symmetry attributes.

Relativity of Symmetry

As a widespread, complex and divergent characteristic of symmetry, chirality evokes a mixed impression of attraction, confusion, and difficulties in prompt understanding (Appendix II) [110].

Chirality is traditionally treated in terms of chiral or non-chiral. However, a simple “black or white” approach leads to the loss of essential and structural information on the shape of the molecules existing in 2-D and -D chirality. The advance in discrimination of structural variability is made by introducing the terms “degree of chirality” and “chiral scale” [111][112] suggesting the relative nature of the symmetry parameters. The RS characteristic is in logical agreement with the experimentally observed effects of chirality induction under impact of light, motion and measurement [113]. Chirality is traditionally treated in terms of chiral or non-chiral. However, a simple “black or white” approach leads to the loss of essential and structural information on the shape of the molecules existing in 2-D and -D chirality. The advance in discrimination of structural variability is made by introducing the terms “degree of chirality” and “chiral scale” [111][112] suggesting the relative nature of the symmetry parameters. The RS characteristic is in logical agreement with the experimentally observed effects of chirality induction under impact of light, motion and measurement [113]. Natural events exhibit symmetry (preservation of states as sort of relative resistance to changes (sort of inertia) under different transformations of space and time variables. Notable, that SM describing chirality-sensitive interaction between EPs [114] shows an apparent analogy to the chirality preference of amino acids (AAs) [97]. The relativity of space and time intervals disclosed by Minkowski and reflected by Lorentz symmetry transformations became Einstein’s main postulates of STR [59][60][61]. The advances in SRT and GTR, made due to the achievements of the quantum theory of EPs and the physics of gravity, brought the STS concept to a new level of understanding. However, the multi-dimensional network of links between space-time symmetry and bio-chirality involved in the origin of life is currently not explored systematically. The islands of experimental verifications are dispersed along the net as random spots. This condition is the main obstacle to providing a systematic review with a linear sequence of arguments.

Long before Noether. Kant pointed out the philosophical significance of chiral objects i.e., the existence of pairing chiral objects (congruent counterparts) distinct from achiral form (incongruent counterparts) reflects essential attributes of the space domain [53][114][115][116], but time was not ready Nother view on symmetry and relativity. The most intriguing scientific discovery reveals that any form of the relativity principle, beginning from Galileo, is associated with the symmetry concept. However, Galileo itself did not comment on this link explicitly. The same is the truth regarding Newton. The association of the symmetry concept with the relativity principle RP attracted attention at the time of Lorentz's transformation and Maxwell's equations. However, Einstein did not treat the relativity principle as based on Maxwell's equations or as a concept associated with symmetry principle [60][117]. But gradually, the link between the two physical principles (relativity and symmetry) attained common recognition. It became the central core of all advanced physical theories only after Noether derived a mathematical formulation of the fundamental association [114][115][116][117][118][119]. An illustrative example is the reformulation of special relativity as an asymmetry property of space-time [120]. According to GTR, the geometrical properties of space are not independent but are determined by matter. If the definition of geometrical properties includes symmetry, then symmetry gains relativity. This conclusion is consistent with the generalized definition of relativity principles, saying that every part of Nature exists relative to the rest of the world. Based on this philosophical view we can assume that two principal factors determining state of matter “around” us (living environment) are EPs and galaxy world [121]. The equivalence of classical and quantum reference frames assumes the coordinate system invariant under elements of the corresponding symmetry group [122]. After formulation of GTR and Noether's theorem, the studies of inherent/genuine connection between STS and relativity principle become an unavoidable trend in all physical theories including StT, SM theories, and (QPT) [111][121][122][123][124][125]. The mathematical formalism of contemporary physics becomes based on the application of two mutually related principles of relativity and symmetry to the space-time domain [125][126]. Symmetry is recognized as the most helpful tool in the physics of EPs and the fundamental force of nature. At the same time, the concern of symmetry breaking in the SM reveals the interactions between strong, weak, and electromagnetic forces, suggesting the fundamental relativity of the symmetry determinants [127]. The left-handed and right-handed states of the SM particles respond differently to the week forces, demonstrating a fundamental left-right asymmetry (LRA) or chirality). The widely accepted statement that "The reflection (or 'mirror') symmetry of space is among the fundamental symmetries of physics" can be fairly complemented by the appreciation of the radical significance of biological chirality. A most remarkable feature of geometrical chirality is its indispensable relativity. One of the known incidents of this relativity is the apparent difference between right-handed' and left-handed Cartesian coordinate systems. However, an absolute geometric definition of right or left- handedness is impossible; only the relationship of opposition between the two can be defined [111]. As an immediate consequence, moleular handedness (chirality) is not an absolute concept but depends on the property being observed [128]. Notably, principles of relativity and symmetry to space-time domains coexist with the observer- independent speed of light, the relativity of photon frequency (Doppler effect), and the known effects of symmetry breaking [129][130][131][132]. We face the situation calling for re-examining existing theories.

Spontaneous Phase Transition

The early universe and biological evolution are described in the theory of PhTrs accompanied by breaking and restoration of phase symmetry [133][134][135]. Spontaneous PhTrs are the key elements of fundamentals of physics underlying understanding all (without exception) aspects of biology. Physiological mechanisms of living organisms communicate all systems work to combine their efforts to make conditions favorable for survival. Non-equilibrium PhTrs play a critical role in maintaining this dynamic condition. The traditional assumption is that life began with the spontaneous self-assembly of carbon-based molecules [136][137]. However, prior down-stream spontaneous assembly of atoms into various molecular structures[IV] is also a legitimate candidate for triggering the life beginning. Notably, all of these "beginnings" occur in non-equilibrium state and are spontaneous, i.e., do not require any additional driving force. The illustrative example is non-equilibrium PhTrs in the community of red blat sell that provide optimal physiological function in the narrow diapason of temperature around 36 °C [138]. One of new development in physics is related to the relativity of mass. STR distinguishing two meanings for the concept of mass, rest mass (an invariant quantity for all observers) and relativistic mass (dependent on the relative velocity of the observer and speed of light] was a declaration of mass relativity (Appendix IV). Theoretical prediction of the mechanism, by which mass-less gauge bosons can acquire non-zero masses in SSB open new aspect of mass relativity linked to the geometry of interaction of physical objects with the external environment [139][140]. Considering the equations of motion describing the behavior of a physical system, which exhibits energy-undefended symmetry (symmetry-conserved aquations), we will find deviation between the symmetry of equations and the symmetry of the system state. While the high energy state may be symmetrical, the low energy state can be split (into two or more equivalent states. In this condition, the system undergoes SSB (phenomenon applies to non-biological and biological objects) - meaning that the system will settle in one of split configurations (with variable lifetime). The most dramatic advances in the understanding of the RS are associated with physics of PhTs and non-equilibrium thermodynamics. The phenomenological core of the theory of PhTs (developed by Landau for condensed matter physics), chiefly concerned with the symmetry of the system, provides the validity of this approach for diverse domains of non-equilibrium physic and (from solid matter to cosmic scale events) [141][142][143] and biology (biological aging) [144][145][146]. Notably, some essential PhTrs do not entail (demand, involve, require) a change in symmetry — e.g., the liquid-to-gas transition. Such PhTrs can only be first order. But this fact does not contradict the notion of relative symmetry. The symmetries "lying at the heart of the laws of nature" make the bridge between GRT, quantum field theory and bio-chirality [147][148].

Conclusion

The invariance of physical laws under the specific set of spatial and temporal translations is the fundamental characteristics of Nature [145][149]. For the same reason, the symmetry principle has equally crucial implications not only for the high level of cognitive psychology but also for the routine performance of sensory perception and psychomotor functions under the name of perceptual constancy (PC) [150]. Other words, the symmetry of fundamental physics [151] is imposed on all aspects of biological evolution [152]. The separation of classical and quantum physics exists only in abstraction-driven imagination. Nature "utilizes both classical physics and quantum physics side by side without "competition" [153]. For living organisms, such "cooperation" is an essential mechanism to obtain maximum benefits [147][148]. So, it is fair to conclude that entire power of Nature, (including the laws of space, time symmetry, and relativity (not just some tiny fraction), is involved in emergence, management, and functioning of human consciousness and intelligence. At present, the physical world asymmetrical is a trivial result of observation [154]. The discovery of the violation of parity in 1956 became the basis for the final rejection of the Galilei-Newtonian time regarding the abstract ideas of homogeneity and isotropy of physical space. Indeed, given the place of the Sun in the spiral structure of the galaxy (Milky Way) and the hierarchical filament stricture of the galaxy system, it isn't easy to expect homogeneity and isotropy of the observer associated with Earth's scale frame of reference [155][156]. Above conclusion immediately evokes associations regarding PBC, which, presumably, along with its internal determinants, can be influenced by a complex of external determinants, including galaxy dynamics. It was shown that chirality, as a geometrical-topological property of the physical and biological object, is a dimension-dependent characteristic (object chiral in the n-dimensional space can be achiral in (n+1) dimension and vise-versa (mathematical details can be found in specific reviews [82]. All variants of the relativity concept distinguish between the frame-dependent and frame-independent quantities of physical objects. Chirality, as the absence of a mirror-related symmetry in objects, has an unexpected (surprising) and attractive consequence in physics and biology [157][158][159][160]. The current review illustrates that the relative (not an absolute) nature of the symmetry parameters for physical and biological objects is a widely studied phenomenon (breaking symmetry, oscillating symmetry, unstable symmetry). In the context of our review, the temporal dynamics of molecular chirality are direct evidence of the symmetry parameters relativity. The review contains a unique collection of articles representing critical advances in the multidisciplinary fields contributing to understanding chirality. Chirality, handedness, laterality, and mirror reflection are closely related but not identical mathematical concepts having different meanings at the distinct hierarchical levels of structural organization [161]. The spectrum of open questions remains, but the broad view of the relativity sheds light in the right direction.

Appendix I

The issue of chirality is of great importance in space-time physics, working for any metric space associated with rigid and flexible objects. However, mathematical extended definitions of extended

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isometries and chirality show that the quantitative concept of chirality, applied to time, space, or space-time combination, may have a dimension-dependent (including opposite) meaning [28][157].

Appendix II

The importance of chirality is appreciated in many sciences, explaining many definitions of corresponding unique geometrical concepts. When biologists justly say that chirality is the critical feature in living organisms [102], the essential omitted objective fact is that chirality is also the key characteristic of the inorganic world and even a fundamental attribute of space and time, known as a primary determinant of existence. Therefore, attention to symmetry's universal role is necessary to interpret life's phenomena adequately.

Appendix III

According to the unified electroweak theory scalar boson (spin 0) and vector boson (spin (Fig. 3) exhibit similar properties under certain transformations, arising from underlying a symmetry principle. During SSB a scalar field is involved in giving mass to other particles including vector bosons [70].

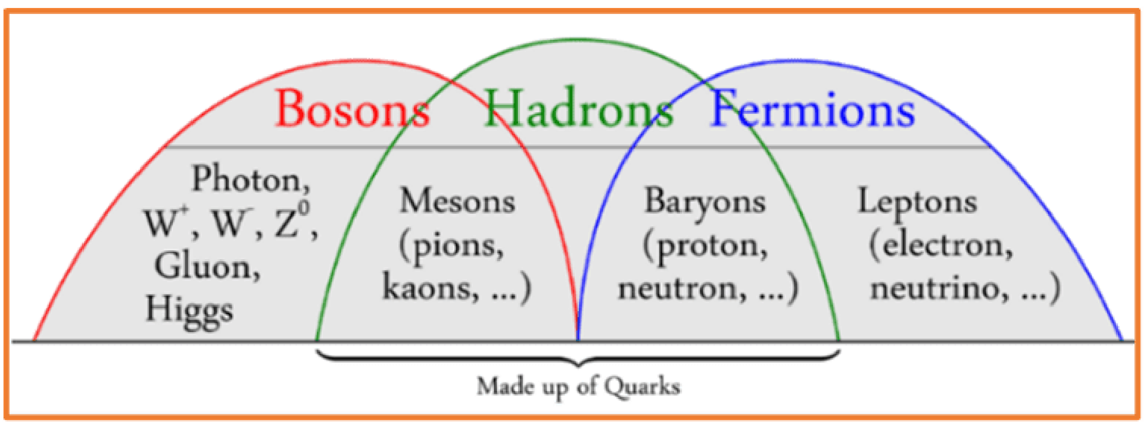

Figure 3. *Bosons form one of the two fundamental classes of subatomic particles, the other being fermions. All subatomic particles must be one or the other. A composite particle (hadron) may fallinto either class depending on its composition.*

Appendix IV

Relativistic mass is dependent on the relative velocity of the observer and speed of light: declaration of mass relativity where "m" is the relativistic mass, "m_0" is the rest mass, "v" is the

$$m = m_0/\sqrt{(1-(v^2/c^2))}$$

object's velocity, and "c" is the speed of light.

Conflicts of interest

There is no conflict of interest.

Footnotes

[I] Not all physicists are aware of the fundamental significance of symmetry concepts in the SM of EPs. Among biologists, only a tiny fraction of the community pays attention to the role of symmetry in physics. This condition may negatively impact on the current experimental design instead of moving our knowledge forward.

[II] Leibniz's position, known as "relationalism", assumes that "spatial and temporal relationships between objects and events are immediate and not reducible to space-time point relations, and all movement is the relational movement of bodies" [43].

[III] It would surely be a remarkable coincidence if the inertial frame, in which your arms hung freely, just happened to be the reference frame in which typical stars are at rest, unless there were some interactions between the stars and you that determined your inertial frame [47][162][62][163][164].

[IV] Mendeleev (1834 - 1907) construct periodic table (1905) based on believe that all chemical elements must be built from the original (primary) building blocks of matter. Remarkably, the periodic table was designed 6 years before Rutherford proposed his structure of atoms (1911). Behind periodicity of table. was hidden the symmetrical structure of atoms.

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