General Principle of Interaction, a Different Approach to Unification in Particle Physics

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Abstract

In modern physics, the two most basic principles of interaction, the principal of space-time involvement of the General Relativity (GR) and the gauge transformation principle of the quantum field theories are incompatible due to the completely different understanding of the space-time. To solve this fundamental inconsistency, the General Principal of Interaction (GPI) is proposed. The GPI requires the Einstein's principal of space-time involvement to be applied to all types of interaction assuming that the space-time is nine-dimensional with five extra spatial dimensions in addition to the ordinary space-time (OST). With the GPI, strong nuclear forces can be understood as geometrical alterations of the compactified three-dimensional "nuclear space" (NS), and electromagnetism and weak nuclear forces can be understood as geometrical alterations of the open two-dimensional "electromagnetic space" (EMS). Thus, the space-time includes three realms: OST, EMS and NS, which are geometrically separated due to the differences in their overall curvatures. The GPI provides a strong basis for the future theory unifying all four types of interaction as it naturally combines the space-time-based understanding of interaction with the quantization by describing all elementary particles as curvature waves in the multidimensional space-time. It is expected that the GPI-based theory will be a fully deterministic self-consistent non-renormalizable theory describing all types of interaction with low number of free parameters and no Higgs mechanism. The mathematical description of this theory is not given; only possible ways to construct suitable framework are being discussed. The GPI-based theory requires absence of gauge bosons and prohibits neutrino, H, W and Z bosons. Considering the fact that all these particles are proven experimentally the conjectured GPI-based theory will make no sense until strong experimental evidence of the opposite is found. Also, it is discussed: 1) why the main principals of the GR and gauge theories are mutually exclusive, 2) application of the GPI to the three interactions currently described by the SM, 3) expected advantages of the conjectured GPI-based theory, 4) possible explanations of the "dark matter" and "dark energy" phenomena, 5) the theory's problems and 6) predictions.

Introduction

The Standard Model (SM) is currently the most successful and useful theory describing three types of interaction (electromagnetism, weak and strong nuclear forces) involving elementary particles [1]. It shows ultimate reliability for any experimental data analysis except the "dark matter" and "dark energy" phenomena. Unfortunately, it contains about 18 unexplained free parameters, does not provide any basis for the unification of the described three types of interaction (except the electro-weak unification) and is incompatible with the Einstein's GR. Therefore, it is a common belief that a certain "more fundamental" mathematically consistent theory that explains and unifies all four types of interaction exists "beyond the SM" and yet to be found.

Presently, some kind of superstring theory (yet not fully described mathematically) is expected to be such a "theory of everything" by the majority of scientists in the field [2]. However, it is also being deeply criticized by others and called "not even wrong" [3]. Unfortunately, all presently known unifying theories have various problems and/or not fully developed. Thus, a self-consistent final unified theory "more fundamental" than the SM remains unknown.

This deep crisis with the theoretical physics is being realized by many leading scientists. In his 2013 public speech, Dr. Neil Turok said: "There've been grand unified models, there've been super-symmetric models, super-string models, loop quantum gravity models…Well, nature turns out to be simpler than all of these models...The extensions of the Standard Model, like Grand Unified Theories, they were supposed to simplify it. But in fact they made it more complicated. The number of parameters in the Standard Model is about 18. The number in Grand Unified Theories is typically 100. In super-symmetric theories, the minimum is 120. And ... string theory seems to predict 10 to the power of 1000 different possible laws of physics. It's called the Multiverse. It's the ultimate catastrophe: that theoretical physics has led to this crazy situation where the physicists are utterly confused and seem not to have any predictions at all...We have to get people to try to find the new principles that will explain the simplicity" [4]. Thus, it is a vital problem of the modern theoretical physics to find the fundamental unified theory (if such theory exists), which not only explains all four types of interaction consistently, but also "explains the simplicity", i.e. has minimum or no unexplained free parameters.

The above mentioned "technical" problems of the unification in particle physics are well known and widely discussed [2, 3]. In addition, there is a core problem of the full unification that involves gravitation, i.e. a very general incompatibility between the fundamental principle of Einstein's GR and the gauge principle of quantum

field theories (QFTs). Unfortunately, it is not well realized that a fundamental unifying theory (a.k.a. the "Theory of Everything") is absolutely impossible without solving the latter discrepancy, and for this reason, the General Principal of Interaction (GPI), an extension of the Einstein's GR principal for the space-time with five extra spatial dimensions is proposed. The GPI applicability to the three types of interaction currently described by the SM and possible ways to construct a suitable framework for the GPI-based theory are discussed below.

Postulating

1. The contradiction between the two principles of interaction.

At present, there is no fully defined self-consistent theory that unifies the three interactions of the SM (electromagnetic, weak and strong nuclear interactions) with the gravitation. It is a common belief that a self-consistent theory of quantum gravity or a superstring theory that describes gravitation and includes the Einstein's GR as a special case might solve the case [2]. However, the problem is much deeper due to the fundamental incompatibility of the two very different principals of interaction used in the GR and the gauge theories. In a QFT, the interaction is based on the gauge transformation principle: simply put, interacting particles exchange a virtual carrier particle (virtual boson or gauge boson) that represents a quantum of the field (a.k.a. the "Ping-Pong principle"). The gauge fields are not properties of the space and time; they are properties of matter. Therefore, the backgrounds (space and time coordinate sets) are typically set by definition; and the theories are considered background-dependent. In the GR, the gravitational interaction is mediated by the curvature of space-time. The gravitational field is the property of space-time, not matter. Therefore, the backgrounds (space-time curvatures) are not set by definition, but derived from the GR equations' solutions; and the theory is considered background-independent. Apparently, these two principals are very different. The key difference between them is that any QFT (including any present string theory) defines the space and time as an empty set of coordinates that is not involved in the interaction (Newtonian view), and the interacting objects (particles, quarks, strings, etc.) possess all the properties required for the interaction (gauge fields). On the contrary, there is absolutely no need for a gauge field (carrier particle) in the GR (although, graviton existence is not prohibited, it is not a gauge boson), instead, the very own property of the space-time (curvature) mediates the interaction. In any logically defined theory, the space and time are either mediate interaction or not, but not both, and therefore, these two principals are mutually exclusive. This fundamental incompatibility will make all attempts to confer the GR with the gauge theories to fail. Therefore, if both approaches are used, the full unification is impossible. If a fundamental theory unifying all four types of interaction is ever found, it must be based on a single general principle. Obviously, it is not possible to apply the gauge principal to the GR. Thus, the only way to remove this major inconsistency is to apply the principal of space-time involvement to all four types of interaction assuming that the space-time has extra dimensions and is involved directly in any type of interaction.

2. Postulating the General Principle of Interaction (GPI).

Proposing direct involvement of space-time in all types of interaction let's postulate the General Principle of Interaction (GPI): any physical interaction is governed by certain alterations of the space-time geometry. The existence of four different interactions should be explained by an intrinsic complexity of the space-time. If the space-time contains extra spatial dimensions somehow separated from the ordinary space-time (OST), each type of interaction occurs in a separate realm of the space-time. The GR explains gravitation with mass-induced curvatures of four-dimensional OST. Similarly, electromagnetism and nuclear forces should be understood as certain geometrical alterations (in a simplest case, curvatures) that occur in the additional spatial dimensions. Like mass curves the OST an electric charge curves the "electromagnetic" realm of the space-time (let's call it "electromagnetic space" or EMS). Similarly, a "color" charge curves separate "sub-nuclear" realm of the space-time (let's call it "nuclear space" or NS). Thus, philosophically speaking, the whole Universe contains nothing but "empty space" modified in different ways, and all various particles of matter with their basic properties (such as "color" charge, electric charge, magnetic properties and mass) are defined by various geometrical alterations of the space-time. It is logical to assume that these three realms of the space-time are separated in the observable Universe, but merge completely at a certain very high energy composing a single unified compactified space-time manifold with one universal interaction. This hypothesis unifies matter and space in general providing a solid philosophical foundation for the future fundamental unifying theory.

According to the GPI, energy should be always understood as a measure of the space-time disturbances; it is higher if the space-time is more curved, and becomes zero with no curvatures. Thus, interaction, in general, is governed by the diverse curvatures in one of the space-time realms (NS, EMS or OST) driven by the principle of minimum energy, i.e. space flatness. Although, there is no evidence at present that this hypothesis is valid, it is shown below that the GPI is applicable to the three types of interaction described by the SM, and a unified GPI-based theory will have a number of advantages.

Unfortunately, the GPI application requires substantial revision of the SM. Any GPI-based theory should be mathematically defined in the "real" multidimensional space-time, not in an abstract Hilbert space. In addition, the GPI requires rejection of the gauge transformation principal and gauge bosons. The rejection of neutrino, H, W and Z bosons is the main problem of the presented theoretical approach, and a GPI-based theory will make no sense until strong experimental conformations of this rejection are found.

Discussion

1. Application of the GPI to electromagnetism.

An application of the GPI to electromagnetism requires an existence of extra spatial dimensions in addition to the four dimensions of the OST. It is obvious that without any extra dimension electromagnetism could not be distinguishable from the gravity. Thus, one has to assume that the EMS with at least two extra dimensions (one for the electric field and one for the magnetic field) exist in the Universe. These two extra dimensions of the EMS should be somehow separated from the OST as gravitation and electromagnetism are two separate interactions. It is logical to assume that the EMS is more curved than the OST, which is almost flat; and the ratio of these basic curvatures is defined by the difference in strengths of the electromagnetic and the gravitational interactions. The two EMS dimensions are very likely separated from each other (as electric and magnetic fields do not interact directly), but are interconnected as electric and magnetic fields are interrelated.

An attempt to unify the GR with electromagnetism based on the existence of a compact extra dimension has been made almost hundred years ago. It is known as the Kaluza–Klein theory (KK theory) [5]. The KK theory postulates five-dimensional space-time with the fifth dimension compactified to a certain microscopic radius, which makes it undetectable on larger scales, while the ordinary four dimensions (OST) are endless. The KK theory describes electromagnetism as a gauge theory on a fiber bundle in a five-dimensional space-time. Notably, in a five-dimensional space-time, the KK theory formulates equations, which can be transformed both to the Einstein's equations of GR for free space and to the Maxwell equations describing electromagnetism. Although the KK theory consistently uses the idea of an extra dimension to describe the electromagnetic interaction, it is not a GPI-based theory because: 1) the fifth dimension, an EMS analog cannot be compactified to a microscopic radius as both electric and magnetic fields exist at large scales, 2) more than one extra dimension is needed to describe the EMS, 3) the KK theory describes electromagnetism as a gauge theory. Never the less, the KK theory remains an elegant example of a consistent unification of electromagnetism and gravity based on the idea of extra dimensions.

Notably, the KK theory had shown a simple way to define mathematically the electromagnetic field as a "part" of the gravitational field. This approach with some modifications can be combined with the GPI. These modifications are 1) an existence of two large extra dimensions, 2) electric and magnetic fields are quantized, 3) description of elementary electric charges/fields as curvature waves in one of these extra dimensions, 4) description of elementary magnetic fields produced by moving or pulsating elementary electric charges as curvature waves in the second extra dimension. Thus, an electric charge curves the "electric" dimension (ED) directly and the "magnetic" dimension (MD) indirectly, while in motion. It is possible that ED and/or MD involve more than one dimension, and the interactions are governed by geometric alterations more complicated than simple curvatures. For simplicity, one may assume that both ED and MD are single-dimensional, and the interactions are governed by curvatures. Unlike gravity, electromagnetic interaction involves two types of entities: positive and negative charges. Assuming that positive and negative charges alter ED geometry in opposite ways (for simplicity, let's suggest that positive charges produce positive curvatures, and negative charges produce negative curvatures) one can understand the interaction as an overlap of the ED curvatures produced by the interacting charges. Assuming that completely flat space has zero local energy one may apply the principle of minimal energy stating that same sign curvatures will increase local curvature and energy, and opposite sign curvatures will decrease them. Thus, two approaching positive or two negative charges are repelled due to the increased combined ED curvature and higher local energy; however, a positive charge attracts a negative charge as their geometrically opposite curvatures cancel each other producing flat ED space. Same principal may be applied to the MD with one restriction: MD curvatures are produced not by magnetic charges (that are never observed experimentally), but induced by curvature pulsations or movements of ED space produced by electric charges. As electric and magnetic fields induce each other in motion, ED and MD curvatures induce each other while moving or pulsating. Thus, ED and MD are somehow interconnected forming the EMS, and the ED and MD curvature waves are always interrelated.

The elementary EMS curvature waves resemble elementary particles with elementary electric charges. Simply put, an elementary electric charge can be seen as a standing ED curvature wave oscillating with positive or negative peak-to-peak amplitude (fig. 1). This assumption naturally explains quantization of the

electromagnetic field. An occupied electron orbital in the atom can be seen as a standing ED curvature wave as well. Two such waves can be co-localized with no increase in overall local curvature if they are in antiphase. Complete co-localization of the two ED curvature waves in-phase will increase the amplitude and local energy causing instability (Pauli Exclusion Principle). Electromagnetic interaction in the atom may be understood as an overlap of EMS curvatures produced by protons, neutrons and electrons. The atomic particles' electric charges produce curvatures in the EMS; however, as the EMS is "imbedded" in the OST, charged particles have their projections in the OST, which are detectable experimentally as their masses. Massless particles, photons can be understood as propagating EMS curvature waves with zero peak-to-peak curvature amplitude, zero charge and no projection in the OST. Therefore, photons cannot be detected in the OST directly, but only by interacting with mass-having fermions, i.e. via absorption. The fact that a photon can be absorbed or emitted by a fermion does not mean that it mediates the electromagnetic interaction. According to the GPI, a fermion-fermion interaction or a fermion-photon interaction occurs via superposition of their EMS curvature waves. Spontaneous photon emission/reabsorption allowed in quantum mechanics is unreasonable in the present model, and virtual photons are simply not needed. Philosophically speaking, virtual bosons are pure speculative and undetectable in principal, and therefore, their omission is in accordance with the Occam's razor rule. Moreover, if the proton-electron interactions involve virtual photons, it is hard to explain how these photons carry enough information to produce unique shapes of the electron clouds in the atom. Obviously, one parameter (wavelength/frequency) is not enough in this case. In the GPI-based model, this question is avoided naturally as there is no any carrier particle. On the other hand, it is not clear how the GPI-based model will explain the experimentally observed effects of vacuum polarization, which are described with virtual electron-positron pairs in the QED [6]. This presents one of the problems of the GPI-based theory.

The above described model explains all electrically charged particles and photons as EMS curvature waves and provides a self-consistent basis for a GPI-based quantum theory of electromagnetism. Mathematical construction of such theory remains an open question. However, a GPI-based theory would obviously have a number of valuable advantages. This space-time-based theory will be compatible with the Einstein's GR by definition. Also, it seems possible that the Kaluza approach may be successfully applied in the presented model. As a starting case, electric charges can be described as five-dimensional (ED+OST) curvature waves, and the equations should provide the Einstein's GR equations under the transformation from the ED+OST to the OST. The theory should be formulated in the "real" multidimensional space-time with no need for renormalization. The theory is also expected to explain important philosophical questions of quantum mechanics, such as wave-function collapse and wave-particle duality. Notably, a GPI-based theory will involve quantization using the EMS curvature waves as basic elements. The possible relation of the GPI-based theory of electromagnetism with the wave-function concept of quantum mechanics is briefly discussed below.

1.1. Avoidance of the renormalization problem.

The renormalization requirement remains the key problem of Quantum Electrodynamics (QED). Its philosophical significance is crucial, and our understanding of particle interactions will never be full until this problem is solved. When a theory requires special *ad hoc* corrections only to agree with experiments, it is always a sign of the limited abilities. In a similar situation, when the famous "ether wind" corrections were added to the Newtonian theory, it was a sign that a new theory of gravity is needed. Unfortunately, the renormalization requirement still remains unexplained. Dr. Richard Feynman called this mathematical procedure a "hocus-pocus" that "prevented us from proving that the theory of quantum electrodynamics is mathematically self-consistent" [6]. Unlike QED that is mathematically defined in Hilbert space, the GPI-based theory will be formulated in the "real" space-time therefore allowing exact solutions and requiring no perturbation expansion calculations and no renormalization. Thus, the GPI application to electromagnetism will naturally avoid the renormalization problem.

1.2. Revision of the wave function concept.

In QED, the state of a particle is described by a complex-valued wave-function defined with the OST coordinates. QED is a U(1) gauge theory, i.e. it operates with U(1) group of one complex variable while describing interactions of electric charges [1, 6]. As the imaginary part of the complex variable can be substituted by an additional real variable it is possible that the complex-valued wave-function can be substituted by a "real" wave-function defined with an extra coordinate, in case the particle is defined in a five-dimensional space-time. This is exactly the case for the GPI-based theory of electromagnetism as in the present model, the charged particle description requires ED coordinates in addition to the OST coordinates. The MD coordinates can be derived from the ED coordinates and vise versa as the electric and the magnetic fields of the particle are interrelated. Therefore, the complex-valued wave-function of an electromagnetically interacting particle might be equivalent to its description as an EMS standing wave in the six-dimensional space-time (EMS+OST).

Thus, the QED successfully worked out the way to describe four-dimensional OST projections of six-dimensional particles by using complex-valued functions. However, this approach does have certain limitations and raises certain philosophical questions, such as, for example, the so-called wave-particle duality and wave function collapse. In the present model, there is no duality as fermions and bosons should be understood as pure waves (or wave packets) in the six-dimensional space-time (EMS+OST) with respective OST projections. The complex-valued Shrödinger wave-function should be substituted with a "real" wave-function defined in the six-dimensional space-time. For electromagnetic interaction, the "real" wave-function will naturally combine the principal of space-time involvement with the quantization by describing all elementary particles as curvature waves. Unlike complex-valued Shrödinger wave-function, the "real" wave-function will operate with real variables providing single fully deterministic solutions and avoiding the "wave-function collapse" problem. It is also expected that the "real" wave-function will also solve the famous EPR paradox by rejecting quantum entanglement and explain quantum tunneling.

2. Application of the GPI to strong nuclear interaction.

In the Quantum Chromodynamics (QCD), strong nuclear interactions are described with SU(3) group, which is defined by a triplet of complex numbers [1]. The three imaginary parts of the three complex variables can be substituted by three additional real variables. Thus, to construct a GPI-based theory equivalent to the QCD, one should describe strongly interacting quarks with three extra spatial dimensions (in addition to the EMS and the OST). Let's call this third realm of the space-time "nuclear space". The NS with three additional spatial dimensions requires six types of "color" charges ("red", "anti-red", "blue", "anti-blue", "green" and "anti-green") associated with quarks. As the strong nuclear forces occur only within small (sub-nuclear) distances, it is logical to assume that those three additional dimensions (let's call them "R", "B" and "G") are fully compactified to the size of a nucleon. Each "color" charge curves the NS in one of the extra dimensions closing it completely. In the three-dimensional NS, "color" charges with opposite signs produce pulsating opposite geometrical curvatures (positive and negative curvature waves) in one of these three additional dimensions. Like EMS curvature waves, NS curvature waves with non-zero peak-to-peak amplitude can be seen as standing waves, i.e. quarks with a "color" charge; and gluons like photons can be seen as propagating curvature waves with zero peak-to-peak amplitude ("neutral" waves). As the quark's NS has maximal curvature and is completely closed, it stays "imbedded" into the EMS, which is "imbedded" into the OST. Thus, a "color" charge has its projection in both EMS and OST, and an electric charge has a projection in OST only. This means that a quark always have a "shadow" electric charge and mass induced by its "color" charge.

There are two major types of strong interaction: 1) quark-antiquark pair: a "color" and an "anti-color" charges attract each other, i.e. a positive and a negative curvature waves merge producing meson or anti-meson (similar to attracting electric charges in Fig.1), and 2) "tricolor" quark triplet: three different "colors" or three different "anti-colors" curve all three nuclear dimensions simultaneously forming a compact 3-sphere or another kind of compact 3-fold and producing baryon or anti-baryon. Notably, a "tricolor" formation does not compactify EMS or OST dimensions as baryons' electromagnetic and gravitational interactions are very similar to the same interactions of particles with no "color" charges. As the baryon's NS is geometrically closed, no internal curvature wave, i.e. standing wave (quark) or "neutral" wave (gluon) can escape it, which explains the confinement. The first type of strong interaction produces unstable particles as the quark's and the antiquark's NS and EMS curvature waves perfectly cancel each other. The second type of strong interaction can produce stable nucleons and is responsible for the proton-proton and proton-neutron interactions in the nucleus. If two nucleons are close enough, an additional "tricolor" charge combination that represents the third geometrically closed NS can be formed with one quark from one nucleon and two quarks from another nucleon. Thus, two bound nucleons having three "color" triplets are geometrically more stable than two separated quark triplets (fig. 2).

With the NS and EMS curvatures, nucleon-electron pair's stability has a simple natural explanation. In case of the hydrogen atom, NS is altered by the proton only, and the electron with no "color" charge cannot cancel the proton's NS curvatures. Thus, a proton-electron pair is very stable unlike a meson's quark-antiquark pair. This also explains why a proton does not "move around" an electron. In a hydrogen atom, despite the fact that the proton and the electron have equal electric charges and interact equally (other forces, except electromagnetic attraction, are negligibly small in this case) their appearances in the OST are unequal. Protons are always localized in the point-like nucleus, and electrons are "dispersed" around it as electron clouds. Such different localization of these particles is hard to explain with QED. However, it can be explained with the NS and EMS curvatures. The proton's NS curvature wave and consequently, its projections in the EMS are "compressed" down to an approximate size of 10^{-15} m, while the electron's EMS curvature wave, i.e. the 1s electron cloud's size is about 10^{-10} m (fig. 3). This size difference between the proton's and the electron's EMS curvature waves prevents their complete co-localization and explains their unequal OST projections.

3. Application of the GPI to weak nuclear interaction.

Historically, weak force was introduced as a special type of interaction in order to explain neutron decay, during which a neutron presumably is converted into a proton, an electron and an anti-neutrino. However, in the present model, weak nuclear forces can be simply understood as electromagnetic interactions. In a hydrogen atom, the ground state electron's EMS curvature wave cannot completely cancel the proton's EMS curvature wave due to the size difference (fig. 3). However, if the electron acquires enough energy (e.g. by absorbing an incoming photon), it either leaves the orbital and moves away or co-localizes with the proton forming a neutron. In the latter case, the electron's EMS curvature wave "compressed" to the sub-nuclear size cancels the proton's EMS curvature wave completely. The energy needed for such "compression" of the electron cloud is higher than the energy released after the complete cancelation of the proton's an electron's EMS curvatures; therefore, a free neutron is unstable and heavier than a proton. However, a neutron paired with a proton is stable due to the strong interaction (fig. 2), and a neutron-proton pair is more stable than a proton-proton pair as the neutron's EMS is completely flat and the electrostatic repulsion is absent.

4. The problem of neutrino and H, W and Z bosons.

Although the GPI-based approach explains weak interaction much simpler than the SM, the above shown explanation of weak interaction does not involve neutrino and W and Z bosons. If a particle has neither electric, nor "color" charge and is not a photon, it isn't an EMS curvature wave; and therefore, it has no possible way to interact with other particles, except via gravitation. Thus, in the present model, neutrino, H and Z bosons are simply prohibited. If a particle has an elementary electric charge, but no "color" charge, it is either electron or positron; therefore, the particles referred to as W^- and W^+ are just some states of electron and positron, respectively. However, these requirements make a serious problem as the neutrino and W and Z bosons are important elements of the SM and were proven experimentally [1]. The experimental discovery of the H particle is being finalized, and it is highly anticipated that the particle found is a boson. Without strong evidence of the opposite the GPI-based theory will be meaningless.

Neutrino was suggested by Dr. Wolfgang Pauli to explain the continuous energy spectrum of beta-rays in beta decay in 1930. Interestingly, this spectrum looks very similar to a bremsstrahlung energy spectrum produced by an electron beam deflected by atomic nuclei [7]. Therefore, there is a possibility that the bremsstrahlung might be responsible for the loss in the energy spectrum of beta-rays. This possibility was not completely ruled out in the beta-ray experiments carried out before the neutrino discovery in 1956. Notably, the detectors were typically shielded from gamma-rays in those beta-ray experiments [7]. Moreover, all currently used types of neutrino detection are always indirect. For instance, famous neutrino telescopes actually detect photons that presumably produced by neutrinos. However, the counted very rare events can be possibly explained with very energetic cosmic rays (highly penetrating gamma-photons). Thus, the neutrino existence may require more careful re-evaluation and additional experiments.

5. Postulated structural hierarchy of space-time and explanation of mass.

According to the Einstein's GR mass is a natural fundamental property of matter that allows massive objects to curve OST. In a QFT, particles' masses are always defined experimentally, not by the theory. A special Higg's mechanism was added to the SM specifically to explain the origin of masses in elementary particles. Philosophically speaking, this is yet another manifestation of the fundamental difference between the GR and gauge theories, which arises from the different understanding of the space and time. In the GR, the OST is directly involved in the interaction, and mass appears naturally as a property of an interacting object to have influence on the space-time. In the gauge theories, the space-time is not directly involved in the interaction, and all the properties of interacting objects have no influence on the space-time; therefore, all these properties including mass require space-time-independent explanations. With the GPI, this problem is avoided naturally, and mass is always understood as the object's ability to curve OST.

The GPI can be consistently applied to all known interactions, but this approach requires a novel understanding of the space-time as a nine-dimensional manifold directly involved in all interactions. The manifold's geometrical structure explains the fundamental properties of interacting objects, such as "color" charge (an ability to curve NS), electric charge (an ability to curve EMS) and mass (an ability to curve OST). If such, any static local curvature or curvature wave with non-zero amplitude in any realm of the space-time (NS, EMS or OST) leads to a local energy increase, which experimentally appears as mass. Thus, all objects producing curvatures in NS (hadrons) and/or EMS (hadrons, leptons) must have masses.

The suggested complexity of the space-time raises certain fundamental questions: 1) what is the "architecture" of the three realms of the space-time (NS, EMS and OST), 3) what factor causes their separation from each

other and 3) under what conditions these realms become unified?

Assuming that all the dimensions can be compactified under certain conditions, it is logical to hypothesize that with certain very high energy all dimensions become compactified together and form a single unified compactified space-time manifold. This state might represent the Universe before the Big Bang. After the Big Bang, the OST (the ordinary space-time) had started decompactification and eventually became nearly flat, while other dimensions remained either fully compactified (NS) or curved (EMS). As the three realms of the space-time undergo decompactification differentially, their present geometrical separation can be explained by the differences in their overall curvatures. However, even separated, these space-time realms still have certain influence on each other, i.e. any curvature (except curvature waves with zero peak-to-peak amplitude) of an enclosed realm (which is either compactified or more curved) always has a projection in the less curved external realm. Thus, a "color" charge (NS curvature) always has projections both in the EMS (electric charge) and the OST (mass), and an electric charge (EMS curvature) always has a projection in the OST (mass), but not in the NS. This structural hierarchy of the space-time explains why quarks have both "color" and electric charges, but leptons have electric charges only, and all those particles have masses.

6. The "Dark matter" and "dark energy" hypotheses.

In general, compactification increases space-time curvature and local energy, consequently reducing stability. Therefore, decompactification increases stability and should be spontaneous. According to the astronomical observations the Universe is continuously expanding, which means that the OST still undergoes decompactification. It is possible (but not evident) that the EMS realm is also decompactifying currently as it is an open space. If so, it is likely that the EMS realm is expanding much slower as it is less flat compared to the OST, and electromagnetic interaction is much stronger than gravity. The primary origin of this decompactification rate difference as well as the reason why the NS remains compactified is unclear. It is also unclear whether and why the Universe was fully compactified before the Big Bang. It is logical to suggest that the space-time was "pressurized" by an unknown external influence (primordial force), which had disappeared at the moment of the Big Bang. Although this hypothesis needs more mathematical evaluation and experimental evidence, it may provide possible explanations for the "dark matter" and "dark energy" phenomena. According to the dominant hypothesis, the "dark matter" is caused by yet undiscovered weakly interacting massive particles (WIMPs), which are not affected by any interaction except gravity. The WIMP hypothesis is based on the common belief that matter composed of massive particles is the only possible source of OST curvatures. However, it was never proven formally that mass is the only origin of OST curvature. Therefore, there is a possibility that certain other reasons can induce the OST curvatures. For instance, certain microscopic OST curvatures might occur spontaneously due to the slight anisotropy of the early decompactification process shortly after the Big Bang before the inflation. At the early stages of the Universe expansion, they appeared as tiny spontaneous "bumps" of the space-time "fabric", became very large after inflation and attracted matter forming galaxies and clusters later. Thus, galaxies and clusters are situated inside these "relic" OST curvature spots, which currently are interpreted as "dark matter" halos. However, the GPI-based approach does not exclude the WIMP hypothesis as massive particles with no "color" or electric charges are not prohibited. Further astronomical observations will help to evaluate both these hypotheses.

As pointed above, decompactification of the OST is likely a spontaneous process, which is being observed astronomically and interpreted as the Universe expansion. The reason why this expansion is accelerated is unclear and referred to as "dark energy" phenomenon. The extreme curvature of the fully compactified unified space-time manifold before the Big Bang is likely the origin and driving force of the OST expansion, which will continue spontaneously until the OST becomes completely flat. This OST "expansion force" decreases continuously and proportionally to the OST flatness and will disappear when the OST becomes completely flat; until that, the Universe will probably have a non-zero lambda value decreasing upon the expansion.

7. Reduction of the elementary particle set.

In the SM [1], the elementary particle set includes 61 components: 36 quarks (2 flavors x 3 generations x 3 "colors" x 2 pairs), 12 leptons (2 types x 3 generations x 2 pairs) and 13 gauge bosons (not including graviton). Notably, some quarks and leptons are not truly elementary as they decay into other elementary particles in experiments. Moreover, the SM requires a number of *ad hoc* parameters and a special Higgs mechanism solely to explain the origin of mass for hadrons and leptons.

The conjectured GPI-based theory will substantially reduce the list of necessary elementary components (Table 1) and require lesser number of free parameters. In this model, the elementary particle set includes minimum of 9 components: 6 quarks (1 flavor x 3 "colors" x 2 pairs), 2 leptons (electron and positron) and

photon (Table 1). Gluon, graviton and WIMP are allowed in principal, but remain elusive. The galactic "dark mass" haloes might be considered as possible candidates for the standing OST curvature waves that were microscopic in the early Universe and became large after the inflation (i.e. "enlarged" WIMPs). There are no virtual bosons or gauge bosons as all interactions are driven by geometrical alterations of nine-dimensional space-time. The photon, gluon and graviton (if found) are "neutral" (zero peak-to-peak amplitude) curvature waves in EMS, NS and OST, respectively, and are not gauge bosons. Consequently, neutrino, H and Z bosons are prohibited as a particle without electric charge, except photon, cannot participate in either electromagnetic or weak nuclear interactions. The particles referred to as W^- and W^+ are certain states of electron and positron, respectively. However, the neutrino and H, W and Z bosons were proven experimentally. This discrepancy presents a serious problem, and the conjectured GPI-based theory will make no sense without evidence that those gauge bosons do not exist.

The GPI-based theory also promises to reduce the number of required free parameters. As particles' masses come naturally as OST projections of "color" and electric charges (see §6), no Higgs mechanism with 15 free parameters is needed. However, the present model cannot explain differences in the hypothetic overall curvatures of the three space-time realms: NS, EMS and OST; therefore the ratios of the overall curvatures NS/EMS and EMS/OST will likely require an *ad hoc* introduction.

All other known particles are either composite or excited states of the elementary components (Table 1). An elementary (**u**) quark and its antiquark represent elementary "color" charges (main properties: NS curvature waves with non-zero peak-to-peak amplitude; inside hadrons, have one of three possible "colors", i.e. curves only one NS dimension; have an EMS projection, i.e. electric charge, and an OST projection, i.e. mass). A (**d**) quark should be seen as a (**u**) quark absorbed an electron (see §5); all other quarks should be seen as excited states (NS curvature waves with higher peak-to-peak amplitude, i.e. higher "color" charge, and consequently higher electric charge and mass). Electron and positron represent elementary electric charges (main properties: EMS curvature waves with non-zero peak-to-peak amplitude, i.e. electric charge; have an OST projection, i.e. mass). Muon and tau are excited states of electron (EMS curvature waves with higher peak-to-peak amplitude, i.e. higher electric charge and consequently higher mass). Photon is a propagating EMS curvature wave with zero peak-to-peak amplitude and no projection in OST. Similarly, gluon and graviton (if exist) are NS curvature wave and OST curvature wave, respectively, with zero peak-to-peak amplitude, with no projections in other realms of the space-time except where they are situated.

In the GPI-based model, the three known generations of quarks and leptons are explained by the gradually increasing "color" or electric charges, respectively. In the SM, muon and tau have same electric charge of -e like electron, but much higher masses. However, if one assumes that muon has charge of -2e and lower mass, that still be in agreement with experimental observations. Similarly, tau may have charge of -3e and lower mass. Quark generations also might be explained similarly, with gradually increasing "color" charges. Thus, the generations of quarks and leptons can be understood as excited states, i.e. curvature waves with higher peak-to-peak amplitudes. It is logical to assume that more than three generations exist, and electrons with charges of -4e, -5e, and etc. and quarks with higher "color" charges will be discovered in future experiments.

Table 1: Elementary particles

Elementary particle	**Fundamental property**	**Induced by**	**Secondary property**	**Amplitude (peak-to-peak)**
Quark, antiquark	"color" charge	NS curvature wave	electric charge, mass	non-zero
Gluon	energy	NS curvature wave	none	zero
Electron, positron	electric charge	EMS curvature wave	mass	non-zero
Photon	energy	EMS curvature wave	none	zero
WIMP*****	mass	OST curvature wave	none	non-zero
Graviton	energy	OST curvature wave	none	zero

***** - galactic "dark mass" haloes might be considered as "enlarged" WIMPs

Table 2: Fundamental properties of space-time

Space-time realm	Curvature appears as	Dimensions	Overall curvature
OST	mass	4 (3 spatial, time)	almost flat, open
EMS	electric charge	at least 2 (ED, MD)	curved, open
NS	"color" charge	at least 3 ("R", "G", "B")	compactified, closed

Table 3: Fundamental interactions

Interaction	Caused by	Elementary "non-zero" curvature waves
Gravity	OST curvatures	Unknown (possibly, WIMPs)
Electromagnetic and weak	EMS curvatures	Elementary electric charges
Strong	NS curvatures	Elementary "color" charges

Conclusion

Despite all the great achievements of the XX century science, modern theoretical physics experiences a very deep crisis and loses its prediction power [3]. Modern theories "beyond the SM" that can explain all physical interactions in principal require too many *ad hoc* parameters and increasingly complicated mathematical concepts [2]. A number of important philosophical questions, such as wave-function collapse, renormalization requirement, confinement, asymptotic freedom, "dark energy" and "dark mass" remain unexplained or poorly explained. Unification of the Einstein's GR with the gauge theories remains problematic because of the fundamental difference in their understandings of the space-time involvement. There is only one simple logical way to remove the latter fundamental incompatibility – by postulating the General Principal of Interaction or GPI universally applicable to all types of known interactions.

The postulated GPI is basically an extension of the Einstein's fundamental principal used in the GR that explains gravitational interaction as the geometrical alterations of space-time, i.e. OST curvatures. GPI states that any physical interaction is governed by alterations of the space-time geometry. Assuming that the space-time is at least nine-dimensional each type of interaction occurs inside its separate realm: OST, EMS or NS (Table 2). Thus, all types of physical interactions are governed by the curvatures of the nine-dimensional space-time with the principle of minimal local energy, i.e. minimal space-time curvature (Table 3). Separated in our Universe these hypothetical realms can merge completely at a certain very high energy composing a single unified compactified space-time manifold ("primordial space") with only one universal interaction. At present, these three realms of space-time are separated very likely due to the difference in their overall curvatures (Table 2). The simplest explanation for their structural hierarchy is to assume that the realms are being decompactified with different rates. Thus, the NS is still compact and enclosed into the EMS; the EMS is curved, but open and enclosed into the OST, and the OST is nearly flat. The differences in overall curvatures of these realms explain the different strengths of strong, electromagnetic and gravitational interactions.

The GPI is consistently applicable to all known types of interaction, and the conjectured GPI-based theory describing all known types of interaction promises a number of advantages over the SM: 1) full compatibility with the GR, 2) fully deterministic description of all interactions, 3) quantization of gravity, 4) reduction of the number of free parameters, 5) reduction of the elementary particle set, 6) no renormalization requirement, 7) simple explanation of the weak nuclear interaction, 8) simple explanation of confinement, 9) possible explanations for the "dark matter" and "dark energy" phenomena. Moreover, the GPI provides a deeply philosophical understanding of matter as being induced by the space-time curvatures. Flat space-time, i.e. absolutely "empty space" or true vacuum is the only one unique primary entity, the single basic "element" of the Universe, and all types of matter are its derivatives (Table 1).

However, the GPI-based approach has a number of serious problems: 1) the requirement of non-existence for neutrino, H, W and Z bosons, 2) no explanation of the fact that NS and EMS curvatures are both positive and negative, whereas OST curvatures are not (i.e. no gravitational repulsion), 3) it is not clear whether the EMS consists of more than two dimensions, and whether the NS consist of more than three dimensions, 4) it is not clear how the EMS dimensions, ED and MD are interconnected, 5) the necessity to explain vacuum polarization effects without virtual particles. The first problem is crucial as without a strong experimental conformation of that requirement (#1 above) the GPI-based theory will be meaningless.

Overall, the GPI provides a solid philosophical foundation for the future unified theory based on the nine-dimensional space-time geometry and expected to describe consistently all known types of physical

interactions. This conjectured GPI-based theory will naturally combine the Einstein's principal of space-time involvement with the quantization by describing all elementary particles as curvature waves of the three realms of space-time. Mathematical development of this theory remains an open question; only possible ways to construct a suitable framework are discussed. The theory nevertheless gives a number of falsifiable predictions: 1) gauge bosons do not exist; photon, gluon and graviton (if found) are not gauge bosons, 2) gravity is quantized, i.e. both zero peak-to-peak OST curvature waves (gravitons) and non-zero peak-to-peak OST curvature waves (WIMPs) exist, 3) neutrino, H, W and Z bosons do not exist, 4) fourth generation of quarks and leptons exist at certain high energies, 5) as the overall OST curvature is approaching complete flatness lambda will further decrease approaching zero, 6) if the EMS is undergoing decompactification, the fine structure constant alpha changes with the decrease of the overall EMS curvature, 7) if the NS is not undergoing decompactification, a spontaneous proton decay is prohibited. Future physical and astronomical observations will possibly validate these assumptions.

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Figures

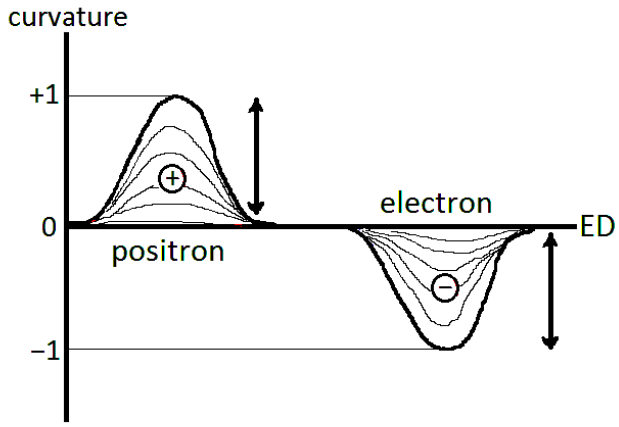

Figure 1: Schematic representation of the elementary electric charges (positron and electron) as standing ED curvature waves oscillating (as shown by the arrows) with positive or negative peak-to-peak amplitude. The two waves completely cancel each other when fully co-localized.

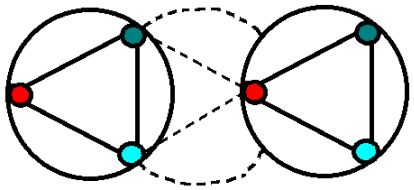

Figure 2: Schematic representation of two bound nucleons (two quark triplets) having an additional "color" triplet. This construct is hypothetically more stable geometrically compared with two separate triplets.

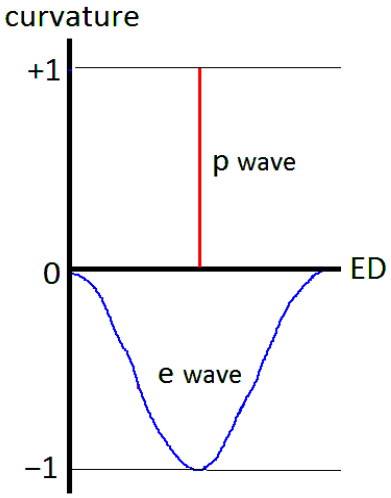

Figure 3: Schematic representation of the size difference (not properly scaled) between the proton's (p wave) and *1s* electron's (e wave) EMS curvature waves in a hydrogen atom that prevents their full co-localization and complete cancelation.