General Principle of Interaction, a Fundamental Concept for Complete Unification in Physics

Truth is ever to be found in simplicity, and not in the multiplicity and confusion of things.
Isaac Newton

Victor Paromov, PhD

Subjects: GR, EC, KK, spacetime, unification, extra dimensions, matter, vacuum

Email: vikus68@yahoo.com

Abstract

It has long been expected that a quantum field theory (QFT) "beyond the Standard Model" (SM) will eventually unify gravitation with particle interactions. Unfortunately, this "Theory of everything" remains elusive. An alternative way is to explain all four types of physical interactions with the geometry of spacetime containing undetectable extra dimensions. The General Principle of Interaction (GPI) presents a materialistic philosophical concept that extends the Einsteinian understanding of geometrically deformed spacetime in order to explain particle interactions and establish a consistent basis for the full unification. Surprisingly, this simple concept remained undeveloped to this day. The GPI assumes that the spacetime includes one time dimension and three subspaces with seven spatial dimensions: ordinary spacetime (OST), "electromagnetic space" (EMS) with one extra dimension, and "nuclear space" (NS) with three extra dimensions. The three main types of interactions (gravitational, electroweak, and strong) are governed by the geometry of these three subspaces (OST, EMS, and NS, respectively). The subspaces are closed and separated by their background curvatures: OST is flat (or almost flat), EMS is more curved, and NS is highly curved and compactified. Thus, gravitational, electromagnetic, weak, and strong interactions are all governed by the spacetime deformations originating separately in these three subspaces (given that the weak interaction is a type of electromagnetic interaction).

It is expected that the Einstein-Cartan (EC) field equations in the 5D spacetime will describe the electromagnetism (assuming the electrostatic field is identified with the EMS curvature, and the magnetic field is identified with the EMS torsion). Leptons and photons can be described as quantized wave-like vacuum deformations originating in the fifth dimension (EMS) with the secondary effects measurable in the OST (electromagnetic and gravitational fields). The EC field equations in the 8D spacetime will describe the strong fields; quarks and gluons can be described as quantized wave-like vacuum deformations originating in the NS with the secondary effects in the EMS and OST. As the original EMS and NS parameters are undetermined in principle, the theory cannot have exact solutions in the EMS or NS, thus requiring the quantum physics methodology (without relying on the gauge transformation principle) for the electroweak and strong interactions, however, remaining the classical field description for the gravity.

It is expected that the GPI-based unified theory will be able to describe all four types of interaction with the "pure geometry" of the 8D spacetime. The theory will provide the vacuum (spacetime) geometry-based full unification and drastically simplify the descriptions of particle interactions by reducing the elementary particle set and the total number of interacting fields.

1. Introduction

The Standard Model (SM) is presently the most useful theory describing the three types of interactions (electromagnetism, weak and strong nuclear forces) involving elementary particles [1]. It shows ultimate reliability for experimental data analysis in particle physics. However, the SM has a number of unexplained free parameters, does not unify the strong interaction with the electroweak theory, and is incompatible with the theory of general relativity (GR) [2]. It is a common belief that a certain more fundamental quantum field theory (QFT) exists "beyond the SM". This hypothetical unification theory should explain and unify all four types of interaction. Unfortunately, this "Theory of everything" has remained elusive for many decades. The present letter proposes an alternative approach, a simple concept, which allows explaining all types of forces solely via the geometry of the spacetime containing a number of undetectable extra dimensions.

1.1. Problems of the QFT-based unification

It has long been expected that a superstring theory, most likely the M-theory, will unify all types of interaction [3]. Unfortunately, no presently known unifying QFT, including all superstring theories, can escape serious problems [4, 5]. Superstring theories have almost no predictive power and are not unique, i.e. the number of possible mathematical descriptions they provide is tremendously great, and it is not clear how to choose the only theory that describes our unique Universe. This long-lasting theoretical crisis raises serious doubts about the ability of quantum physics to provide a self-consistent unique unified theory. The roots of this crisis are much deeper than just methodological and mathematical difficulties with the development of such unified quantum theory. It is an overwhelming fact that the two main pillars of modern physics, the GR and the SM stand on two completely different fundamental philosophical principles. The basic definitions of matter, vacuum, and interaction used in the main theories of particle interactions (SM) and gravitation (GR) are completely different. In QFT, an interaction is understood with the gauge transformation principle, i.e. quantum objects exchange a field carrier quantum, gauge boson. Notably, any QFT (including any superstring theory or loop quantum gravity) is based on the Newtonian definition of vacuum and matter, i.e. vacuum is an empty "set of coordinates" that is not involved in the interaction, while the interacting matter (particles, quarks, strings, etc.) possesses all the properties required for the interaction. Quantum vacuum is not an interacting object *per se* (even considering "spontaneous births" of virtual particle pairs that can interact). On the contrary, the GR is based on the concept of curved spacetime that requires no gauge bosons and involves the Einsteinian understanding of vacuum and matter [2]. Gravitational interactions are mediated directly and solely by the vacuum (spacetime) via its curvature. Thus, the vacuum in the GR is the primary interacting object, as its geometrical properties define the interaction directly while the matter is involved only indirectly, via its ability to curve the vacuum (spacetime). In a logically defined theory, vacuum either mediates interaction or not, but not both, and hence, these two basic principles of interaction are mutually exclusive. Thus, no unification theory could allow for both of these principles simultaneously.

Therefore, the two different strategies can be considered for the full unification:

1) Let the GR to be converted into a QFT, and any interaction to be described with the gauge transformation principle (i.e. QFT-based unification), or

2) Let all types of interaction to be described with vacuum (spacetime) deformations (i.e. vacuum geometry-based unification).

Notably, the second approach does not involve gauge bosons or other virtual particles and relies solely on the Einsteinian understanding of vacuum and matter that is more advanced philosophically than the Newtonian definition used in QFT. Moreover, the phenomenon of dark energy (an acceleration of the Universe expansion that cannot be explained using the observed amount of total matter) shows that vacuum at the scale of the Universe does possess a certain "interacting property", not fitting with the Newtonian definition. Surprisingly, the vast majority of active theorists continue to ignore the second approach.

Relying on the Newtonian understanding of non-interacting vacuum and interacting matter fields, QFTs provoke a number of fundamental questions. These include continuously debated philosophical problems of observational indeterminism, non-locality, and wave-particle duality. Another example is the renormalization problem, which appears when calculations of certain finite physical values result in infinities that can be removed only by a certain *ad hoc* procedure. Richard Feynman called this mathematical procedure a "hocus-pocus… prevented us from proving that the theory of quantum electrodynamics is mathematically self-consistent" [6]. In terms of quantum electrodynamics, when an electron interacts with a photon, the vacuum creates an infinite number of secondary interactions involving virtual particles. When the infinite number of these virtual interactions are accounted for, they add infinities to the calculated values requiring renormalization in order to get finite results. However, if one could describe particle interactions with no virtual particles, none of the secondary interactions would be needed, thereby removing the renormalization issue as a matter of course. Notably, the virtual interactions are non-deterministic, and their rejection does not contradict any observation because virtual particles cannot be directly detected in principle. Unfortunately, this is impossible for any QFT, as all QFTs are based on the gauge transformation principle, which understands any interaction as virtual particle exchange.

Overall, it seems that the QFT-based unification approach has a number of issues of a philosophical significance. The gauge transformation principle that became a dogma is principally incompatible with the Einsteinian understanding of matter and vacuum. Unfortunately, there are no signs that this approach can lead to a major breakthrough in the field of unification.

1.2. Problems of the GR-based unification

An alternative to the QFT-based unification would be the vacuum geometry-based unification relying completely on the Einsteinian understanding of vacuum and matter. It was the greatest Einstein's dream to explain the "base wood" of all forces as manifestations of the "pure marble" of spacetime geometry. Einstein had studied the GR-based unification extensively; unfortunately, this noble mission was never accomplished. This approach has two major problems, which even Einstein himself was unable to overcome: 1) how to identify forces other than gravity with some kinds of deformations of the four-dimensional (4D) spacetime, and

2) how to build a quantum unified theory if the 4D spacetime is described by a classical theory. Notably, these problems cannot be solved in case the geometry of the 4D spacetime defines gravitational forces only.

Some of Einstein's unification models did include the extra dimension [7]. In an attempt to unify gravity and electromagnetism within a classical field theory, Einstein and co-authors [8, 9] used the concept of 5D spacetime suggested by Theodor Kaluza [10]. Einstein and co-authors have described a charged particle as a wave propagating in the fifth dimension and curving 4D spacetime [7, 9]. Unfortunately, the latter quality made the electromagnetic field indistinguishable from gravitation as both ended up having the same action power. Although Kaluza's brilliant idea to add an unseen extra dimension to the 4D spacetime made it possible to unify the GR with Maxwell's theory of electromagnetism, it remained merely a mathematical trick and has not led either to a viable theory of particle interactions or to a complete unification of all forces. Neither Einstein nor Kaluza has assumed that electromagnetic interaction actually occurs in the fifth dimension and is primarily defined by its geometry, not by the 4D spacetime geometry. Moreover, Kaluza had proposed the cylinder condition stating that physics does not depend on the extra coordinate. In 1926, Oscar Klein [11, 12] had proposed that the fifth dimension is compactified. Since then, all the theories extending the GR by introducing a 5D spacetime (even with a noncompact fifth dimension) are called Kaluza-Klein (KK) models. Both then and now, theorists have understood electromagnetism as a field coexisting with gravitation in the 4D spacetime, but not as geometrical deformations of the extra dimension. The former understanding allows for a QFT-based description of electromagnetism, and all the theorists except Einstein had used this possibility in order to keep the quantum field, not a classical description of the electromagnetism. Thus, all the 5D GR extensions using the KK approach made before [11, 12] and after [13, 14] Einstein's 5D models [8, 9] did not reject the gauge transformation principle completely and hence cannot be seen as the vacuum geometry-based unifications.

The present ignorance of the possibility that electromagnetism, weak and strong forces are originated in the undetectable extra dimensions seems odd, as no formal prohibition for a GR extension with extra dimensions is known. However, this approach has two fundamental complications. First, a philosophically consistent concept describing all types of interaction solely with the spacetime geometry was never proposed, i.e. it was never explained consistently how spacetime geometry can define an interaction other than gravity. To resolve this issue, the General Principle of Interaction and the concept of extended spacetime are proposed below (see §2). And even though the spacetime is extended with some extra dimensions, it seems impossible to apply the Einsteinian understanding of vacuum (as curved spacetime) to the particle interactions due to the fact that the nature of gravitational and particle interactions are very much different, e.g. the electromagnetic interactions are governed by charges that either attract or repel while gravitation is only attractive, and no gravitational charge is known. Secondly, the GR is not a complete theory of gravitation as it does disregard any torsional deformation. Dealing with gravitation alone, such approximation is acceptable, as it reduces the calculational complexity at a very low price, as gravitational torsion is typically negligible. However, it is likely that torsion (in the extra dimensions) plays a substantial role in the particle interactions (see §3.1). Hence, the GR cannot be used as a base theory for the vacuum geometry-based unification. In addition, the GR has a number of other problems. The GR cannot explain inflation of the early Universe and the dark energy problem; it miscalculates the rotational curves of galaxies and clusters leading to the dark matter problem. The GR cannot avoid singularities in describing black holes and the Big Bang. The GR lacks any technical ability to describe intrinsic angular momentum (e.g. spinning gas in galaxies) or an exchange of intrinsic and orbital angular momentum (spin-orbit exchange). Finally, the GR is a classical field theory and does not involve quantization, which is necessary for describing particle interactions. Clearly, the GR cannot be used as a unification platform until these questions are resolved.

Notably, the GR was incomplete right from the moment it was created. For the sake of simplicity, Einstein had disregarded any possible torsional deformation. For a full description of all possible geometrical deformations, a theory of gravitation needs to consider both curvature tensor (present in the GR) and torsion tensor (disregarded in GR). In 1922, Élie Cartan proposed such theory that includes non-zero affine torsion and known as the Einstein-Cartan (EC) theory [15]. The EC removes the technical issues of describing spin-induced gravitation or spin-orbit exchange. Interestingly, gravitational torsion is quite useful in explaining all the above-listed problems of the GR, except quantization and the dark matter problem. According to the EC, 4D spacetime can undergo some torsional deformations (presumably induced by spinning matter) in addition to the curvature deformations. This additional gravitational force is immeasurably small in the present Universe; however, it becomes testifiable at high densities of spinning matter, e.g. in black holes and the Big Bang. Recently, Nicodem Poplawski showed that gravitational torsion induced by spinning matter removes central singularities in black hole models [16] and explains inflation in the early Universe [17]. A similar approach had been applied in an attempt to explain the dark energy and the dark matter problems with torsion; however, it seems that the amount of spinning matter in the Universe is insufficient to induce the forces estimated in the both cases [18, 19]. However, there is still a possibility to explain the dark energy with gravitational torsion in case vacuum itself has a certain small, but non-zero torsional deformation not induced by any matter and present before the Big Bang. This means that the whole Universe spins constantly. Could it be that the unexpected alignment of the large-scale fluctuations in the power spectrum of cosmic background radiation (the so-called cosmic “Axis of Evil”) [20], as well as the unexpected alignment and preferred handedness of galaxies’ spins observed astronomically [21], are actually the signs of the rotation of the Universe? This indeed can explain the dark energy phenomenon (but not the dark matter). As for the dark matter, the hypothetical Weakly Interacting Massive Particles (WIMPs) remain the leading candidates for the bulk of dark matter [22]. Unfortunately, both the GR and the EC have no clear predictions about any purely gravitational particle. The prediction of WIMPs based on the GPI-based unification is discussed below (see §3.4).

Finally, there is one more fundamental question related to both the GR and the EC, i.e. quantization. Both these theories understand gravitation as a continuous (classical) field and hence do not involve quantization. Obviously, unification of all forces is impossible until this requirement is fulfilled. This brings a dilemma of how to achieve quantization of particle interactions without conversion of the theory of gravitation (the EC or the GR) into a QFT. This problem is further discussed in §3.1.2 below. Briefly, the hypothesis of elementary vacuum deformations explains all the elementary particles as wave-like vacuum deformations with integer wavelengths, i.e. quantized naturally.

Overall, the GR-based unification has a number of serious problems. Some of them can be avoided with a switch to the EC; however, the main question of how the spacetime geometry can define any interaction other than gravitation still needs an explanation. Below, we propose a concept that allows explaining all types of interaction as geometrical deformations of spacetime containing undetectable extra dimensions.

2. The General Principle of Interaction

Based on the Einsteinian understanding of matter and vacuum, we formulate the General Principle of Interaction: any physical interaction is governed by certain alterations of spacetime geometry. Assuming that all deformations of the 4D ordinary spacetime (OST) are always of gravitational nature, the GPI postulates that the spacetime to contain some undetectable extra spatial dimensions somehow separated from the OST. Then, electromagnetism, weak and strong forces can be understood as certain geometrical deformations that originally occur in the extra spatial dimensions. The three types of interaction (gravitational, electroweak, and strong) are governed by geometrical deformations originated in the three separate subspaces of the extended spacetime. Electric charges induce deformations in the fifth dimension, i.e. “electromagnetic space” (EMS), and “color” charges alter the geometry of the “nuclear space” (NS), which consists of three additional spatial dimensions. Together with the time dimension the three subspaces form an 8D spacetime, however remaining separated by their background curvatures: OST is flat (or almost flat), EMS is more curved (but noncompact), and NS is highly curved and compactified. These differences ensure certain hierarchy as only more curved subspace can influence a less curved one. Thus, NS deformations induce secondary deformations (projections) in the EMS, and EMS deformations induce projections in the OST. Hence, the quarks’ electric charges are induced by their “color” charges, and the masses of all electrically charged particles are induced by their electric charges. Consequently, the Higg’s mechanism and Higg’s boson are avoided (the nature of the discovered so-called Higg’s boson is discussed in §3.6 below).

With the GPI, all known elementary particles can be potentially explained with the six truly elementary vacuum (spacetime) deformations originated in the undetectable extra dimensions (electron, positron, photon, quark, antiquark, gluon). The minimal number of elementary deformations for each subspace is three: 1) “positive” half wave (soliton with a positive curvature), 2) “negative” half wave (soliton with a negative curvature), and 3) “neutral” full wave (a combination of the two above-mentioned solitons). The OST elementary deformations are hypothetical. The concept of elementary vacuum deformations is further discussed in Section 3 below.

According to the GPI, the Universe contains nothing but “empty” vacuum geometrically altered in different ways, and all types of matter are various elementary deformations of this vacuum. The separation of the three subspaces ensures the separation of the three types of forces (gravitational, electroweak, and strong). However, at a very high energy (extreme curvature and torsion), all spacetime dimensions become equal, forming a symmetrical compactified manifold with no subspaces and only one universal interaction. Thus, the concept of extended spacetime together with the GPI provides a simple self-consistent materialistic philosophical basis for the vacuum (spacetime) geometry-based unification of all forces.

According to the GPI, energy is a measure of spacetime deformation that increases with any curvature or torsion. This extends the Einsteinian understanding of the gravitational energy (given by the field equations) for electromagnetic, weak and strong forces, assuming that their potential energies are also determined by the spacetime curvature and torsion within the undetectable EMS and NS subspaces. Thus, all interactions are driven by the principle of minimum energy, i.e. minimal curvature/torsion. The GPI-based descriptions of the four types of interaction are discussed below (see §3.1 – §3.4).

Overall, the GPI has a great potential to explain all types of physical fields with the geometry of extended spacetime. Moreover, in case all types of these geometrical alterations are described as wave-like deformations with integer wavelengths, they are quantized naturally. The number of fundamental fields consequently reduces to just three, i.e. gravitational, electroweak and strong fields defined as geometrical alterations of the three distinct subspaces (OST, EMS, and NS, respectively). The weak field is understood as a type of electromagnetic field. Being based on the Einsteinian understandings of matter and vacuum, the GPI is incompatible with the gauge transformation principle (see §1.1) and thus excludes all gauge fields, gauge bosons, and virtual particles.

3. The GPI-based hypothesis of elementary vacuum deformations

3.1. The EMS elementary wave-like vacuum deformations

3.1.1. The modified 5D Kaluza vacuum. According to the GPI, deformations of the EMS vacuum represent the "original" electromagnetic field. It is assumed that the EMS vacuum and the OST vacuum behave in such a way that the electromagnetic field is determined by the EMS geometry, whereas gravity is determined by the OST geometry. Thus, the electromagnetic field parameters in the OST (4D spacetime) are always secondary and determined by the "original" EMS-related parameters. The electromagnetic field has two interrelated, but distinct components - the electrostatic field and the magnetic field. Assuming the former and the latter are two separate fields, they should be identified with two different types of geometrical alterations. It is logical to assume that the EMS curvature defines the electrostatic field, and the EMS torsion defines the magnetic field. These two types of deformation separately coexist in the fifth (EMS) dimension.

The elementary electric charges presumably induce certain elementary vacuum deformations in the EMS. This assumes the existence of at least one extra spatial dimension (EMS) in addition to the ordinary spatial dimensions (OST) responsible for gravitation. In the simplest case, the EMS vacuum can be described as a 1D circle extension at each point of the 4D spacetime exactly as suggested by Kaluza in 1921 [10]. Then, the simplest topological 5D vacuum model comprises the EMS subspace (a 1D circle), the OST subspace (a 3D de Sitter sphere), and one time dimension embedded together in an embedding dimension. The main difference of this model compared to the original Kaluza's description (in addition to the dropped cylinder condition) is that the embedding of the subspaces should provide such a hierarchy that EMS deformations induce secondary deformations ("shadows") in the OST, but not vice versa. The embedding should also provide the separation of gravity and electromagnetism and ensure the difference of their action powers. The precise description of such embedding is not clear, however, it is hypothesized that the EMS and OST are separated due to the difference in their background geometry. The EMS background parameters (curvature and torsion) are much higher than the same OST parameters. Assuming that electric charges induce deformations in the extra dimension, EMS cannot be compactified. For a compactified EMS, its geometrical alterations are limited to the microscopic size consequently having a very short range of action, which is not the case as both electric and magnetic fields are macroscopic.

In the 5D, this vacuum model should satisfy the EC vacuum field equations (in the absence of matter) and the Einstein vacuum field equations of the GR (in the absence of matter, in cases when torsion is disregarded). In addition, it should satisfy the cosmological parameters of the Universe observed in the 4D spacetime. The detailed mathematical description of this vacuum model is beyond the author's scope.

3.1.2. The 5D EC field equations. It is expected that the 5D vacuum model, as well as the EMS elementary deformations induced by the electric charges, satisfy the Einstein–Cartan field equations in five dimensions. In a very general form given by Sciama and Kibble [23] (with the addition of Λ), the equations are:

$\check{R}_{ab} - ½ \check{R} \breve{g}_{ab} + \Lambda \breve{g}_{ab} = k \check{T}_{ab}$ (1)

where the symbol ~ denotes 5D parameters; $\check{R}_{ab}$ is the Ricci tensor, and $\check{T}_{ab}$ is the canonical stress-energy-momentum tensor, which both contain certain asymmetric contributions due to a nonzero torsion tensor. $\check{R}$ is Ricci scalar, and $\breve{g}_{ab}$ is metric tensor; Λ is cosmological constant in 5D, and *k* is coupling constant.

The cylinder condition is dropped, so $\breve{g}_{ab}$ generally depends on the 5th coordinate:

$\delta\breve{g}_{ab} / \delta x^5 \neq 0$ (2)

The 5D vacuum is never flat, as the EMS vacuum presumably has nonzero background curvature and torsion, which both increase in the presence of electric charges, hence:

$\check{R}_{ab} \neq 0$ (3)

However, as electric charges directly affect only the EMS geometry, not the OST geometry, (4D) R_{ab} can be approximated as zero in the presence of electric charges and absence of mass.

$\check{T}_{ab}$ contains the fifth dimension-related part T^{EMS}, i.e. the canonical electromagnetic stress-energy-momentum tensor, and the OST(4D)-related part, $T^{OST} = T_{\mu\nu}$, i.e. the classic canonical stress-energy-momentum tensor associated with gravity. Assuming that electric charges directly affect the fifth dimension (EMS) only, the T^{EMS} vanishes in the absence of charge. Then, the field equations (1) are subsequently reduced to the classic EC (4D) field equations, which can be substituted with the GR equations by disregarding gravitational torsion.

In the OST, it seems logical to expect that $T_{\mu\nu}$ vanishes in the absence of mass. However, this is true in the absence of charge only. In the presence of charge, the theory is expected to show the effect of "induced" mass, similar to the KK models with large fifth dimension, Ricci-flat 5D vacuum (i.e. $\check{R}_{ab} = 0$) and no torsion. Paul Wesson [14] has shown that even if $\check{T}_{ab} = 0$ in 5D spacetime, $T_{\mu\nu} \neq 0$ in 4D spacetime. In such case, the nonzero 4D stress-energy-momentum appears from the derivatives of the 5D metric with respect to the fifth coordinate. In the presented model, a similar effect is expected for the cases with $\check{T}_{ab} \neq 0$. If so, the leptons' gravitating masses are actually induced by their electric charges. Moreover, the 5D vacuum itself may induce a certain gravitational effect in the OST due to the EMS nonzero background curvature and torsion; i.e. the geometry of the 5D vacuum may determine the cosmological constant in the 4D spacetime. The T^{EMS} has two independent parts: the electrostatic field-related part (defined by the EMS curvature) and the magnetic field-related part (defined by the EMS torsion). These two tensors "induce" two separate parts of the $T_{\mu\nu}$ in the OST, and it is expected that the EMS torsion-induced part is negligibly small compared to the EMS curvature-induced part of the $T_{\mu\nu}$. Thus, the mass in the 4D spacetime is induced mostly by the vacuum curvature in the 5^{th} dimension. Notably, if the EMS torsion can be algebraically replaced by the EMS spin tensor, the magnetic field can be described by the "spin-spin" nonlinear self-interaction.

It is expected that the elementary EMS vacuum deformations can be described with certain wave equations, i.e. wave-like solutions of the 5D field equations (1). In case these waves (or solitons) have integer wavelengths, they are quantized naturally. It is expected that the dynamics of these waves can be described by a form the Klein-Gordon equation. Notably, Wesson has already shown that for his “vacuum waves” modeled in the Ricci-flat 5D vacuum with no torsion [24]. Thus, it seems likely that the wave-like solutions of the field equations (1) will also have dynamics described by a form of the Klein-Gordon equation. The latter will allow understanding the electron as a quantized wave-like EMS deformation with a secondary deformation in the OST (“induced” mass). Unfortunately, the Klein-Gordon equation cannot describe electron motion in quantum electrodynamics, because it only applies to zero-spin particles and, hence, calculates the electron’s energy levels in the atom incorrectly [25]. However, within the presented approach, the magnetic field-related "spin-spin" interaction (the EMS torsion effect) will be accounted for in addition to the EMS curvature-induced electrostatic field. Hence, in the present theory, it is possible that the Klein-Gordon equation will be applicable to the electron motion. This additional 5D torsion-induced effect was not accounted for in all previous KK models. Description of the wave-like solutions of the 5D field equations (1) and derivation of the relevant Klein-Gordon equation is beyond the author’s scope.

A very important feature of the proposed 5D description is that the T^{EMS}, which defines the “original” electromagnetic field, as well as the metric tensor $\breve{g}_{ab}$ defining the 5D geometry, cannot have exact descriptions simultaneously (as they both depend on the “unseen” fifth coordinate). Thus, the undetectable nature of the EMS naturally creates the uncertainty of the electromagnetic interaction. For instance, if one sets a precise value for the T^{EMS}, the $\breve{g}_{ab}$ cannot be determined in principle, and vice versa. Hence, in the 5D spacetime, the field equations (1) cannot have exact solutions (however, the same is not true for the 4D OST). Thus, the EMS-originated interactions can only be described with the complex-valued operators, and hence, the 5D theory will require the quantum field description, whereas the same theory in 4D will remain classical.

The proposed theory has a tremendously increased complexity even compared to the GR and the EC. Moreover, it is not clear yet if it has solutions useful for describing electron and photon. Even the geometry of the 5D vacuum (i.e. the embedding of EMS and OST) is not completely clear at present. However, it is very likely the simplest possible way to describe electromagnetism solely by the spacetime geometry without the gauge transformation principle. Unfortunately, all previously explored simplifications within the KK approach (the cylinder condition, compactified fifth dimension, Ricci-flat 5D spacetime) were not able to provide a successful quantized unification theory. The proposed theory does promise that, as it requires the quantum physics methodology (without relying on the gauge transformation principle) for the electromagnetism, however, preserving the classical field description for the gravity. Thus, the theory actually builds a bridge between the spacetime geometry and quantum physics. As additional advantages, the expected effect of “induced” mass allows avoiding the Higg’s mechanism. By rejecting the gauge transformation principle the renormalization problem will be avoided naturally (see §1.1). The quantum uncertainty should be explained by the undetectable nature of the extra-dimensional interactions.

3.1.3. The predicted EMS vacuum deformations. At present, the mathematical description of the elementary EMS vacuum waves is beyond the author's scope. Nevertheless, it seems possible to predict the simplest descriptions of such waves and analyze their behavior in general.

Interacting elementary 5D vacuum deformations induced by the electric charges can be seen as portions of geometrically-altered spacetime, which affect each other according to the principle of minimum energy, i.e. minimizing the resulting deformation. Thus, in general, a positively curved EMS deformation attracts a negatively curved one but repels another positively curved EMS deformation. This is a simplified description of the electrostatic field-related interaction. A similar pattern is valid for the EMS "spin-spin" (torsion-induced) interaction related to the magnetic field.

Let us assume that an elementary electric charge deforms the EMS vacuum inducing an oscillating standing wave (or soliton) with the curvature and the torsional components: a curve (positive or negative) identified with its "original" electrostatic field and a twist (left or right) identified with its "original" magnetic field. Thus, only three "original" parameters would describe this local EMS deformation (let's call it half wave): curve, twist, and frequency. The curve is unchangeable, which ensures the law of charge conservation; the twist has a constant value, but its direction can change during interactions. Thus, an elementary electric charge always has a magnetic moment and induces both electrostatic and magnetic fields. This assumption excludes an existence of a magnetic monopole, as both these fields are induced by the same charge.

In the simplest case, there are three types of elementary EMS deformations:

1) electron, a half wave (soliton) with a negative curve, 2) positron, a half wave (soliton) with a positive curve, and 3) photon, a full wave, a combination of the two half waves with opposite curves and twists (Fig. 1).

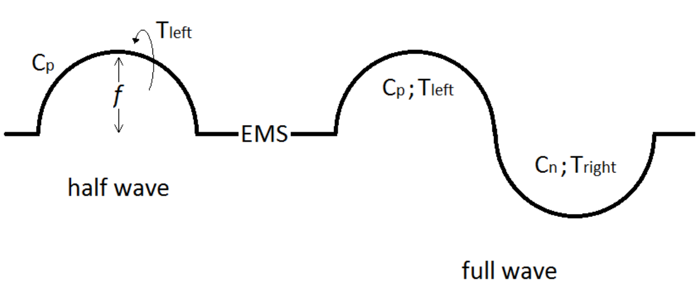

Figure 1: Schematic representations of the elementary EMS wave-like vacuum deformations. The half waves (electron and positron) have three main parameters: curve **C** (positive or negative), twist **T** (left or right) and frequency ***f*** (as they oscillate as shown by the arrows). The horizontal line depicts a fragment of the fifth dimension (EMS). The EMS full wave (photon) is a combination of the two EMS half waves (electron and positron) with opposite curves and twists oscillating with the same frequency in counterphase.

All the waves oscillate with a certain frequency. The photon wave components oscillate with the same frequency in counterphase. In a sense, a photon can be seen as a stable electron-positron pair. The half waves induce nonzero local EMS curvature identified with the electrostatic field and nonzero EMS torsion identified with the magnetic field. In the OST, the EMS half wave induces a secondary deformation, a "shadow" OST half wave (projection) identified with the lepton's rest mass. The full wave induces zero average EMS curvature and zero average EMS torsion as it combines two half waves completely canceling each other's effects in time. In the OST, the EMS full wave has a projection, "shadow" full wave, a massless gravitational wave. This concept explains why leptons have charges and masses, but photons are chargeless and massless. Leptons interact with other leptons and photons, but also with the EMS deformations induced by quark triplets (see §3.2). The full waves cannot attract or repel each other or the half waves due to the zero average EMS curvature and torsion. However, the full waves can co-localize together in a resonance state (laser), or with the half waves (absorbance). These interactions require the interacting waves to have the same frequency. The latter effect is seen experimentally either as excited electron states or as more energetic leptons, muon or tau. These states are associated with increased energies and hence unstable.

In addition to the EMS curvature-mediated interaction, the leptons' interactions can be driven by the EMS torsion. This ensures the Pauli Exclusion Principle explaining why two electrons with the same twist cannot share one atomic orbital. If the curves of the two electrons oscillate in counterphase, they can share the same orbital; however, if their twists have the same direction, the torsional EMS deformation increases forcing one of the electrons to change the twist direction. The separation of the curvature and the torsional effects also explains the fact that a macroscopic electrostatic field can exist in the absence of a magnetic field (even if electrons in a substance are rearranged so they induce an electrostatic field, the electrons' twists can cancel each other canceling their magnetic fields). A macroscopic magnetic field is also possible in the absence of an electrostatic field when the electrons' electrostatic fields are canceled by the protons' fields, but the electrons' twists are in order (mostly left or mostly right) and induce a nonzero average EMS torsion. This concept also allows explaining electromagnetic induction with the EMS geometry. (A magnetic field induces electric current when, for example, a magnetized body with co-oriented electron twists is moving about a metal rod. Then, the rod's electron twists also become co-oriented but in an opposite direction. As the rod's electrons are now bound with the body's electrons via the magnetic field, the rod's electrons will follow the body's movement producing an electric current in the rod. An electric current induces a magnetic field if moving electrons tend to have their magnetic twists co-oriented with the direction of motion.)

3.2. The NS elementary wave-like deformations

Strong interaction is governed by the three types of "color" charge, has extremely short action distance and high power. It is expected that by extending the 5D spacetime (see §3.1) with an additional subspace ("nuclear space" or NS) with three extra spatial dimensions, both strong and electromagnetic interactions can be understood with the spacetime geometry. Thus, the 8D vacuum model needed for the full unification should include the OST, the EMS and the NS subspaces and a time dimension embedded together in an embedding dimension. The three subspaces are presumably separated by the differences in their background curvatures reflecting the differences in their action powers. The NS can be simply viewed as a 3D spherical extension (in addition to the EMS 1D circle extension) at each point of the OST subspace (Kaluza-like approach).

It is expected that the 8D vacuum model, as well as the NS elementary vacuum deformations induced by the "color" charges, satisfy the Einstein–Cartan field equations in eight dimensions. It is also expected that the 8D EC theory will have an effect of "induced" electromagnetic charge, similar to the effect of "induced" mass expected for the 5D EC theory (see §3.1.2). As with the 5D theory, the 8D theory cannot have exact solutions for the NS-originated interactions due to the undetectable nature of this subspace. Hence, the NS vacuum deformations can only be described with the complex-valued operators like the EMS deformations. The detailed description and analysis of the 8D EC extension remain beyond the author's scope.

Similar to the elementary EMS deformations (Fig. 1), the elementary NS deformations induced by "color" or "anticolor" charges should include three main types: 1) **uuu** quark triplet, a 3D half wave (soliton) with a positive curve, 2) **ūūū** antiquark triplet, a 3D half wave (soliton) with a negative curve, and 3) gluon or **uuuūūū** quark sextet, a 3D full wave with zero average curvature and torsion, a combination of the two half waves. All the waves oscillate with a certain frequency. The gluon wave components oscillate in counterphase.

The simplest geometrical description of the half wave elementary NS deformation would be a compactified 3D sphere with a constant radius oscillating in the embedding dimension, a 3D analog of the EMS half waves. Thus, the NS half wave (baryon) is a 3D compactified object with one EMS projection (1D "shadow" wave) and one OST projection (3D "shadow" wave). The former defines baryonic electric charge, and the latter defines baryonic gravitational mass. The baryons cannot induce EMS compactification as their electromagnetic fields do interact at long distances. The 3D NS deformation can have only the same curvature (either positive or negative) in all three embedded dimensions. Hence, no **uūu** or **ūuū** quark triplets exist. From the geometrical point of view, these compactified 3D spheres are ultimately stable NS deformations. Therefore, no 1D NS half waves (i.e. single quarks) exist (confinement), until the NS dimensions are separated into three 1D subspaces. The NS full wave (gluon) is a combination of a sphere and an inverted sphere having opposite curves and twists. The gluon has a projection in the EMS (a "shadow" photon), and thus it is indistinguishable from a photon while interacting electromagnetically.

As it was explained above (see §3.1.3) EMS half waves with the same curves repel. Surprisingly, NS half waves, baryons show opposite behavior and always attract. This phenomenon can be explained taking into the account one important difference between these two subspaces. The two positive (or negative) EMS half waves tend to increase local EMS curvature while the background EMS curvature prevents that and drives them apart. The two similar NS half waves, however, do not "feel" any background NS curvature (as the NS is compactified down to the size of the wave, the NS half wave's curve and the NS background curvature are the same). Thus, two or more NS spheres can combine within the compactification distance and form a smaller NS sphere consequently increasing the NS curvature.

In addition to the NS-originated interactions, the NS half waves interact via the "shadow" deformations they induce in the EMS. Thus, the "naked" **uuu** quark triplet does not exist in a free state due to its EMS "shadow" (electrostatic charge +2e) and always bound to one (**uud**) or two electrons (**udd**). Those interactions are obviously electromagnetic. The **uud** triplet (proton) is more stable than the **uuu** triplet. However, the neutron (**udd**) is less stable than the proton. This phenomenon can be explained by the fact that the "shadow" EMS half wave induced by the quark triplet cannot be perfectly canceled with the two EMS "half waves" induced by the two electrons. In order to cancel the former half wave, the latter two half waves should form a more energetic single wave with a higher curvature (Fig. 2). An additional energy required for this transformation reflects the difference in mass-energy and stability between the neutron and the proton. Thus, the proton is the most stable baryon, and it cannot decay spontaneously.

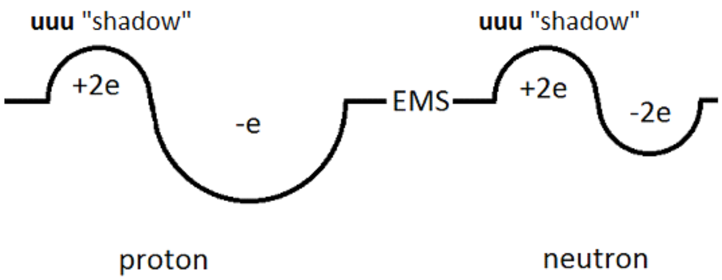

Figure 2. Schematic representations of the EMS deformations induced by the proton and the neutron. When proton binds an electron and forms a neutron, its "shadow" EMS half wave (+2e charge) induced by the **uuu** triplet should be completely canceled by the (two -e charges) induced by the two electrons. That is possible only after the latter two EMS half waves induce a single EMS half wave (-2e charge), which is more curved (smaller) than the two original half waves (-e charge) and hence requires an additional energy.

The heavy **c**, **s**, **t** and **b** quarks can be explained as excited states of **u** or **d** quarks bound to an energetic gluon. As the quarks are three-dimensional, these are actually **uuu**, **uud** or **udd** triplets in resonance with a gluon, which increases the hadrons' energy making them more massive in terms of mass-energy.

In particle physics, there is a special class of unstable hadrons, mesons that consist presumably of a quark-antiquark pair. A stable closed 1D deformation is impossible in a closed 3D NS subspace; hence a single quark-antiquark pair cannot exist. Mesons can be explained as 3D NS full waves (gluons) associated with EMS half waves (electrons or positrons) and/or EMS full waves (photons). For instance, π^+ pion is a gluon (**uuuūūū**), which EMS "shadow" is bound to a positron (e^+), i.e. **uudūūū** sextet, and π^- pion is a gluon bound to an electron. Then, π^0 pion is a gluon (**uuuūūū**), which EMS "shadow" is bound to a photon (e^+e^-), i.e. **uuddūū** sextet (which experimentally is seen as a pair of photons, one "shadow" and one original). Charged mesons are obviously not stable; in the EMS, they can be seen as an excited state of electron or positron with an absorbed "shadow" photon. Neutral mesons are likely gluon-photon combinations with various energies.

In general, it seems possible to describe the strong interaction together with electromagnetism and gravity using a minimal EC extension in the 8D spacetime. The extended theory will describe strongly interacting NS full waves (gluons), NS half waves (baryons), and their projections: secondary EMS deformations ("induced" electric charges and induced magnetic moments) and secondary OST deformations ("induced" gravitational masses). In the 5D spacetime, the theory will reduce to the 5D EC theory (see §3.1.2).

3.3. The weak interaction

Historically, the weak nuclear force was introduced as a special type of nuclear interactions in order to explain neutron decay. However, there is no special charge identified with the weak interaction. For protons and electrons, the weak forces are calculated based on the electric charges. Hence, it is logical to assume that the weak interaction is actually a kind of electromagnetic interaction involving electric charges and "color" charges. In hadron-lepton interactions, "color" charges interact indirectly, via the induced "shadow" electric charges (see §3.2). A simple explanation of the neutron instability is given above (see §3.2). When the neutron decays, the extra energy is emitted as a photon. A more detailed description of this interaction should come with the future GPI-based theory of electrodynamics.

Although the GPI-based concept explains the weak interaction in a much simpler way than the SM, this comes with a price of rejecting W and Z bosons (as GPI allows no gauge bosons) and neutrinos. If the neutrino has neither electric nor “color” charge and is not a photon or gluon, it cannot induce any EMS deformation. Hence, the neutrino can interact with other particles only via gravitation, which makes no sense. Notably, these rejections do not contradict any experiments, as the weak bosons and neutrinos are undetectable in principle. In bubble chambers and all other types of detectors, weak bosons and neutrinos make no visible track, and, therefore, cannot be distinguished from photons (or gluons). Thus, the neutrino telescopes actually detect high-energy photons (or gluons), but not neutrinos. The neutrino was originally suggested by Wolfgang Pauli to explain the continuous energy spectrum of beta-rays in the beta decay. However, this spectrum [26] can be explained by the Bremsstrahlung effect when the electrons (beta-rays) are deflected by the neighbor atomic nuclei and emit photons (gamma-rays). The electrons show a continuous energy spectrum because they lose various amounts of energy when passing the nuclei at various angles. The Bremsstrahlung radiation was completely ignored in the early beta decay experiments as the detectors were typically shielded from gamma-rays [26]. Therefore, the present concept of the weak interaction requires careful re-evaluation.

3.4. The OST elementary wave-like deformations

A number of problems that remains unsolved by the GR have discussed above (see §1.2). Some of those issues can be solved with the switch to the EC; however, the two fundamental questions still remain. As mentioned above, both these theories have no predictions about the dark matter and dark energy. The GPI-based logic though does bring some interesting suggestions.

First, even if there is no source of the dark energy in the OST, it can be explained by the 5D vacuum geometry, as the EMS background curvature and torsion may “induce” a certain gravitational effect in the OST associated with the cosmological constant (see §3.1.2).

Secondly, for the sake of symmetry, it is logical to assume that there are three types of purely gravitational elementary deformations: $\mathbf{G_p}$, positively curved OST half wave; $\mathbf{G_n}$, negatively curved OST half wave; and $\mathbf{G_0}$, OST full wave ($\mathbf{G_0} = \mathbf{G_p G_n}$). It is possible that the “gravitational charges” ($\mathbf{G_p}$ or $\mathbf{G_n}$) might have been already observed indirectly and interpreted as dark matter particles, WIMPs. The dark matter is cold and collisionless (i.e. it does not interact strongly or electromagnetically), and must be stable or at least metastable [22]. Indeed, the elementary OST half wave (soliton) induced by a negative “gravitational charge” ($\mathbf{G_n}$) might be an ideal candidate for the dark matter WIMP. As it has no "shadow" deformations (i.e. no projections in the NS and EMS) it cannot interact strongly or electromagnetically. $\mathbf{G_n}$ is attracted to the baryonic “positive” OST “shadows” tending to form with them a full wave. This interaction may partially cancel baryons’ rest masses (given the latter are bigger than the $\mathbf{G_n}$ rest mass). Considering the observed excess of the dark matter in the Universe, all baryons should be bound to the $\mathbf{G_n}$ WIMPs. The leptons’ “negative” OST “shadows” repel $\mathbf{G_n}$, thus the leptons’ masses are not affected by the WIMPs. This hypothesis assumes the following hierarchy of the gravitational masses: baryon's OST effect > lepton's OST effect > WIMP's OST effect. However, it is not fully clear how those hypothetical "gravitational charges" interact with each other? Are they fully attractive like NS half waves or both repelling and attractive like EMS half waves?

As there is an excess of positive "color" charges (baryons) and negative electric charges (electrons) in the Universe, it is logical to assume that there is also an excess of certain "gravitational charges", e.g. $\mathbf{G_n}$. The latter is gravitationally attracted to the baryonic "shadow" OST deformations making the dark matter haloes around the galaxies. Advances in the astronomical methods will soon allow for a direct detection of the dark matter, thus making the WIMPs discovery highly expectable.

3.5. Big Bang or Big Unroll?

According to the present widely accepted theory of the Big Bang and cosmic inflation, the Universe has started from an infinitesimally small point. It is still not clear what force has driven the Big Bang, and what force has driven the inflation. The GPI-based logic suggests that the Universe has started from a fully compactified symmetrical 8D spacetime, "primordial ball" with a very small but finite size. As the actual size of the "primordial ball" was very small, its initial (assumingly positive) curvature and torsion (and hence the energy) were tremendously big. This energy excess was likely the driving force for the followed expansion. For some unknown reason the expansion did not occur symmetrically (i.e. equally) for all the dimensions, and the primordial 8D spacetime had separated into the three subspaces (NS, EMS, and OST) that expanded differentially. The OST and EMS had expanded to macroscopic sizes while the NS expansion was limited, and it remains compactified. The OST had expanded to a flat (or an almost flat) state and is expanding presently according to the astronomical observations. The EMS should have a relatively high remaining background curvature, and assumingly it is expanding as well. For an unknown reason, the NS cannot expand more than the size of a baryon. As the OST and EMS continuously expanded but did not decompactify the NS, they ripped the NS apart into multiple compactified objects thus creating an excess of the positively curved NS half waves (**uuu** baryons).

In addition to the baryons, the Universe appears to have an excess of the negatively curved EMS half waves, electrons and (hypothetically) the negatively curved OST half waves, $\mathbf{G_n}$ WIMPs. The origin of the electron/WIMP excess is not obvious. As a possible scenario, the "primordial ball" with a positive curvature (proto-universe) had absorbed another 8D primordial object with a negative curvature of a lower value. The inequality of the two primordial curvatures had created the further asymmetry of the Universe's expansion in the three subspaces. In the NS, the **uuu** baryons were partially converted into full waves, gluons by absorbing the second primordial object's NS curvature, however, some baryons had remained intact. In the EMS, the baryons' geometrical projections ("shadow" EMS deformations) had "anchored" the negative EMS curvature of the second primordial object creating negatively curved EMS half waves, electrons (two per a baryon). Thus, the baryons formed neutrons, and later, protons and atoms. Similarly, the baryons' "shadow" OST deformations created an excess of negatively curved $\mathbf{G_n}$ WIMPs by "anchoring" the negative OST curvature of the second primordial object. The details of this Big Unroll scenario should be addressed in the future cosmological research.

3.6. Reduction of the elementary particle set

The SM elementary particle set presently includes 61 components: 36 quarks (2 flavors x 3 generations x 3 “colors” x 2 quark-antiquark pairs), 12 leptons (2 types x 3 generations x 2 particle-antiparticle pairs) and 13 gauge bosons (8 gluon types, photon, W^+, W^-, Z, and H bosons, not including graviton). From materialistic philosophical grounds, some quarks and leptons are not truly elementary as they decay into other elementary particles or transform into each other. In addition, the SM requires a number of *ad hoc* parameters and a special Higg’s mechanism explaining masses of hadrons and leptons.

The GPI-based concept of particle interactions assumes an 8D spacetime with three separate subspaces and one shared time dimension (Table 1) and understands all the elementary particles as elementary wave-like spacetime deformations (solitons) of those three subspaces. This approach reduces the number of fundamental interactions and fields down to three (Table 2). The list of elementary objects is reduced to six half waves and three full waves (Table 3 and Fig. 1). The two elementary baryons (**uuu** and **ūūū**) are 3D NS deformations (half waves) induced by the elementary “color” charges. The two elementary leptons (electron and positron) are 1D EMS deformations (half waves) induced by the elementary electric charges. In addition to the curve (elementary curvature deformation), these elementary NS or EMS wave-like deformations have a twist (torsional deformation) and frequency (as they oscillate). The NS half waves (baryons) always induce secondary ("shadow") deformations, projections in the EMS identified with the baryons’ electric charges. The EMS half waves (baryon charges and leptons) induce secondary deformations in the OST identified with the gravitational masses of hadrons and leptons. As particles’ masses come naturally as a secondary effect of the EMS deformations, no Higg’s mechanism is needed. The experimentally discovered massive intermediate interpreted as the Higg’s boson is likely a form of baryon or neutral meson (either quark-gluon or gluon-photon combination with a higher mass-energy compared to the known particles).

Table 1: Three subspaces of the 8D spacetime (1 time and 7 spatial dimensions total)

Subspace	**Description**	**Projections**	**Dimensions**
OST	almost flat, closed, noncompac	none	3 spatial
EMS	curved, closed, noncompact	into OST	1 spatial
NS	extremely curved, closed, compactified	into EMS and OST	3 spatial

Table 2: Fundamental interactions

Interaction	**Field origin**	**Primary entities**
Gravitational	OST deformations	Hypothetical “gravitational charges” (2 types)*
Electroweak	EMS deformations	electric charges (2 types)
Strong	NS deformations	“color” charges (2 types)

***** - No “gravitational charges” inducing OST half waves have been discovered yet

Table 3: Elementary deformations of the 8D spacetime

Elementary object	Description	Curve* (average)	Twist** (average)	Primary effect	Secondary effects (induced)
Baryon (**uuu**), Antibaryon (**ūūū**)	NS half waves (solitons)	nonzero	nonzero	strong field	electromagnetic field, gravitational field
Gluon (**uuuūūū**)	NS full wave	zero	zero	strong field (zero average)***	electromagnetic field, gravitational field (zero average***, both)
Electron (e^-), Positron (e^+)	EMS half waves (solitons)	nonzero	nonzero	electromagnetic field	gravitational field
Photon (e^+e^-)	EMS full wave	zero	zero	electromagnetic field (zero average)***	gravitational field (zero average)***
$\mathbf{G_n}$ WIMP, hypothetical $\mathbf{G_p}$ WIMP, hypothetical	OST half waves (solitons)	nonzero	nonzero	gravitational field	none
$\mathbf{G_0}$ WIMP, hypothetical	OST full wave	zero	zero	gravitational field (zero average)***	none

***** - Curvature deformation averaged in time (as the waves oscillate)
****** - Torsional deformation averaged in time (as the waves oscillate)
******* - The two parts of a full wave cancel each other's effect in time, however, the actual deformation still exist promoting interactions

All gauge bosons and virtual particles are avoided as all interactions are driven solely by the 8D spacetime geometry. Photons and gluons are not gauge bosons, but wave-like deformations (full waves) originated in the EMS and the NS, respectively. Neutrinos are indistinguishable with photons, the only uncharged particles interacting with charged particles. Spontaneous births of particle-antiparticle pairs are prohibited, as the full waves (photons or gluons) are stable and cannot decay spontaneously.

Thus, all particles except the elementary baryons (**uuu** and **ūūū**), the elementary leptons (positron and electron), and the hypothetical gravitational WIMPs ($\mathbf{G_n}$ and $\mathbf{G_p}$) are either composite or excited state of these elementary half waves. The full waves are stable combinations of two half waves with opposite curves and twists and same frequency. The proton (**uud**) and the neutron (**udd**) resemble the bound states of the elementary baryon (**uuu**) with one or two electrons. Quarks and leptons of the second and the third generations cannot be considered elementary as they decay into the first-generation quarks and leptons. The baryons (quark triplets) containing higher generation quarks (**c**, **s**, **t** and **b**) can be alternatively explained as excited states of the **uuu**, **uud** or **udd** triplets bound to a high-energy gluon. Mesons can be explained as NS full waves, gluons associated with EMS half waves (electrons or positrons) and/or EMS full waves, photons (see §3.2). The muon and tau leptons are two excited states of an electron in-resonance with a high-energy photon (or a gluon EMS "shadow"). In case of no limit for the "associated" photon, more energetic excited states of the electron interpreted as another lepton generations can exist. The same reasoning is generally applicable to the baryon-gluon excited states, i.e. another quark generations may be possible as well. Future collider experiments should justify these assumptions.

The reduced elementary "particle" set (Fig. 1 and Table 3) includes three hypothetical elementary OST deformations. The concept of GPI and the extended spacetime allows for the elementary OST half waves and full waves, i.e. purely gravitational objects (with no projections in the NS or EMS) matching the description of WIMPs. No such WIMPs have been detected yet; however, if exist, they should perfectly fit within the GPI-based theory. If our Universe has an excess of certain NS and EMS half waves (i.e. baryons and electrons), it is logical to assume that there is also an excess of certain OST half waves, e.g. $\mathbf{G_n}$ WIMPs (see §3.4), which represents the dark matter.

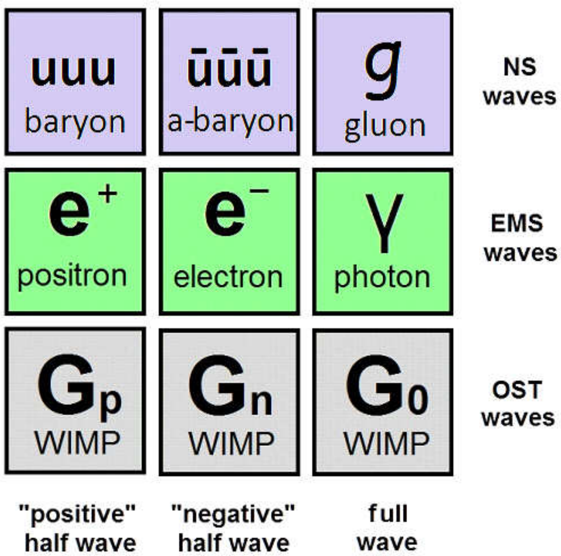

Figure 1: The GPI-based complete set of elementary wave-like spacetime deformations. The NS and OST waves are three-dimensional, and the EMS waves are one-dimensional (if disregard the time coordinate). The NS waves induce "shadow" waves (projections) in the EMS and OST, the EMS waves induce "shadow" waves in the OST only, and the OST waves have no "shadows". The photon and the gluon are full (combined) waves, i.e. $\gamma = e^+e^-$ and $g = uuu\bar{u}\bar{u}\bar{u}$ (see §3.1 and §3.2, respectively). As the full waves are composite, they are not truly elementary, however, they might be considered elementary due to their stability. As the masses of hadrons and leptons are "induced", the Higg's mechanism and Higg's boson are avoided (see §3.1.4). As the weak interaction is a type of electromagnetic interaction, W, Z bosons and neutrinos are avoided (see §3.3). The elementary OST waves (WIMPs) are hypothetical (see §3.4).

4. Conclusion

Despite all the great achievements of quantum physics, complete unification of the four fundamental forces of nature remains beyond its reach. The main theoretical effort is currently concentrated on the development of a superstring unified QFT. In the quest for the "Theory of everything", the majority of theorists continue to ignore the second possible approach, the vacuum (spacetime) geometry-based unification. Following this second path remains challenging as even Einstein himself was unable to unify gravitation and electromagnetism by the "pure geometry" of spacetime. It is likely that the Einsteinian concept of spacetime limited by its four-dimensionality is unable to explain the quantum world. Unfortunately, neither Einstein nor other theorists had ever assumed that the electroweak and strong interactions actually occur in the "unseen" extra dimensions. The GPI (see §2) extends the Einsteinian definition of spacetime with undetectable extra dimensions promising a simple self-consistent way to unify all four types of interaction. This definition of spacetime includes three separate subspaces: 3D OST, 1D EMS and 3D NS (all "bound" to one time dimension) providing that each type of interaction is separately governed by certain geometrical alterations in one of these subspaces. The geometrical separation of these subspaces allows preserving the general differences between the interaction types (action distance and power). The assumption that all the nongravitational interactions primarily occur in the undetectable extra dimensions allows for a universal definition of interaction applicable to gravitational and particle interactions. The GPI has a great capability to resolve the two major problems of the vacuum geometry-based unification: 1) define the spacetime deformations that are responsible for each type of particle interactions without confusing them with the 4D OST (gravitational) deformations, and 2) adopt the quantum physics methodology without relying on the gauge transformation principle. The remaining difficulties of the GPI-based unification strategy are mainly technical, and a correct description of the multidimensional spacetime geometry will eventually bring the right theory.

In the early years of quantum physics, Einstein and others had rendered it incomplete for its incompatibility with the two materialistic principles of scientific observation: determinism and causality [27]. During that time, they expected that a complete theory of particle interactions eventually reveals the "hidden parameters" always missing in the QFTs. However, later experiments [28] have proven in general the Bell's theorem [29] and showed that although quantum mechanics violates both locality and realism, it is nevertheless the best possible theory describing particle interactions. However, the Bell's theorem assumes the four-dimensional reality and does not take into the account any "unseen" extra dimensions. Thus, it still remains questionable whether the quantum field description is the best possible way to deal with the particle interactions, as the extra coordinates may indeed represent the "hidden parameters".

Surprisingly, the introduction of undetectable extra dimensions makes the spacetime geometry compatible with the quantum physics. The undetectability of the extra coordinates naturally explains the uncertain nature of particle interactions without breaking determinism and causality. Moreover, this undetectability justifies the quantum field mathematical description of interaction as the general method, consequently making any classical field theory (e.g. the GR or the EC) a limiting case relevant only for the "detectable part" of the spacetime. For instance, one cannot describe an electron with a classic field approach, as both the EMS geometry and the "original" (EMS-originated) electroweak field cannot be determined simultaneously (see §3.1.2). Hence, one needs the complex-valued operators to describe the EMS parameters. Then, one will inevitably end up with the quantum field descriptions, however, avoiding the gauge transformation principle and all related problems (see §1.1). Thus, the GPI concept may resolve the famous argument between Einstein and Bohr. If the extra dimensions exist, the Copenhagen interpretation is completely inappropriate, as the particles do have definite properties, and the uncertainty is not the nature of the interaction but is an observational limitation. Then, Einstein was right, as nature always remains completely deterministic at all levels, however, our observational abilities may be strictly limited by our four-dimensionality. In the case of the famous EPR paradox [27] in particular, this would justify an absence of any "spooky action at a distance", as the quantum entanglement phenomenon is caused by the unavoidable measurement limitations, not by the particles' abilities to interact in a "spooky" way.

The 8D spacetime geometry-based unification strategy holds a great promise to fulfill Einstein's vision of reducing physics to the "pure geometry" of spacetime. Following the general Einsteinian definitions, the GPI unifies matter and vacuum at a very basic level. Philosophically speaking, the "true vacuum", i.e. the 8D spacetime in the absence of any deformation, is the only one primary entity, a very basic "element" of the Universe, and all types of matter are its geometrical alterations. All known elementary particles can be understood with various combinations of just six elementary extra-dimensional wave-like spacetime deformations, with an addition of the three hypothetical OST deformations explaining the dark matter (Fig. 1).

The GPI-based approach allows for a background-independent unified field theory describing all four types of interaction with wave-like deformations of the 8D spacetime. It is expected that the 8D EC field equations can describe these elementary vacuum deformations. The 8D EC theory cannot have exact solutions for the extra-dimensional interactions due to their undetectable nature. Hence, the theory will have to adopt the QFT methodology, however, rejecting the gauge transformation principle and avoiding any virtual interactions. In addition, the theory is expected to have the effects of "induced" electromagnetic charge for the NS deformations and "induced" mass for the EMS deformations (see §3.1.2). The cosmological constant can be explained by the similar effect of the EMS vacuum "inducing" gravitation in the OST. The theory promises a number of advantages (see §§3.1-3.4) over the SM and the QFT-based unification strategies: 1) fully deterministic understanding of all interactions and adaptation of the quantum field methodology with quantization; 2) background-independence and inclusion of the GR and the EC as limiting cases; 3) the effect of "induced" gravitational masses of hadrons and leptons with consequent avoidance of the Higg's mechanism; 4) rejection of the gauge transformation principle and avoidance of the renormalization problem; 5) reduction of the elementary set (Fig. 1); 6) simple explanation of the confinement; 7) explanation of WIMPs as the elementary OST deformations and understanding of the cosmological constant as the 5D vacuum-induced.

Overall, the GPI and the extended concept of spacetime provide a simple universal materialistic basis for the vacuum geometry-based full unification. The proposed 8D EC extension combines the Einsteinian understanding of interaction driven by the spacetime deformations with the quantum field methodology by describing all elementary particles as wave-like vacuum deformations originated in the undetectable extra dimensions. In addition, the theory will describe purely gravitational 4D elementary deformations explaining the dark matter. Adopting the quantum field methodology in general, the unified field theory will, however, reject the gauge transformation principle, avoid virtual bosons, and prohibit spontaneous births of particle-antiparticle pairs. Mathematical development of this theory is a complex task and remains an open question; possible modifications of the Kaluza-Klein approach for the GPI-based electrodynamics are discussed in §3.1.2. It is nevertheless possible to make a number of falsifiable predictions (see §§3.1-3.6). Future experiments and astronomical observations will be needed to validate these predictions.

5. References

1. L. Hoddeson, L. Brown, M. Riordan, and M. Dresden. The Rise of the Standard Model: Particle Physics in the 1960's and 1970's. (Cambridge University Press) 1997
2. Einstein. Outline of a Generalized Theory of Relativity and of a Theory of Gravitation. Part I. Zeitschrift für Mathematik und Physik, 62, 225, 1913
3. M. Duff. The theory formerly known as strings. Scientific American, 278 (2), 64, 1998
4. P. Woit. Not Even Wrong. The Failure of String Theory and the Continuing Challenge to Unify the Laws of Physics. (Jonathan Cape, London) 2006
5. L. Smolin. The Trouble With Physics: The Rise of String Theory, The Fall of a Science, and What Comes Next. (Mariner Books, Reprint edition) 2007
6. R.P. Feynman. QED, The Strange Theory of Light and Matter. (Penguin) 1990
7. J. van Dongen. Einstein and the Kaluza–Klein particle. Studies in History and Philosophy of Science, Part B, 33 (2), 185, 2002
8. A. Einstein and P. Bergmann. On a generalization of Kaluza's theory of electricity. Ann. Math., 34, 683, 1938
9. A. Einstein, V. Bargmann, and P. Bergmann. On the five-dimensional representation of gravitation and electricity. In Theodore von Karman Anniversary Volume. California Institute of Technology, 1941
10. Th. Kaluza. Zum Unit¨atsproblem der Physik. Sitzungsber. Preuss. Akad. Wiss., Phys. Math. Kl. 966, 1921
11. O. Klein. The atomicity of electricity as a quantum theory law. Nature, 118, 516, 1926
12. O. Klein. Quantentheorie und funfdimensionale Relativitatstheorie. Z. Phys., 37, 895, 1926
13. Modern Kaluza-Klein theories, ed. Appelquist, A. Chodos and P. G. O. Freund (Addison-Wesley) 1987
14. J.M. Overduin and P.S. Wesson. Kaluza-Klein gravity. Phys. Rep., 283, 303, 1997
15. É. Cartan. Sur une généralisation de la notion de courbure de Riemann et les espaces à torsion. C. R. Acad. Sci. (Paris) 174, 593, 1922
16. N.J. Poplawski. Nonsingular, big-bounce cosmology from spinor-torsion coupling. arXiv:1111.4595v2, 2012
17. N.J. Poplawski. Cosmology with Torsion: an Alternative to Cosmic Inflation. arXiv:1007.0587, 2010
18. T. Schucker and A. Tilquin. Torsion, an alternative to the cosmological constant? arXiv:1109.4568v2, 2013
19. A. Tilquin and T. Schucker. Torsion, an alternative to dark matter? arXiv:1104.0160v3, 2013
20. K. Land and J. Magueijo. The axis of evil. Phys. Rev. Lett. 95, 071301, 2005
21. M. J. Longo. Does the Universe Have a Handedness? arXiv:astro-ph/0703325, 2007
22. J. R. Primack, B. Sadoulet, and D. Seckel. Detection of Cosmic Dark Matter. Ann. Rev. Nucl. Part. Sci. B38, 751, 1988
23. A. Trautman. Einstein-Cartan Theory. arXiv:gr-qc/0606062v1, 2006
24. P. S. Wesson. Quantum-Mechanical Waves in Closed Vacuum States. arxiv:1012.6036, 2010
25. C. Itzykson and J-B Zuber. Quantum Field Theory. (McGraw-Hill Co.) pp. 73–74, 1985
26. G. J. Neary. The beta-Ray Spectrum of Radium E. Roy. Phys. Soc. (London), A175, 71, 1940
27. A. Einstein, B. Podolsky, and N. Rosen. Can quantum-mechanical description of physical reality be considered complete? Phys. Rev. 47, 777, 1935
28. B. Hensen, et al. Loophole-free Bell inequality violation using electron spins separated by 1.3 kilometers. Nature, 526, 682, 2015
29. J. S. Bell. On the Einstein–Podolsky–Rosen paradox. Physics 1, 195, 1964