General Principle of Interaction, a Philosophical Concept for Extended Spacetime Geometry-based Complete Unification in Physics

Truth is ever to be found in simplicity, and not in the multiplicity and confusion of things.
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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 and problematic. An alternative way is to explain all four types of physical interactions with the geometry of spacetime extended by unseen extra dimensions. The General Principle of Interaction (GPI) presents a philosophical concept that extends the Einsteinian understanding of geometrically deformed vacuum (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 extended 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, and each type of interaction is governed by the geometry of one of these subspaces. 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 and strong interactions are governed by spacetime deformations originating separately in these three subspaces (OST, EMS or NS, respectively), and the weak interaction is a type of electromagnetic interaction.

Additionally, it is hypothesized that all elementary particles can be described as quantized wave-like vacuum deformations originating in the extra dimensions (NS and/or EMS) with certain secondary effects measurable in the OST (mass, electromagnetic and strong fields). 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 should be developed as a minimal extension of the Einstein-Cartan (EC) theory accessing both curvature (via 8D metric) and torsion (via 8D torsion tensor) in the three subspaces. Unlike gravitation, the electromagnetic and strong interactions (i.e. EMS and NS deformations) cannot be described by a classical field theory, as the extra coordinates (NS or EMS) are immeasurable within the OST subspace. Hence, the future theory should accept quantum field methodology (at least to a certain extent), however rejecting the gauge transformation principle and relying solely on the spacetime geometry, which ensures background-independence and avoiding any virtual particles or gauge bosons. This concept promotes the vacuum (spacetime) geometry-based full unification and drastically simplifies 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 observational data including all the experiments. However, SM has a number of unexplained free parameters, does not unify the strong interaction with the electro-weak theory, and is incompatible with the theory of general relativity (GR). 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 strategy, a philosophically consistent concept explaining all types of forces solely via the geometry of the spacetime extended with a number of unseen 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 [2]. Unfortunately, no presently known unifying QFT, including all superstring theories, can escape serious problems [3, 4]. Superstring theories have almost no predictive power and are not unique, i.e. the number of possible mathematical descriptions of the physical reality is tremendously great, and it is not clear how to choose the one theory that particularly describes our Universe. This long lasting theoretical crisis raises serious doubts about the ability of quantum physics to provide a philosophically consistent basis for the full unification. The roots of this crisis are much deeper than just methodological and mathematical difficulties with the development of a unified quantum theory. It is an overwhelming fact that the two main pillars of modern physics, GR and SM stand on two completely different basic philosophical concepts. Simply put, the basic definitions of matter, vacuum and interaction used in the main theories of particle interactions (SM) and gravitation (GR) are completely different. In QFTs, an interaction is understood with the gauge transformation principle, i.e. quantum objects exchange a field carrier quantum, a 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 interacting matter (particles, quarks, strings, etc.) possesses all the properties required for the interaction. Quantum vacuum is not an interacting object *per se*, although it allows for "spontaneous births" of pairs of virtual particles that can interact. On the contrary, GR is based on the concept of curved spacetime that requires no gauge bosons and involves the Einsteinian understanding of vacuum and matter. Gravitational interactions are mediated directly and solely by the very own property of vacuum, spacetime curvature. Thus, the vacuum in GR is the primary interacting object, and 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, and no unification theory could allow for both of these principles simultaneously.

Thus, only the two completely 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 (QFT-based unification), or

2) Let all the four types of interaction to be understood as vacuum deformations (spacetime geometry-based unification).

The second approach does not involve virtual particles or gauge bosons and relies solely on the Einsteinian understanding of vacuum and matter that is more advanced philosophically than the Newtonian definition used in QFTs. 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 have ignored the second approach completely for many decades.

Relying on the Newtonian understanding of non-interacting vacuum and interacting matter fields, QFTs provoke a number of fundamental questions. One of them is the renormalization problem, which appears when calculations of certain finite physical values result in infinities removed 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" [5]. 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 these “virtual interactions” are accounted for, they add infinities to the calculated values requiring renormalization in order to get finite results. If one could describe particle interactions without any virtual particles, none of the secondary interactions would be needed, thereby removing the renormalization issue as a matter of course. Notably, a rejection of virtual particles does not contradict any observation because virtual particles cannot be directly detected by definition. However, this rejection is principally impossible within a QFT, as all QFTs are based on the gauge transformation principle, which explains any interaction as virtual particle exchange. In addition, the QFT-based approach will always bring a number of old continuously debated philosophical problems of quantum physics such as observational indeterminism, wave-function collapse, and wave-particle duality.

Thus, the QFT-based approach to full unification has a fundamental inability to acquire the Einsteinian understanding of matter and vacuum. This philosophical problem cannot be solved without a complete rejection of the gauge transformation principle and avoidance of virtual particles.

1.2. Problems of the GR-based unification

An alternative to a QFT-based unification strategy would be the spacetime 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 GR-based unification extensively; unfortunately, this noble mission was never accomplished. Notably, some of his later approaches include the extra dimension [6].

In an attempt to unify gravity and electromagnetism within a classical field theory, Einstein and co-authors [7, 8] used the concept of 5D spacetime suggested by Theodor Kaluza [9]. Einstein and co-authors have described a charged particle as a wave propagating in the fifth dimension and curving 4D spacetime [6, 8]. 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 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 [10, 11] had proposed that the fifth dimension is compactified. Since then, all the theories extending GR by introducing a 5D spacetime (even with a non-compact fifth dimension) are called Kaluza-Klein (KK) models. Both then and now, physicists have understood electromagnetism as a field coexisting with gravitation in 4D spacetime, but not as geometrical deformations of the extra dimension. The former assumption inevitably leads to a QFT-based description of electromagnetism. Thus, all 5D GR extensions using the KK approach made before [10, 11] and after [12, 13] Einstein's 5D models [7, 8] always consider electromagnetism as a gauge field and hence unable to support spacetime geometry-based unification.

The present ignorance of the possibility that electromagnetism and strong fields can be originated by the spacetime deformations in the unseen 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 spacetime geometry was never proposed, i.e. it was never explained consistently how spacetime geometry can define an interaction other than gravitation. To resolve this issue, the General Principle of Interaction and a 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 is very much different, i.e. both strong and electromagnetic interactions are governed by charges that either attract or repel while gravitation is only attractive, and no gravitational charge is known. This problem is further discussed in §3.4 below. Secondly, it is unlikely that GR is the most complete theory of gravitation, and hence another base theory for the spacetime geometry-based unification is needed. Although GR is currently the standard theory of gravitation, it too has a number of fundamental problems. GR cannot explain inflation of the early Universe and the dark energy problem; it miscalculates rotational curves of galaxies and clusters leading to the dark matter problem. GR cannot avoid singularities in describing black holes and the Big Bang. 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). GR is a classical field theory and does not involve any quantization, which is necessary for describing particle interactions. It is clear that GR cannot be used as a unification platform until these questions are resolved.

In some sense, GR was incomplete right from the moment it was created. For the sake of simplicity, Einstein had disregarded *ad hoc* 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 GR) and torsion tensor (disregarded in GR). In 1922, Élie Cartan proposed such a theory including non-zero affine torsion and known as the Einstein-Cartan (EC) theory [14]. 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 GR, except quantization and the dark matter problem. According to 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, Poplawski showed that EC removes central singularities in black hole models with spinning matter [15] and that gravitational torsion can induce an extremely high repulsion force, thereby explaining inflation in the early Universe [16]. Thus, gravitational torsion induced by spinning matter removes singularities and explains inflation. 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 observed in the Universe so far is insufficient to induce the forces estimated in the both cases [17, 18]. There is an additional possibility that vacuum itself has a certain small, but non-zero deformation not induced by any matter. This cannot be a curvature, as the Universe remains constantly flat in the observable region; however, this can be a torsional deformation, e.g. in case the whole Universe spins. This primordial spin creates an additional vacuum torsion, which can be added to the torsion induced by spinning matter in order to explain the dark energy. 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") [19], as well as the unexpected alignment and preferred handedness of galaxy spins observed astronomically [20] are actually the signs of a rotational axis of the Universe? If so, the torsion induced by this rotation and existing at each point of spacetime independently of matter may actually explain the mysterious dark energy. However, this vacuum torsion is way too weak to have a sufficient effect on the scale of galaxies, and hence cannot explain the dark matter. Therefore, hypothetical Weakly Interacting Massive Particles (WIMPs) remain the leading candidates for the bulk of dark matter [21] and should be explained by the theory. Unfortunately, both GR and EC have no clear predictions about any purely gravitational particle. The prediction of WIMPs by a GPI-based theory is discussed below (see §3.4).

Finally, there is one more fundamental question related to both GR and 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 without any conversion of the base theory (EC or GR) into a QFT. It is expected that in the future vacuum geometry-based unified theory, the equations of motion will have certain wave-like solutions describing the elementary spacetime deformations (elementary particles) as curvature/torsion waves with integer wavelengths, i.e. quantized naturally. The hypothesis of elementary deformations of the extended spacetime is further discussed in §3 below.

Thus, the GR-based unification too has a number of serious problems. Some of them can be possibly avoided with a switch to EC; however, the main question of how spacetime geometry can define any interaction other than gravitation still needs an explanation. Below, we propose a concept that allows for consistent explanations of all types of interaction as geometrical deformations of spacetime with unseen extra dimensions. We hope that a complete unification theory will be developed by setting EC as a base theory (i.e. 4D theory of gravitation) and describing spacetime with a certain number of undetectable extra dimensions, deformations of which define electromagnetism and strong forces.

2. The General Principle of Interaction

Assuming direct involvement of spacetime in all types of interaction, one can formulate the General Principle of Interaction: <u>any physical interaction is governed by certain alterations of spacetime geometry</u>. Assuming that all deformations of the ordinary Einsteinian spacetime are always of gravitational nature, the GPI assumes that the spacetime to contain some unseen extra spatial dimensions somehow separated (at least partially) from the ordinary spacetime (OST). Then, electromagnetism and strong forces can be understood as certain geometrical deformations that originally occur in the extra spatial dimensions. The three types of interaction (gravitational, electromagnetic, 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, and NS is highly curved and compactified. These differences ensure certain hierarchy as only more curved subspace can influence a less curved one, so NS deformations induce secondary deformations (projections) both in the EMS and OST, and EMS deformations induce projections in the OST only. This assumption explains why quarks have electric charges and masses in addition to their “color” charges, and why leptons have masses in addition to their electric charges. Thus, masses of all known particles are induced by their “color” charges and/or electric charges.

With the GPI, all elementary particles can be potentially explained as elementary spacetime deformations. There are three types of truly elementary deformations: 1) positively curved half wave, 2) negatively curved half wave, and 3) full wave, which is a combination of the first two types. The NS half waves (quark triplets) and the OST half waves (hypothetical WIMPs) are three-dimensional (if disregard the time coordinate) and always attractive, and the EMS half waves (leptons) are one-dimensional (if disregard the time coordinate) and both attractive and repelling (Fig. 1). The hypothesis of elementary spacetime 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, all known elementary particles are 4D projections of certain NS and/or EMS elementary deformations. The separation of the three subspaces ensures the separation of the three types of forces. However, at a very high energy, all spacetime dimensions are likely to 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 consistent philosophical basis for the vacuum (spacetime) geometry-based unification of all forces.

According to the GPI, any potential energy is a measure of the spacetime deformation, and it increases with any curvature or torsion. This extends the Einsteinian understanding of the gravitational energy given by the GR field equations (stress-energy tensor is proportional to the spacetime curvature) for electromagnetic and strong forces, assuming that their potential energies are also determined by the curvature (and also torsion) of the spacetime extended with the EMS and NS subspaces. Thus, all interactions can be 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).

Thus, the GPI has a great potential to explain consistently all types of physical fields as certain deformations of the extended spacetime. Moreover, in case all types of these deformations are described as waves with integer wavelengths, interactions are always quantized. The number of fundamental fields consequently reduces to just three, i.e. gravitational, electromagnetic and strong fields defined as geometrical deformations of the three distinct subspaces of the 8D spacetime (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 deformations

3.1. The EMS elementary wave-like deformations

3.1.1. Leptons and photons as wave-like deformations. According to the GPI, elementary electric charges primarily induce elementary deformations in the EMS subspace of the extended spacetime. This requires the existence of at least one extra spatial dimension (EMS) in addition to three ordinary spatial dimensions (OST). It seems reasonable to describe EMS as a 1D circle extension at each point of the 4D OST exactly as suggested by Kaluza in 1921 [9]. Then, electric charge-induced deformations of the EMS should represent the “original” electromagnetic field. The electromagnetic field has two interrelated, but distinct components - the electrostatic field and the magnetic field. In order to be distinguishable, these two fields 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 one dimension (not counting the embedding extra dimension). An elementary electric charge deforms EMS vacuum inducing an oscillating standing wave with the curvature and the torsional components: a curve (positive or negative) identified with its electrostatic field and a twist (left or right) identified with its magnetic field. Thus, only three parameters can describe the EMS 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.

There are three types of elementary EMS deformations induced by elementary electric charges: 1) half wave with a negative curve (electron), 2) half wave with a positive curve (positron), and 3) full wave (photon), a combination of the two half waves with the opposite curves and twists (Fig. 2). In a sense, a photon can be seen as an unbreakable 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 gravitational 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 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). The latter effect is seen experimentally either as an excited electron (positron) states (in the case of low-energy photons) or as more massive (in terms of mass-energy) leptons, e.g. muon or tau lepton (in the case of high-energy photons). These states are more energetic and hence less stable. As the OST and the EMS are separated, the “real” speed of light (in the EMS) is immeasurable in principle and not necessarily limited to the OST speed of light.

In addition to the curvature-mediated interaction, leptons’ interactions can be driven by the 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.)

3.1.2. EC extension for the 5D spacetime. In order to describe electromagnetism and gravitation as two separate forces, the spacetime should include two separate closed subspaces: an almost flat 3D OST and more curved 1D EMS presumably embedded in a flat embedding dimension together with one time coordinate. Although this spacetime description has obvious similarities with known KK models [10-13], there are some notable differences. First, we assume that physics does depend on the extra coordinate, and any electromagnetic interaction occurs primarily in the fifth dimension (let’s call this the anti-cylinder condition). This ensures that the electromagnetism has a different action power (because of the high EMS background curvature) and is distinguishable from the gravitation. Secondly, 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. Notably, although both Klein [10, 11] and Einstein [7, 8] did consider the fifth dimension as an origin of electric charges, the electromagnetic field was never understood as deformations of the fifths dimension. Despite the core difference in their basic understanding of interaction (Einstein's KK models were built as classical background-independent theories and Klein's model relied on a gauge field description), both these approaches have understood electromagnetism only as a 4D field, i.e. not being physically present in the fifth dimension (the cylinder condition). On the contrary, the GPI-based approach assumes that the electromagnetic field is originated in the fifth dimension (the anti-cylinder condition), and its OST (mass-related) manifestations are only secondary. Even though, the EMS half waves still can be approximated as point particles with masses and certain electromagnetic field parameters in case the fifth coordinate is disregarded. Unfortunately, neither Einstein nor other theorists worked with KK models never explore this assumption.

In order to describe the electromagnetic field as geometrical deformations of the fifth dimension, one can construct a minimal extension of EC with a 5D metric and a 5D torsion tensor. The metric will describe the electrostatic field as EMS curvatures and "main" gravitational field as OST curvatures, while the torsion tensor will describe magnetic field as EMS torsion and "additional" gravitational field as OST torsion. The actual formulations of these 5D tensors are yet unknown. Obviously, none of the known 5D metric definitions described in the KK models [12, 13] can fit for a number of reasons: 1) they disregard torsion, 2) EMS curvature cannot be described by a scalar, and 3) time coordinate should be included in the both EMS and OST-describing parts of the tensors.

In addition, the EMS vacuum itself should be described with a certain nonzero background curvature and torsion unrelated to the charged particles. The difference between the OST and the EMS background curvatures can ensure the present physical separation of the OST and the EMS together with the fact that the electrostatic field is stronger than gravitation. The right 5D metric should allow describing "shadow" OST deformations induced by the primary EMS deformations (the particles' masses induced by the charges). This effect is similar to the "induced matter" phenomenon of the noncompactified KK models [13]. The right 5D torsion tensor should describe electric charge-induced EMS torsion, i.e. the magnetic field. This EMS torsion also induces a "shadow" OST deformation, an "additional" gravitational mass also induced by the charge. The torsion-induced mass should be negligibly small compared to the curvature-induced mass.

3.1.3. Quantization of the electromagnetic field. Quantization of the electromagnetic field comes naturally if elementary electric charges, electron or positron, are described as wave-like EMS deformations. In the noncompactified KK models, an equation of electron motion derived from the 5D metric is mathematically equivalent to the Klein-Gordon equation allowing wave-like solutions [13]. Thus, it seems possible that the field equations derived from the 5D metric/torsion tensors developed for the future GPI-based theory will be also a form of the Klein-Gordon equation that describes electron (or positron) as a quantized wave-like EMS deformation inducing secondary deformation in the OST (see §3.1.2). 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 [22]. However, in a GPI-based theory, this does not apply due to the replacement of the spin with the twist (EMS torsion parameter).

3.1.4. Connecting spacetime geometry with quantum physics. At a first glance, it seems that the GPI-based approach completely rejects quantum physics and calls for a purely classical unified theory. Surprisingly, it is the opposite. Although classical field approach works well with gravitation, it cannot describe the EMS deformations because the EMS coordinate is immeasurable in principle. Only the secondary effects of the EMS deformations (4D electromagnetic field parameters and particles' masses) are detectable. If so, how can we describe these undetectable EMS waves? Surprisingly, the mathematical methods of quantum electrodynamics could be the answer. It seems very likely that the complex-valued wavefunction (or complex-valued operator-based mathematics in general) to be the method that describes the EMS deformations depending on an extra coordinate, which is always hidden. The "undetectability" of the fifth dimension explains the uncertain nature of particles' behavior and wave-particle duality.

As shown above, interacting elementary charges should be originally defined as EMS waves; however, they can be also approximated as point particles with masses in the OST if the fifth coordinate is disregarded. As the particles' behavior is primarily defined by the immeasurable extra (EMS) coordinates, the GPI-based theory of electromagnetism has to adopt the methods of quantum, not classical physics and the complex-valued mathematics. Then, the uncertainty and probabilistic nature of the particles should be predetermined by the "undetectability" of the fifth dimension. Moreover, the assumption that the electromagnetic interaction actually occurs in the fifth dimension (the anti-cylinder condition) allows preserving both local relativistic causality and observational determinism of the interaction. Any "spooky action at a distance" questioned by the famous EPR paradox [23] remains local in case it actually occurs in the extra dimension. Accepting the quantum electrodynamics' methodology, the GPI-based description of electromagnetism can build a bridge between the spacetime geometry and quantum physics. Being based on the extended spacetime geometry, it will naturally avoid the renormalization problem (see §1.1). In addition, the GPI-based approach brings a simple definition of the leptons' gravitational masses, which appear naturally as a secondary effect ("shadow" OST deformations) and should be fully described by the geometry (see §3.1.2). This definition removes the need for *ad hoc* explanation of particles' masses, such as Higg's mechanism. However, these advancements come with a price - a complete rejection of the gauge transformation principle and virtual particles.

The future 5D spacetime geometry-based electrodynamics is expected to describe photons and leptons with an equation of motion derived in the 5D spacetime, most likely a form of the Klein-Gordon equation (see §3.1.3), which should be able to replace both Schrödinger and Dirac equations of quantum electrodynamics. It is encouraging that both quantization and wave dynamics already have been shown in both compactified [10-12] and noncompactified KK models [13, 24]. Although the future GPI-based theory will require a certain metric (not yet found) additionally combined with a torsion tensor (see §3.1.2), the basic similarity is likely to remain.

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 spacetime needed for the unification of gravitation, electromagnetism, and strong forces should include OST, EMS and NS subspaces and a time dimension embedded together in a flat 9th (embedding) dimension. The three subspaces are presumably separated by the differences in their background vacuum 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).

Similar to the elementary EMS deformations (Fig. 2), the elementary NS deformations induced by “color” or “anticolor” charges should include three main types: 1) 3D half wave with a positive curve (**uuu** quark triplet), 2) 3D half wave with a negative curve (**ūūū** antiquark triplet), and 3) 3D full wave with zero average curvature and torsion, a combination of the two half waves (gluon or **uuuūūū** quark sextet). The simplest geometrical description of the half wave NS deformations would be compactified 3D spheres curved (either negatively or positively) in the embedding dimension with a constant radius, a 3D analog of the 1D EMS half waves. Thus, the NS half wave (baryon) is an 8D object with three compactified extra dimensions (NS) and one non-compactified extra dimension (EMS). It is unlikely that baryons induce EMS compactification as baryons’ electromagnetic fields interact at long distances. The 3D NS deformation can be formed only with 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, this compactified 3D sphere is an ultimately stable NS deformation. Therefore, 1D NS half waves (single quarks) cannot exist (confinement), unless the NS dimensions somehow get separated into subspaces. The NS full wave (gluon) is a combination of the two 3D spheres, one of which having a positive curve (and a twist), and another having a negative curve (and a twist) in the embedding dimension. The NS full wave has a projection in the EMS (“shadow” photon) and likely is indistinguishable from a photon while interacting electromagnetically.

As it was explained above (see §3.1.1) 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 combining positive (or negative) EMS half waves tend to increase local EMS curvature; however, the background EMS curvature prevents that and drives them apart. The two similar NS half waves, however, do not have any background NS curvature (as the NS is compactified to the size of the wave, the NS half wave's curve is the NS background curvature). Thus, two or more NS spheres can combine within the compactification distance and form a smaller NS sphere consequently increasing the NS curvature. The NS sphere always induces a “shadow” 1D deformation in the EMS (the EMS projection) and a “shadow” 3D spherical deformation in the OST (the OST projection). The former defines baryonic electric charge, and the latter defines baryonic gravitational mass.

In addition to the NS-originated interactions, the NS half waves interact in the EMS via the “shadow” deformations. Thus, **uuu** quark triplets do not exist in the "free state" due to the EMS “shadows” (excessive electrostatic charge) and bind electrons. Those interactions are obviously electromagnetic. An example is the **uud** triplet (proton) formation (electrostatic charge +e) when a **uuu** triplet (electrostatic charge +2e) closely interacts with an electron (electrostatic charge -e). Similarly, the **ūūđ** triplet (antiproton) is formed when a **ūūū** triplet binds a positron. It seems that the neutron and antineutron (**udd** and **ūđđ**, respectively) must be the most stable baryons due to the neutral electric charge. However, they are less stable than the proton and antiproton. 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. 3). An additional energy required for this transformation reflects the difference in mass-energy and stability between the neutron (**udd**) and the proton (**uud**). This additional energy can be added to the proton by photon absorption and makes the neutron less stable than the proton. Thus, the proton is the most stable baryon (as it cannot decay spontaneously with the emission of an electron) due to the stable full wave formation in the EMS out of the proton's "shadow" half wave and the electron's half wave.

All the baryons represented by the triplets containing heavy **c**, **s**, **t** and **b** quarks can be explained as excited (and hence more massive in terms of mass-energy) states of the **uud** (proton) triplet or **udd** (neutron) triplet, when an energetic NS full wave (gluon) co-localizes with the NS half wave (quark triplet).

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 certainly 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**) bound to a positron (e^+), i.e. **uudūūū** sextet, and π^0 pion is a gluon (**uuuūūū**) bound to a photon (e^+e^-), i.e. **uudđūū** sextet (which experimentally is seen as a pair of photons, one “shadow” and one original, because the NS core, a free gluon is indistinguishable from a photon). Charged mesons are obviously not stable; in the EMS, those are just excited forms 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 with a minimal EC extension in the 8D spacetime embedded in a flat 9D space. This will require an 8D metric tensor and an 8D torsion tensor. As with the 5D tensors describing electric charge-induced EMS deformations (see §3.1.2) the main (extradimensional) components of the 8D metric and torsion tensors should be identified with the “color”-induced NS deformations. Other components of the 8D tensors will describe secondary effects of “color” charges (“shadow” EMS and OST deformations). As a result, the extended theory will describe strongly interacting NS full waves (gluons) and NS half waves (baryons) and their projections: secondary EMS deformations (induced electric charges and induced magnetic moments) and secondary OST deformations (induced gravitational masses). Quantization will be achieved in a similar way as for the GPI-based electrodynamics (see §3.1.3) by describing the “color” charge-induced NS deformations as waves with integer wavelengths. Like with EMS waves, classical field description for these NS waves may not be possible due to the “undetectability” of the NS dimensions. Hence, the new theory will have to accept (at least partially) the quantum field methodology to describe both NS and EMS deformations, but again rejecting the gauge transformation principle and virtual particles. In overall, the GPI together with the concept of extended 8D spacetime sets a philosophically consistent framework for the future spacetime geometry-based theory of strong, electromagnetic and gravitational interactions.

3.3. The weak interaction

Historically, the weak nuclear force was introduced as a special type of nuclear interactions that explains 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 electric charges (see §3.2). A simple explanation of the neutron instability is suggested 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 does not 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 W and Z bosons and neutrinos cannot be detected directly. In bubble chambers and all other types of detectors, bosons and neutrinos make no visible track, and, therefore, cannot be distinguished from photons (or gluons). Thus, the neutrino telescopes actually detect photons, which are presumably produced by the neutrinos. However, the counted rare events interpreted as neutrino detection can be alternatively explained by the high-energy cosmic gamma radiation. The neutrino was originally suggested by Wolfgang Pauli to explain the continuous energy spectrum of beta-rays in beta decay. However, this spectrum [25] can be explained by the Bremsstrahlung when the electrons are deflected by the neighbor atomic nuclei and show a continuous energy spectrum. The Bremsstrahlung radiation was completely ignored in the early experiments as the detectors were typically shielded from gamma-rays [25]. 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 GR were discussed above (see §1.2). Some of those questions including the dark energy problem can be potentially solved by analyzing the “additional”, i.e. torsion-induced gravitation and switching to EC. Even though, the two fundamental questions still remain out of reach. First, both GR and EC cannot explain why no any gravitational charge can be seen while strong and electric charges do exist, and why gravitational interactions are always attractive. Secondly, both these theories have no predictions regarding dark matter. Let’s examine these questions from the GPI-based point of view. For the sake of symmetry, it is logical to assume that the three types of purely gravitational deformations exist in the nature: $\mathbf{G_p}$, positively curved OST half wave, $\mathbf{G_n}$, negatively curved OST half wave, and $\mathbf{G_0}$, OST full wave (Fig.1). 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 interacts via a strong or electromagnetic charge), and must be stable or at least metastable [21]. Indeed, purely gravitational OST 3D half waves induced by the positive gravitational charges ($\mathbf{G_p}$) might be ideal candidates for the dark matter particles. They resemble baryonic "shadow" OST deformations, but unlike $\mathbf{G_n}$ they cannot cancel baryons' OST "shadows" (by forming a full wave) and thus decrease the gravitational effect of baryonic masses. As gravitational half waves have no "shadow" deformations (i.e. no projections in the NS and EMS) they do not interact strongly or electromagnetically. 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 also might be an excess of positive gravitational charges, $\mathbf{G_p}$ WIMPs. They interact only gravitationally (i.e. very weakly) with the ordinary matter-induced OST deformations and form spherical haloes around the galaxies. Advances in the astronomical methods will soon allow for a direct detection of the dark matter, and the gravitationally charged WIMPs could be discovered in the near future.

Although the hypothesis of $\mathbf{G_p}$ WIMPs excess provides a viable explanation of dark matter, some important questions still remain unclear. 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? The **uuu** baryons induce positively curved 3D half waves in the NS and OST exhibiting attractive behavior in the both subspaces. Therefore, it is likely that the gravitational OST half waves ($\mathbf{G_p}$ or $\mathbf{G_n}$) are also fully attractive. The geometrical reason for this attractive behavior can possibly be given by the fact that the OST is flat (or almost flat) and its background curvature is negligibly low (unlike the EMS one) and does not force the two half waves with the same curve to repel.

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 drives one to an assumption that the Universe has started from a fully compactified symmetrical 8D spacetime "ball" with a very small but finite size. As the actual size of this primordial object was very small, its initial (assumingly positive) curvature and hence energy was tremendously big. This energy excess was very likely the driving force for the followed expansion. For some unknown reason the expansion did not occur symmetrically (i.e. in an equal manner) 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 expanded to macroscopic sizes while the NS expansion was limited, and it stays compactified. The EMS is likely to retain some background curvature, but the OST expanded to a flat (or an almost flat) state and continue to expand presently according to the astronomical observations. It is logical to assume that the EMS continues to expand as well. For an unknown reason, the NS cannot expand more than the size of a baryon. As the OST and EMS continuously expand but cannot decompactify the NS, they tear the NS in multiple compact pieces creating an excess of the positively curved NS half waves (**uuu** baryons). In addition, the Universe appears to have an excess of the negatively curved EMS half waves (electrons) and (hypothetically) the positively curved OST half waves ($\mathbf{G_p}$ WIMPs).

The origin of the electron/WIMP excess is not obvious. As a possible scenario, the primordial 8D spacetime object with positive curvature (proto-universe) had bumped into another primordial object with negative curvature. The second primordial object was probably bigger and less curved, and the result of this interaction was not symmetrical for the first object's geometry. In the NS, the **uuu** baryons were partially converted into full waves, gluons. The baryons' size had grown up to the nuclear scale, and they dropped some curvature accordingly but remained compactified. In the EMS, the impact was bigger, and its size had grown to a macroscopic scale while the curvature decreased, and lots of full waves, photons had appeared. During the EMS expansion, the baryons' geometrical projections ("shadow" EMS deformations) anchored the negative curvature of the second primordial object creating negatively curved EMS half waves, which interacted with the baryons forming protons, neutrons, and hydrogen atoms. In the OST, the initial curvature was altered greatly, and it had grown to the cosmic size becoming nearly flat. During the OST expansion, baryons' geometrical projections ("shadow" OST deformations) had anchored the negative curvature of the second primordial object creating negatively curved OST half waves, $\mathbf{G_n}$ WIMPs; the electrons similarly created $\mathbf{G_p}$ WIMPs. These $\mathbf{G_n}$ and $\mathbf{G_p}$ WIMPs should become $\mathbf{G_0}$ WIMPs, however, for an unknown reason, the Universe seems to have an excess of the $\mathbf{G_p}$ WIMPs (see §3.4) forming the dark matter halos around the galaxies. The details of the Big Unroll scenario are not yet clear. It raises a number of cosmological questions that hopefully will be addressed in the future.

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 philosophical grounds, some quarks and leptons are not truly elementary as they decay into other elementary particles or transform into each other. In addition, 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 a time dimension (Table 1) and understands all the elementary particles as elementary wave-like spacetime deformations originated in the different subspaces. This approach reduces the number of fundamental interactions and fields down to the three types (Table 2). The list of elementary interacting objects is reduced to six half waves and three full waves (Fig. 1 and Table 3). 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 (elementary torsional deformation). The NS half waves (baryons) always induce secondary ("shadow") half wave deformations (projections) in the EMS and OST. The EMS half waves (leptons) induce only OST secondary deformations (projections). Thus, the baryons' electric charges and the masses of hadrons and leptons are "induced", i.e. the secondary effects of their NS and/or EMS deformations.

All gauge bosons and virtual particles are avoided as all interactions are driven only by the geometry of the 8D spacetime. Thus, H, W, and Z bosons (experimentally indistinguishable from photons) are not needed. Photons and gluons are not gauge bosons, but wave-like deformations (full waves) originated in the EMS and the NS, respectively. Neutrinos are prohibited as uncharged particles, except photons, cannot interact with charged particles. As particles' masses come naturally as the secondary effects of the NS and/or EMS deformations, no Higg's mechanism is needed. Spontaneous births of particle-antiparticle pairs are prohibited because full waves (photons or gluons) are more stable than two opposite half waves (leptons or baryons).

All particles except the elementary baryons (**uuu** and **ūūū**), the elementary leptons (positron and electron), and the hypothetical gravitational WIMPs (**G_n** and **G_p**) are either composite or excited states of these elementary half waves. The full waves are stable combinations of two half waves with opposite curves and twists. The proton (**uud**) and the neutron (**udd**) resemble the bound states of the elementary baryon (**uuu**) with one or two electrons (Fig. 3). 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 explained by an increased energy (frequency) of the NS full waves (gluons) associated with the NS half waves (baryons). 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 similarly represent the excited states of electron combined with a high-energy photon (EMS half wave and EMS full wave). If there is no limit to the maximum energy of the associated photon, it is possible that more than three generations of leptons exist. Similarly, the number of quark generations can be greater as well, and future 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 OST half waves and full waves that have no projections in the NS or EMS, i.e. purely gravitational WIMPs. No such WIMPs have been detected yet; however, if exist, they would perfectly fit within the future GPI-based theory. If our Universe has an excess of certain NS and EMS half waves (baryons and electrons), it is possible that there is also an excess of certain OST half waves, e.g. **G_p** WIMPs (see §3.4) that can explain dark matter.

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

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

Table 2: Fundamental interactions

Interaction	**Field origin**	**Primary elementary deformations**
Gravitational	OST deformations	Unknown* (2 types, hypothetical)
Electromagnetic and weak	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 origin**	**Secondary effect(s)**
Baryon (**uuu**), Antibaryon (**ūūū**)	NS half waves	nonzero	nonzero	“color” charge	electric charge, mass
Gluon (**uuuūūū**)	NS full wave	zero	zero	“color” charges	none
Electron (e^-), Positron (e^+)	EMS half waves	nonzero	nonzero	electric charge	mass
Photon (e^+e^-)	EMS full wave	zero	zero	electric charges	none
$\mathbf{G_n}$ WIMP, hypothetical $\mathbf{G_p}$ WIMP, hypothetical	OST half waves	nonzero	nonzero	unknown	none
$\mathbf{G_0}$ WIMP, hypothetical	OST full wave	zero	zero	unknown	none

***** - Curvature deformation averaged in time
****** - Torsional deformation averaged in time

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 vast majority of present theorists continue to ignore the second possible approach, the spacetime geometry-based unification. Following this second path remains challenging as even Einstein himself was unable to unify gravitation and electromagnetism with the “pure geometry” of spacetime. The concept of spacetime limited by its four-dimensionality seems unable to explain particle interactions. Unfortunately, it was never assumed that the electromagnetic and strong interactions can be actually originated in the unseen extra dimensions. As shown above (see §2), the General Principle of Interaction (GPI) simply overcomes this major difficulty by extending the Einsteinian understanding of geometrically deformed vacuum (spacetime) and making it applicable to all four types of interaction. The extended 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 particle interactions primarily occur in the undetectable extra dimensions (the anti-cylinder condition) for the first time allows for a consistent concept of particle interactions that resolves (or at least have a clear capability to do so) the two major problems of the spacetime geometry-based unification: 1) define clearly what kinds of spacetime deformations are responsible for each type of particle interactions without confusing the latter with OST deformations (which always are of gravitational nature), 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, some scientists, including Einstein, rendered it incomplete for its incompatibility with the two philosophical principles of scientific observation, determinism and causality [23]. During that time, many have expected that a complete theory of particle interactions eventually reveal some hidden parameters missing in the QFTs. However, recent experiments [26] have proven in general the Bell’s theorem [27], which states that although quantum mechanics violates both locality and realism, it is nevertheless the best possible theory describing particle interactions. Notably, the Bell’s theorem had been formulated for the four-dimensional reality, but what if nature is a bit more complicated, and unseen extra dimensions do exist? Then, the question of the general incompleteness of the quantum field description of particle interactions will rise again, and the extra coordinates could indeed present the additional “hidden” parameters.

At the first glance, the introduction of unseen extra dimensions seems irrational and unnatural. However, it may, in fact, build a bridge between spacetime geometry and quantum physics. The “undetectability” of the extra coordinates explains the uncertain and dualistic nature of particle interactions and forces one to describe the interactions with the technical methods of quantum, but not classical field theories. For instance, one cannot describe an electron with a classic field approach due to the "hidden" nature of the EMS, which defines the electromagnetic field. For the EMS parameters, the best way would be to use the complex-valued operator-based descriptions. Then, one would naturally arrive at the quantum field description, but without the gauge transformation principle and all related problems. Moreover, the concept of extra dimensions resolves the famous argument between Einstein and Bohr. If the extra dimensions exist, the both sides are right! According to the Copenhagen interpretation, particles cannot have definite properties, and this is true because the extra coordinates defining particles’ interactions cannot be observed in our four-dimensional reality. Yet, according to the Einsteinian view, nature remains completely deterministic at all levels, however, our deterministic abilities may be strictly limited by our four-dimensionality.

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. The GPI unifies matter and vacuum (spacetime) at a very basic level. Philosophically speaking, the "true" vacuum, i.e. the spacetime in the absence of any curvature or torsional deformations, is the only one primary entity, a very basic "element" of the Universe, and all types of matter can be understood as its geometrical deformations. All known matter particles, as well as the hypothetical dark matter particles, can be seen as various combinations of just six types of the elementary wave-like spacetime deformations (Fig. 1).

The GPI-based approach allows for a background-independent unified field theory describing all known types of interaction as wave-like deformations of the extended 8D spacetime. This future theory likely to be developed as an extension of EC with the 5D metric and torsion tensors (describing electromagnetism and weak forces) and the 8D metric and torsion tensors (describing strong nuclear forces). In order to operate with immeasurable extra coordinates, the theory will have to accept the QFT methodology (at least to a certain extent), however, rejecting the gauge principle of interaction and avoiding any virtual particles. This approach promises a number of advantages over the SM and any other QFT-based unification strategy (see §§3.1-3.4): 1) fully deterministic understanding of particle interactions and acceptance of the quantum field methodology and quantization with the description of all elementary particles as wave-like deformations; 2) background-independence and full compatibility with GR or EC; 3) understanding of the gravitational masses of hadrons and leptons as "induced" with consequent avoidance of the Higg's mechanism; 4) complete rejection of the gauge transformation principle with consequent avoidance of the renormalization problem; 5) reduction of the elementary particle set (Fig. 1); 6) simple explanation of the confinement; 7) prediction of the OST half waves identified with the dark matter WIMPs. In addition, the future theory should be in accord with the explanation of dark energy as "vacuum energy", the gravitational torsion created by self-rotation of the Universe (see §1.2).

Overall, the GPI and the concept of extended 8D spacetime provide together a philosophically consistent basis for the spacetime geometry-based full unification. The future GPI-based theory will naturally combine the Einsteinian understanding of interaction driven by the spacetime deformations with natural quantization and quantum field methodology by describing all elementary particles as wave-like deformations originated in the unseen extra dimensions. Adopting, in general, the quantum field methodology, the future unified theory will not, however, rely on the gauge transformation principle avoiding virtual bosons and prohibiting spontaneous births of particle-antiparticle pairs. Mathematical development of this theory remains an open question; possible modifications of the Kaluza-Klein approach for the GPI-based electrodynamics are discussed above in §3.1.2. It is possible nevertheless to make a number of falsifiable predictions discussed above (see §§3.1-3.6). Future physical experiments and astronomical observations would possibly validate these predictions.

5. References

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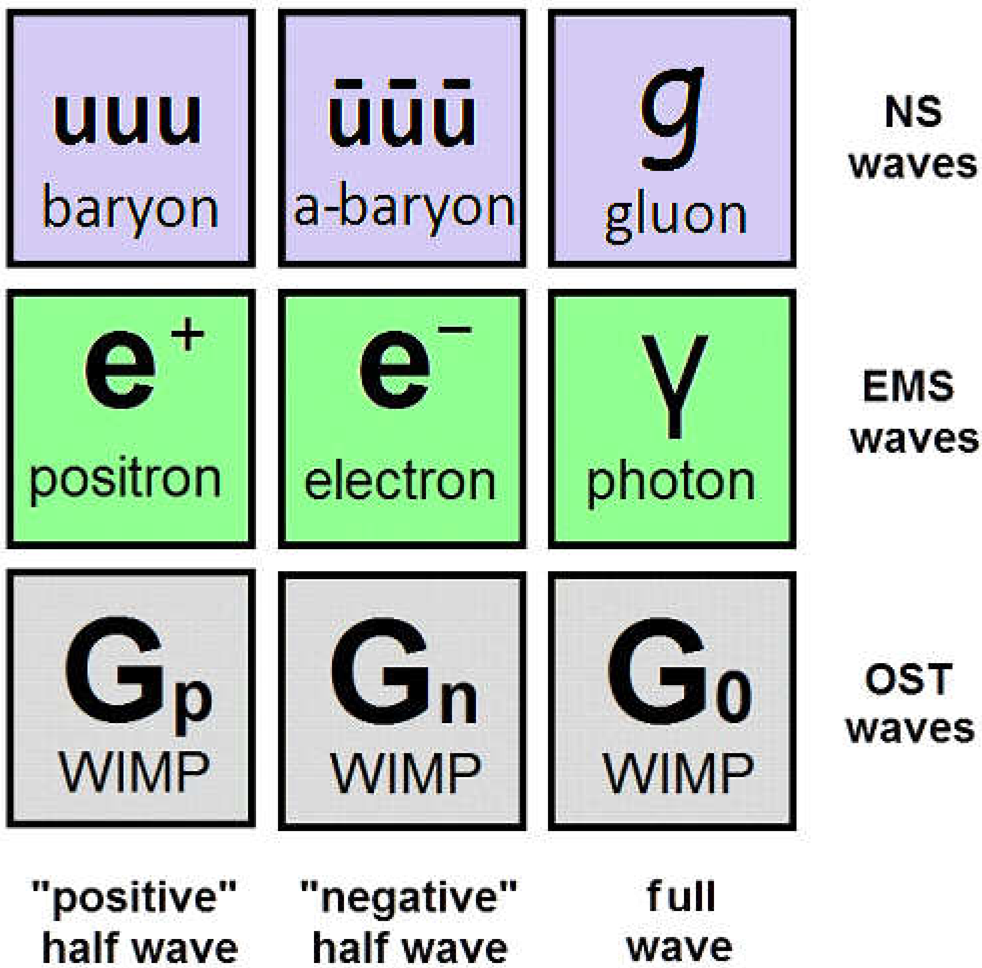

Figure 1: The Reduced Standard Model (RSM), the GPI-compatible complete set of elementary wave-like deformations. As the GPI rejects gauge transformation principle and gauge bosons, all the interactions are understood as wave-like geometrical deformations of the extended 8D spacetime. The NS and OST waves are three-dimensional, and the EMS waves are one-dimensional (if disregard the time coordinate). The NS waves induce "shadow" waves 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 waves made by the combination of two half waves, i.e. $\gamma = e^+e^-$ and g = uuuūūū (see §3.1 and §3.2, respectively). Although the full waves are composite, they have zero average curve and twist and hence lower energy than the two half waves; therefore, they can be considered elementary as well. As the masses of hadrons and leptons are "induced", the Higg's mechanism and Higg's boson are avoided (see §3.1.4). The weak interaction is understood as a type of the electromagnetic interaction, and neutrinos are avoided as well (see §3.3). The three elementary OST waves (WIMPs) are hypothetical (see §3.4).

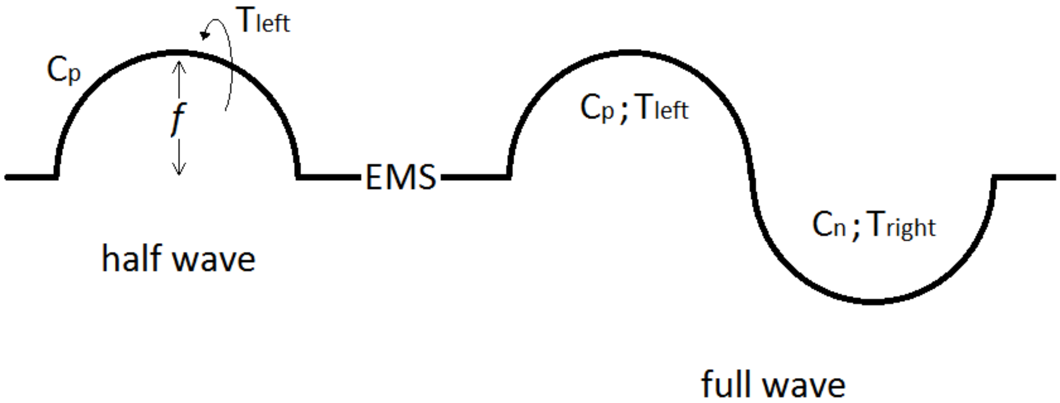

Figure 2: Schematic representations of the EMS wave-like deformations. The half waves (electron and positron) have three main parameters: curve **C** (positive or negative), twist **T** (left or right) and frequency ***f*** (as they oscillate as shown by the arrows). The horizontal line depicts a fragment of the fifth dimension (EMS) assumed as a 1D closed circle extending each point of 4D ordinary spacetime (OST) as suggested by T. Kaluza [9]. 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.

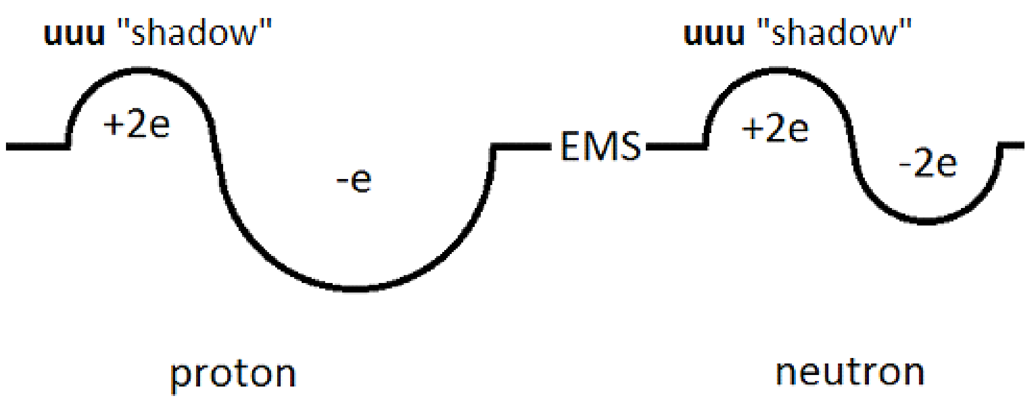

Figure 3. Schematic representations of the EMS deformations induced by the proton and the neutron. When proton binds an electron and forms neutron, its "shadow" EMS half wave (+2e charge) induced by the **uuu** triplet should be completely canceled by the (two -e charges) induced by the two electrons. This is possible only after the latter two EMS half waves induce a single EMS half wave (-2e charge), which is more curved and smaller than the two original half waves (-e charge) and hence requires an additional energy.