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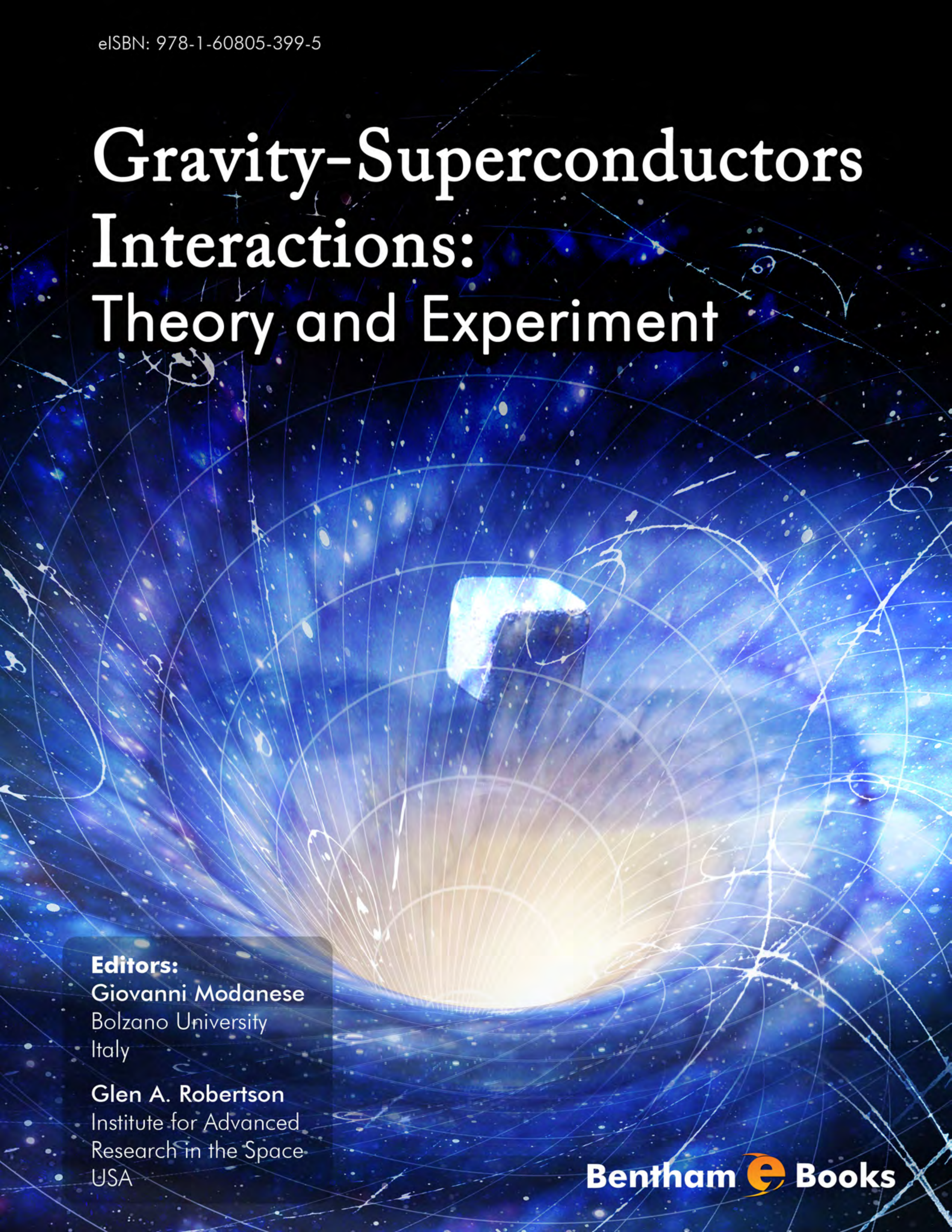

Gravity-Superconductors Interactions:
Theory and Experiment

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FOREWORD

It is our pleasure to write the Foreword for *Gravity-Superconductors Interactions*, the first eBook to further its goal of presenting to the scientific community the state of theoretical and experimental research concerning the latest results in the emerging field of *physics for novel gravity-like fields* that might represent a new paradigm shift regarding the very nature of gravitation.

We were privileged to work together for several years at the European Space Agency (ESA), experiencing first-hand the immense technical difficulties and extreme cost to place relatively small payloads into low earth orbit. Space propulsion is still dealing with the technologies developed in the 50s and 60s of the last century, and the vision portrayed by Werner von Braun in his famous article in Collier's magazine in 1952, entitled *Man on the Moon*, did not become a reality.

The shuttle era is coming to an end soon, and NASA is thus preparing to fly as soon as possible its next generation space vehicle, *Ares I-X*, a two stage rocket, which, to some extent, is looking like a modernized version of the Saturn V rocket from the Apollo moon program developed by von Braun in the 1960s. In his recent article, T. Jones in Aerospace America, May 2009, is describing clearly the enormous development efforts, the vast infrastructure, and the sophisticated technology required to eventually deliver 25 metric tons of payload into low earth orbit, which is somewhat less than the 29 metric tons of the soon to be retired space shuttle. Despite all the engineering ingenuity, undoubtedly displayed in the design of *Ares I-X*, it is a sobering lesson to learn that these extreme technological efforts will result in a space transportation system of relatively modest capability, but being of highest technological complexity.

The problem is not with the engineering, which even goes beyond the present state of the art. It is linked to the underlying propulsion physics that remains unchanged since the days of ancient Chinese rockets. It is the physical principle of classical momentum conservation which stands in the way of producing an efficient and effective propulsion system. It is the *basic physics* itself that prevents progress. The same holds true in the field of energy generation, especially fusion which may be out of reach as was discussed in the recent article by M. Moyer entitled *Fusion's False Dawn* in Scientific American, March 2010. As it seems, only *novel physics* can overcome this barrier.

Therefore, the motivation to further exploring the mysterious nature of gravitation is understandable, aiming beyond Newtonian (Einsteinian) gravity. Gravitation has maintained the interest of researchers at every stage in the history of physics, and it became Einstein's quest to unify gravitation with the other forces since 1916, the year he published his general relativity theory. The still unfinished manuscript on his desk, found after he passed away, clearly showed that he was still elaborating on his lifelong dream, namely to extend the description of the force of gravity as geometry, which had worked so marvellously well in the case of gravitation, to the other physical interactions. The *geometrization of physics*, *i.e.,* associating a metric tensor with each physical interaction, is still an open question, and it remains to be understood, if and how this beautiful principle can be extended to encompass all the other forces.

Hence, it should be no surprise that *new theoretical attempts along with experimental work* are presented in this eBook to continue where Einstein was forced to leave off. The quantization of the gravitational field has been unsuccessful, despite great efforts in this direction. The problem may be that the number of fundamental forces is not known, in other words, there is a *belief that only four forces exist* (strong, weak, electromagnetic, and gravitational force). Perhaps gravity is of a more subtle nature than Newtonian gravity, and an interaction between gravity and electromagnetism might exist? At least, the Maxwell equations of electrodynamics and the linearized Einstein field equations, termed Einstein-Maxwell equations, show surprising structural similarity.

New gravitational experiments have been published since 2006, and geometrical theories from the 1950s (for instance, by Finzi, Heim, Wheeler) were extended and combined with concepts of modern physics (symmetry, symmetry breaking, London equations, Ginzburg-Landau theory, spacetime as a physical field, *etc.*) and have gained some prominence, trying to explain novel experimental results for extreme gravitomagnetic and gravity-like fields. In his monograph on *Quantum Field Theory*, M. Kaku presents a calculation of the Coleman-Weinberg potential that might be employed to calculate the coupling strength for the extreme gravitomagnetic fields. Most recently, as pointed out by A. Zee in *Quantum Field Theory in a Nutshell*, gravity might be the square of two spin 1 fields (it should be noted that particles of spin 1 can be described by Yang-Mills fields), an idea that also might be applicable in the explanation of the experiments on extreme gravitomagnetic fields that are 18 orders of magnitude larger than those predicted by general relativity, and, if confirmed, are outside general relativity. These and other exciting ideas are presented here to the reader, and might shed new light on the nature of gravity as well as the number and type of fundamental forces that exist in Nature.

Novel theories on the geometrization of physics should provide new statements and propositions that unmistakably should lead to recognizable facts, which should, for instance, occur from the existence of extreme gravitomagnetic and gravity-like fields observed at cryogenic temperatures, rather than by speculation or chance. As Einstein felt, the most important objective of any theory is to comprise as few and basic elements as possible without contradicting physical experience in conjunction with practical applications. For example, as presented in this text, a relationship between the different phenomena of electromagnetism and gravitation might have been discovered. Any novel theory must be verifiable by laboratory experiments or astronomical observations. In order to verify a theory, it must provide a procedure on how the measurable information can be extracted. Since experiments do not produce physical principles, any novel theory must produce meaningful forecasts and also be falsifiable.

According to *Dirac's dictum*: a special regulator of a theory that reflects quality is its beauty. Einstein's theory of general relativity is an example of such a theory. The successful geometrization of physics combined with proper symmetries (group theory) would fit this picture as would the experimental generation of gravity-like fields at cryogenic temperatures by symmetry breaking.

In this eBook, these two important topics are addressed and discussed from various points of view. Needless to say, beauty cannot be the sole yardstick for the correctness of a theory or physical phenomenon, and there is always the danger that, for instance, physical models are invented to fit an experimental situation. An example to be remembered are the (non-existing?!) gravitational waves measured by Weber. It is of utmost importance that any discovery is verified by other laboratories before it can be claimed as valid. Verifying gravitational experiments is not an easy endeavour since highly sensitive devices have to be produced and utilized at cryogenic temperatures, often at liquid Helium temperature. Even if experimental findings or theories eventually cannot be verified, one should not denounce the serious experimenter or theorist for failure, since the history of science has shown that every step forward is a complicated venture, needless to say that all programs for novel theoretical models initially contain many unclear points. But this is true even for established theories. The theory of general relativity has unified gravity with inertia. The equation of motion is for material points moving along geodesics. General relativity interprets gravitation in terms of curvature of spacetime that is, the homogeneity and isotropy of spacetime are violated. Energy and momentum conservation are valid only in flat spacetime, Since gravitational waves require the full nonlinear Einstein field equations, the superposition principle does not seem to hold, in contrast to electromagnetic waves. This would be true only in the weak field limit.

Recently, a number of important and interesting experimental results on gravitomagnetic and gravity-like fields, *generated in the laboratory*, have been obtained. Gravitational experiments are notoriously difficult as can be seen from the fact that the physics of gravitational wave astronomy, despite the early efforts of J. Weber starting out in 1969, is still not an established fact.

As was pointed out by the well known theoretical physicist Richard P. Feynman in his now famous lecture, *There's Plenty of Room at the Bottom*, given already in 1960, and published in the journal *Engineering and Science* (February 1960), there occur numerous strange phenomena in the complex situations of solid state physics. He prophetically foresaw an enormous number of technical applications that could arise from such physics. He also mentioned Kammerling Onnes, the pioneer of low temperature physics and superconductivity. Why should it not be possible that a combination of low temperature and solid state physics could lead to strange phenomena and, this is the most important point, to a large number of technical applications, but this time in the field of gravitational engineering? This is what this eBook is all about.

Finally, in order for science to progress, both theorists and experimenters have to be willing to take a certain scientific risk that is, *getting off the trodden path*. If a blind alley is met, the courage to reverse one's direction of research is required. If, however, ideas of novel gravitational fields at cryogenic temperatures turn out to be true, the new scientific age of gravitational engineering might have begun. It also would mean that famous string theory is not the answer or, at least, not the complete answer, and thus will not reveal the secret of the Universe.

Whether or not this eBook is telling the final scientific truth, or even stands for a paradigm shift cannot be decided at this moment. Nevertheless, we are convinced that substantial benefit for the reader does come from it.

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CHAPTER 11

Emerging Physics for Gravity-Like Fields

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Abstract: Based on theoretical ideas under development since 2002, termed Extended Heim Theory (EHT), as well as experiments performed at AIT Seibersdorf, Austria since 2006, it is argued that there is evidence for the *existence of novel gravity-like fields* and thus also *different types of matter*. These gravity-like fields are not described by conventional Newtonian (Einsteinian) gravitation, *i.e.*, by the accumulation of mass. Instead, under certain conditions, they should be producible in the laboratory by small ring or disk shaped masses rotating at cryogenic temperatures. *EHT*, in describing these novel fields, postulates six fundamental physical interactions, three of them of gravitational nature. The two additional gravity-like fields may be both attractive and repulsive. It is further argued, based on both *EHT* and experiments, that these gravity-like fields are outside the known four physical fundamental forces, and may result from the conversion of electromagnetic into gravitational fields. The gravitomagnetic effect of these fields is found to be some 18 orders of magnitude larger than classical frame dragging of General Relativity. This fact seems to be in accordance with recent experiments performed at AIT Seibersdorf. A non relativistic semiclassical model will be presented as an attempt to explain the physical nature of the novel gravity-like fields. There seems to be a special phase transition, triggered at cryogenic temperatures, responsible for the conversion of electromagnetic into gravitational fields. The features of the six fundamental physical interactions are utilized to investigate the potential of the novel gravity-like fields for propulsion purposes as well as energy generation.

Keywords: Gravitational forces, theories of gravitation, superconductors, general relativity, gravitomagnetism, novel gravity-like fields, fundamental physical interactions, extended heim theory, phase transitions, classical frame dragging, geometrization of physics.

1. PHYSICS OF GRAVITY-LIKE FIELDS

Physics, as we know it, is based on the belief of the existence of exactly four fundamental forces. There are two long range forces (interactions) electromagnetism and gravitation. Gravitation is believed to be always attractive, while electromagnetism can be both attractive and repulsive. The bosons that mediate the force between the charged particles that is, particles having mass and/or electric charge, are the hypothetical graviton and the photon, respectively. The other two interactions are the weak force (β decay) and the strong force (atomic nuclei), which are of short range, *i.e.,* their range is about 10^{-15} *m*. The two cornerstones of modern physics, general relativity and quantum theory, are predicting highly different magnitudes of the energy of the vacuum, whose ratio is about 10^{120}, which means the error is in the exponent [51]. This might be an indication that physics as it is understood at present is not complete and has to be complemented by novel concepts in the form of additional interactions.

Based on ideas, first proposed by Heim in the late 1950s, a so called poly-metric tensor has been constructed by the authors. In this article the main physical concepts leading to the proposed six fundamental forces are presented; the details can be found in the references (see Section 2). These theoretical concepts are termed *Extended Heim Theory* (*EHT*), though *EHT* does not have reached the status of a theory, but should be conceived as a *phenomenological model* to explain the existence of the six fundamental forces. These concepts demand two additional gravity-like fields that may be both attractive and repulsive originating from an interaction of electromagnetism and gravitation as well as new types of matter. Therefore, there should exist six fundamental interactions, three of them of gravitational type. It was

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Giovanni Modanese and Glen A. Robertson (Eds)

quite unexpected when in 2006 experiments were published on the existence of gravity-like fields by Tajmar *et al.* performed at AIT (Austrian Institute of Technology) and in 2007 by Graham *et al.* (Section 1.3). Also, the NASA-Stanford Gravity-Probe B experiment might have been subjected to these gravity-like fields, see below. These novel fields, *if confirmed*, may have the potential to serve as a basis for a completely different technology on transportation, as well as energy generation.

Hence, it is of great interest to obtain at least a heuristic understanding of the underlying physical phenomena and to establishing rules for the scaling of the gravitational effects that are of non Newtonian type. In this article we consider possible applications to propulsion, but the concepts can be directly employed to any type of transportation and might also aid in the stabilization of fusion plasmas. The physics of space flight is based on the century old rocket equation that is an embodiment of the conservation of linear momentum [52]. As a consequence, chemical rockets, which are the most powerful propulsion systems of today, are flying fuel tanks. In the following paragraph, a brief discussion of the advanced concepts for space propulsion is presented. It should be noted, however, that all of the physical principles presented have been known since the 1950s, but no significant progress regarding their technical realization was made [1-5].

1.1. Recent History of Gravity-Like Field Experiments

During the last two decades, numerous experiments related to gravity shielding or gravitomagnetic interaction (coupling between electromagnetism and gravitation) were carried out. In the 1990s a Russian scientist claimed to have measured gravitational shielding. However, Woods *et al.* [6] have delivered experimental evidence that these two claims cannot be substantiated. This kind of gravitational shielding does not seem to exist. In 1997, a Japanese free fall experiment using an encapsulated spinning gyro [7] reported differences in free fall time depending on the direction of rotation. The authors concluded that an asymmetry (parity violation) caused the generation of anti-gravity. But the equations of motion for a free falling body in an atmosphere are highly complex, because of aerodynamic lift and drag (pressure drag, friction drag) that also may be time dependent. Although the spinning gyro was encapsulated, it might have transferred angular momentum, for instance, by friction effects, to the free falling body causing a rotation of the body. This rotation would have changed the free fall time. If the gyro had a small geometrical asymmetry, a rotation in one direction (18, 000 rpm) might cause a transition from laminar to turbulent flow, and thus may lead to a different transfer in angular momentum, depending on the direction of rotation. Since the authors do not address these possible sources of error, it cannot be decided whether or not this set of experiments is reliable. The experiments were conducted at room temperature.

Hence, the conclusion concerning the above experiments is that they must be considered as incorrect or, at least, inconclusive, and therefore are not considered in our experimental analysis.

1.2. Theoretical Concepts for Geometrization of Physics

On the theoretical side, most advanced physical theories like string theory, grand unification theory, or super-symmetry under development for several decades and aiming at unifying the four known fundamental forces, do not predict any additional physical interactions. In addition, they require a higher dimensional space, but so far there is only evidence for the existence of four-dimensional spacetime. On the other hand, the geometrical concept of Einstein [8], trying to geometrize physics by associating a metric tensor with each known interaction, has been abandoned long ago by theoretical physicists, since all attempts by Einstein and others in constructing a metric which encompasses all physical interactions proved to be unsuccessful. Since then, this concept is believed to be valid for gravitation only.

However, in the 50s of the last century the German physicist Heim and the Italian mathematician Finzi presented novel ideas on how to construct a polymetric describing all physical interactions in order to revive the powerful geometric idea of Einstein. Heim introduced the concept of a six-dimensional space, interpreted and utilized by us as an internal space, possessing three subspaces and constructed several metric tensors that he associated with physical interactions. In Extended Heim Theory *EHT* as proposed by the authors [9, 10], these ideas were extended to an eight-dimensional internal space by adding the subspace I^2 that enables the exchange of information among physical systems. Consequently a total of 15 metric tensors (termed Hermetry form which stands for physical meaning of geometry) are constructed. It should be noted that the name Extended Heim Theory is not really appropriate in that *EHT*, at least at present, is only a collection of ideas on the geometrization of physics for determining the number and type of all fundamental physical interactions. The name of Heim is used, since he was the first one to constructing a poly-metric or multiple metric by employing the idea of structured (internal) space.

The most important aspect of *EHT* is that it postulates the existence of six fundamental interactions. The additional two gravity-like fields predicted by *EHT*, might serve as the basis for a completely novel propulsion principle based on force fields. In other words, according to *EHT*, it should be possible for a space vehicle to generate its proper gravity-like field capable of accelerating the vehicle against its reference frame. Such a propulsion scheme would work without propellant. Even if such an acceleration field would be weak compared to the acceleration on the surface of the Earth, but it may be large when compared with today's state of the art ion propulsion that delivers a thrust of about 20 mN, and, if sustained over a long enough time, the $\Delta\mathbf{v}$ would be substantial.

The question, of course is, does there exist any experimental evidence of such fields? Surprisingly, the answer seems to be *affirmative*, and the recent experiments presented in the following section, might be a first sign for the existence of novel physical interactions. If this turns out to be true, a propulsion scheme based on the concept of a gravity-like force field might be realizable, since the technology, derived from the novel gravity-like fields, should be *substantially easier to realize than chemical propulsion*, once the underlying physics is completely understood.

1.3. Existence of Additional Gravitational Force Fields

Up to 2006, to the knowledge of these authors, no credible experiments on novel physical forces existed. However, on 23 March 2006, the European Space Agency (ESA), on their webpage, announced novel experimental results, reporting on the generation of gravitomagnetic and gravity-like fields (acceleration or artificial gravitational field in the laboratory [11-13]). So far several different interpretations of this phenomenon have been given by the experimenters; the latest one indicates that the effect is due to the action of the liquid He itself. A different physical interpretation of these experimental results, based on the existence of two additional gravity-like fields, for instance, was published in [10].

Since 2006, Tajmar *et al.* [11-13] have refined their experimental setup, repeating their experiments. In July 2007, Graham *et al.* [14] published a paper seeing a similar effect for a superconducting lead disk, but using a completely different measurement technique. However, the sensitivity of their laser-ring gyro was about two orders of magntiude less than the equipment of Tajmar, so their results are *not conclusive*. In September 2007 Tajmar *et al.* [13] published a comparison between the two sets of experiments. The most recent results by Tajmar *et al.* show varying signal strengths depending on the layout of the geometry as well as the materials utilized in the experimental setups A, B, and C employed. *EHT* was used to analyze these experiments and to provide an explanation for the different strengths of the measured gravitomagnetic fields. Moreover, in 2007 results of the Stanford-NASA Gravity Probe B (GP-B) [15, 45] experiment became available. GP-B employed four small, extremely precise gyroscopes in the form of Nb coated quartz spheres at liquid He temperature as its main tool for detection of geodetic (spacetime deformation by a static mass) and frame dragging (spacetime twisting by a rotating mass) effects. Since in GP-B there are two pairs of counter-rotating superconducting niobium coated quartz spheres, each of the two gyros in a pair should feel the presence of the gravitomagnetic field generated by its partner. This situation bears a certain similarity to Tajmar's and Graham's experiments (see Section IA [10]). According to *EHT*, an extreme gravitomagnetic field should be observed, that is completely different from the gravitomagnetic field predicted by *GR*, leading to substantial *gyro misalignment (i.e.,* spacetime *twisting acting as a force that pushes on the gyro axis and forces it out of alignment as it circles around the Earth)*. Second, a tangential gravity-like field (acceleration field) should be observed, generated by the rotation of a gyro in the spatially non-homogenous gravitomagnetic field of its partner, where one of the gyros is *accelerated* and the other one is *decelerated*. Therefore, the misalignment of the axes of the GP-B gyroscopes over time should not be completely explainable by conventional assumptions like electrostatic forces between the housing of the gyro and the gyro surface *etc.* The same holds true for the second gyro anomaly, namely the measured gyro frequency shifts in GP-B, meaning that one of the gyros in each of the two gyro pairs was accelerated over the measuring period of 10 months, while the other one was decelerated. This behavior was analyzed in detail [16-20]. It has been shown that there is room for this so called *Tajmar effect*, but, because of the other sources of misalignment present, it cannot be concluded that the extreme gravitomagnetic fields have been generated in GP-B.

The generation of gravitomagnetic and/or gravity-like field(s) in all three sets of experiments, namely by Tajmar, Graham and GP-B seems to follow a similar mechanism.

- First, an *extreme gravitomagnetic field* is observed for a rotating Nb or Pb ring, sphere, or disk at a specified cryogenic temperature (above the critical temperature, T_C, for superconducting and therefore *different* from the mechanism of the Cooper pairs), which is many orders of magnitude larger than predicted by *GR*.

- Second, a *gravity-like field* (gravitational acceleration field) seems to be generated by producing a time-dependent gravitomagnetic field. The ensuing gravitational force observed is more in the range of the electromagnetic force. In other words, the coupling constant for the gravity-like field must be completely different from common gravitational coupling. A coupling between electromagnetism and gravitation seems to take place, however, not with Newtonian gravitation.

Hence, we are in the fortunate situation to have at least some experimental data for the validation of these entirely novel physical concepts and models, in contrast to current theoretical physics (*e.g.*, string theory). Arguably, there exist three different types of experiments, employing very different measurement techniques, performed both on *Earth* and in space, but reporting similar physical phenomena.

Regarding the reliability of the experimental results, investigated in [10], it should be mentioned that Tajmar *et al.* [11-13] at the AIT Seibersdorf, Austria (a certified ESA test center) had carried out these experiments over a period of about three years prior to publication. The authors report that a rotating Nb ring of some 15 cm diameter generated a *gravitomagnetic field* below temperatures of about 30 K, *i.e.,* the temperature where the phase transition takes place. In addition, every time the cryogenic Nb ring was subjected to angular acceleration at around 4 K, a *gravity-like field* was measured in the plane of the ring in circumferential direction. The induced acceleration field was opposite to the angular acceleration, following some kind of gravitational Lenz rule. In addition, an acceleration field was also observed when the Nb ring was rotating with constant angular velocity, but undergoing a phase change that is, from the normal to the (superconducting) state. This was achieved by reducing the temperature below 9.2 K, the critical temperature for Nb. Moreover, no acceleration was measured when the Nb ring was in normal conducting state.

GR predicts that any rotating massive body (*Earth*) drags its local spacetime around, called the *frame dragging* effect, generating the so-called *gravitomagnetic field*. Since spacetime itself gets twisted, a gyro whose axis of rotation remains invariant, should exhibit a misalignment, since the local coordinate system is no longer inertial. This effect, predicted by Lense-Thirring in 1918, however, is far too small to be seen in any laboratory on Earth. For this reason the GP-B experiment was launched in 2004 after more than 40 years of preparation (see Section IA in [10]). On the other hand, the values measured by Tajmar *et al.* [11-13] were *about 18 orders of magnitude higher* than predicted by *GR*, and therefore are outside *GR*. They *cannot be explained by the classical frame dragging effect of GR* and would represent a *new kind of physical phenomenon*. In other words, the cryogenic rotating Nb ring, with a mass of about 400 grams, causes approximately the same frame dragging effect as a white dwarf, as was calculated [20].

1.4. Novel Experiment for Vertical Gravity-Like Field

When analyzing the experiments by Tajmar *et al.* [11-13], it became obvious that an experiment could be devised, demonstrating the generation of a gravity-like field pointing in the *vertical direction* (along the axis of rotation) that might be capable of lifting a vehicle from the surface of the Earth [10] if scaled accordingly.

Since this effect only occurs at very low temperatures it is surmised that a *phase change* takes place. In *EHT* the concept of matter is extended to both ordinary and non-ordinary matter. This means that *particles of real and imaginary mass* should exist under spacial conditions. Consequently, the concept of virtual particle is extended also to virtual particles of imaginary mass and real charge. This type of virtual particle is deemed to be responsible for the conversion of the electromagnetic into a gravitational force, which do not necessarily have to form Cooper pairs, but instead might form some kind of Bose-Einstein condensate (although the temperature is much higher), causing these novel physical interactions. Based on calculations of *EHT*, the technical requirements for a vertical gravity-like field, for instance, magnetic induction field strength, current density, supply power *etc. should easily be met with present technology*.

Required values for such an experiment are substantially lower than for the previously proposed experiments that assumed *fermion coupling to achieve vacuum polarization* as discussed in [17].

Extreme caution is needed when announcing novel physical interactions. Several years ago, a novel physical interaction (fifth force) was announced by a group of physicists at Purdue University and Brookhaven National Laboratory (Fischbach, 1986) who claimed to have found experimental evidence for a distinct deviation from Newton's law at intermediate distances between 1 m and 1 km. After four years of elaboration and 12 more experiments, agreement was reached that there was no fifth or sixth force. This time, however, the situation is different in that no geological structure or chemical composition of the environment is of importance. The physical effects measured by Tajmar and Graham are large, and should be clearly reproducible, independent on location and geological formation.

What does theoretical physics have to say about these experiments and physical phenomena? The answer is very short, namely there is no place for these experimental results. According to currently favored string *theory* or any other *supersymmetry theory* nothing should have been measured. What about alternative theories? At present, there are no theories available that are capable of completely explaining these experiments. Using the geometrization approach of *EHT*, the so called doubled coordinate transformation (for instance [26]) that is currently reformulated using the mathematical framework of nonlinear σ – theory [27] in order to obtain a connection between geometry (specific metric tensors also termed Hermetry forms), results in postulating two additional fundamental gravitational like interactions, which are subsequently utilized to analyze all three types of experiments (see Section I in [10]). However, experiments are producing numerous new results, and no final quantitative conclusions are available at present.

2. THEORETICAL CONCEPTS FOR GRAVITOMAGNETIC AND GRAVITY-LIKE FIELDS

In this section a discussion of the theoretical background for recent experimental results by Tajmar *et al.* [11-13], Graham *et al.* [14], and the Stanford-NASA Gravity-Probe experiments is presented, which shows that there is evidence for additional gravity-like fields. Before, however, the physical fundamentals of *EHT* are discussed, which aims at the geometrization of all physical forces, additional evidence for the existence of gravity-like fields will be evoked stemming from astrophysics observations. These extraordinary phenomena could be related to the recent experiments by Tajmar *et al.* The hitherto unexplained gravitational phenomena in the form of dark matter and dark energy clearly exist, and have been verified beyond doubt by cosmological observations.

2.1. Hints from Cosmology for Additional Gravitational Fields

In the following, cosmological observations will be discussed that provide evidence for additional gravitational interactions. As will be shown below, *EHT* predicts six fundamental interactions. Three of these fundamental forces are of gravitational nature, which can be both attractive and repulsive. From astrophysical observations it is known that about 4% of the matter in our *Universe* is ordinary (visible) matter made of neutrons and protons. This baryonic matter is described by known physics, *i.e.*, the standard model, which now needs 26 free parameters. All the fundamental properties of matter have to be provided to the model. The coupling constants of the four fundamental forces need to be supplied and cannot be calculated from the model. However, galaxy formation requires additional mass beyond known baryonic matter. The current status can be summarized such that a new type of invisible matter (*dark matter*), dominating ordinary matter (about 26%), exists in the *Universe*, but current physical theory cannot explain its nature. Moreover, observations of very distant Type I supernovae require the accelerated expansion of the *Universe*. This phenomenon is attributed to the so called *dark energy*, which comprises about 70% of the total mass of the *Universe*. Dark energy causes a repulsive force, whose density has changed in the course of the evolution of the *Universe*. The physical properties of this unusual energy are virtually unknown. Both, dark matter and dark energy exhibit gravitational interaction. In quantum theory, gravitation, because of its weakness, is not accounted for. Quantum field theory (QFT) only works because it neglects Newtonian gravity. The situation would become even more severe if two additional gravitational interactions existed, that also cannot be accounted for in QFT. On the other hand, *GR* only explains the gravitational behavior of ordinary matter, *i.e.,* those 4% of the total matter of the *Universe* that are assumed to be known. However, for the remaining 96% of matter present physics does not have a satisfactory explanation.

However, if dark matter and dark energy each are associated with their own proper gravitational interaction, then there exist three gravitational forces that can be both *attractive* and *repulsive*. In addition, there are three non-gravitational forces described by quantum theory (electromagnetism, weak, and strong force). Thus, cosmological considerations suggest that there are six fundamental forces. If this is the case, *novel field quanta* must also exist. The messenger particles for these interactions, as predicted in *EHT*, are identified as gravitophoton (ν_{gp}^0), which can decay into attractive ν_{gp}^+ and repulsive, ν_{gp}^- gravitophotons or, *via* a second decay mode, into a graviton (ν_g) and a quintessence particle (ν_q, repulsive), for instance see the description in [9, 10, 23-25]. The latter decay mode seems to take place in the experiments by Tajmar *et al.* [11-13]. There is the possibility that one of these unknown gravitational fields might be usable as novel propulsion principle. Furthermore, it might be necessary to *extend the principle of momentum and energy conservation* to both ordinary and non-ordinary matter and including the interaction of the local spacetime filed with these two types of matter [9, 10, 24]. For instance, $\mathbf{m}+\mathbf{m}'=0$ where $\mathbf{m}$ and $\mathbf{m}'$ denote momentum of ordinary and dark matter, respectively. If only $\mathbf{m}$ is measured this would be seen as violation of the momentum conservation principle. As will be shown in the next section, *EHT* predicts that photons can be converted into gravitophotons (enabling an interaction between electromagnetism and gravitation), but this type of gravitation is not mediated by the grviton, which only is the messenger particle for Newtonian gravitation. The combined energy densities of attractive ν_{gp}^+ (negative energy density) and repulsive ν_{gp}^-) (positive energy density) gravitophotons should be zero. It is currently believed that the combined energy density of baryon mass and gravitation add up to zero. However, ν_{gp}^+ interacts with ordinary matter and thus generates a force. The repulsive gravitophoton ν_{gp}^- should not interact with ordinary matter since otherwise Newton's law could not be valid; instead, it seems to drive the *Universe* apart at the present time. The total amount of energy extracted from the vacuum would be zero. However, there would be a net effect on ordinary matter the spacecraft is made from. In general, *conservation principles need to be applied to a closed physical system, which includes both ordinary and non-ordinary matter and the local* spacetime *field*.

2.1.1. Geometry and Physical Interactions

In this section the fundamental ideas of *EHT* are presented with regard to gravitomagnetic phenomena. In Dröscher and Hauser [20] these predictions are compared further with recent experiments. Presenting theory only without experimental validation may lead to the loss of physical reality. Experiment without theoretical insight might lack any deeper understanding, and necessary guidelines for advanced propulsion systems might not be obtainable.

In a series of articles, starting 2002, the existence of additional gravity-like fields was proposed by the authors. In the following an overview of the fundamental assumptions on the underlying physical ideas of *EHT* is presented, which is based on concepts from the German physicist Heim [28, 30] and the Italian mathematician Finzi [32].

2.1.2. Theories with Higher Dimensions

The approach taken by *EHT* is different from supergravity, supersymmetry or superstring theories, for instance see [33]. These theories increase the number of real physical spatial dimensions to construct a single $N \times N$ metric tensor to include Maxwell's equations (*i.e.,* the gauge boson for electromagnetic interaction) or the Young-Mills field, in order to describe electromagnetism and the weak and strong interactions. Already in the 1920s additional spatial dimensions were introduced to unify gravitation and electromagnetism. Supergravity increases the number of dimensions further to incorporate matter in the form of quarks and leptons. For instance, in supergravity 11 dimensions are used. Hence the metric tensor would have 11^2 elements, but not all of them are independent. Since the extra dimensions have not shown up in any experiment, they are considered to be sufficiently compactified (Planck length $l_P \approx 10^{-35}\ m$), so that present energy probes cannot see any of these additional dimensions. The metric tensor that characterizes *GR* is given on the left of Equation (2). In the theory by Kaluza [34, 37], in order *to unify gravitation and electrodynamics*, the metric tensor is a 5×5 matrix, which is depicted on the right hand side. That is, at each point in spacetime a circle is attached, meaning that this dimension is curled up, and thus is not directly visible.

$$\begin{pmatrix} g_{11} & g_{12} & g_{13} & g_{14} \\ g_{21} & g_{22} & g_{23} & g_{24} \\ g_{31} & g_{32} & g_{33} & g_{34} \\ g_{41} & g_{42} & g_{43} & g_{44} \end{pmatrix}; \qquad \textbf{(1)}$$

$$\left(\begin{array}{cccc|c} g_{11} & g_{12} & g_{13} & g_{14} & A_1 \\ g_{21} & g_{22} & g_{23} & g_{24} & A_2 \\ g_{31} & g_{32} & g_{33} & g_{34} & A_3 \\ g_{41} & g_{42} & g_{43} & g_{44} & A_4 \\ \hline A_1 & A_2 & A_3 & A_4 & \end{array}\right), \qquad \textbf{(2)}$$

where $A = (\Phi, \mathbf{A})$ denotes the four potential of electrodynamics. Adding six or seven curled up spatial dimensions (hypersphere) leads to a single 10 or 11 dimensional metric tensor that describes gravitation, electrodynamics, strong and weak forces as well as quarks and leptons (matter). However, the gravitomagnetic experiments (as is shown in Section II of [10]) would have no place in this higher dimensional metric tensor. Furthermore, there is no evidence for higher spatial dimensions. There is also *no explanation for dark matter and dark energy through this single metric tensor*. This type of metric is termed *monometric*.

Therefore, physics takes place in a space $M^4 \otimes K$ where M^4 is the four-dimensional spacetime manifold and K denotes the compactified additional space. For example, the 5×5 metric tensor of Kaluza and Klein, 1926, to unify gravity and electromagnetism has 15 independent components, while Einstein's original metric tensor in our four-dimensional spacetime accounting for gravity only, has 10 independent quantities.

EHT differs from this approach in that there is only four-dimensional spacetime, but multiple 4×4 metric tensors are constructed, termed Hermetry forms.

EHT is described by a *poly-metric*, based on the double coordinate transformation that is derived in the subsequent section. The word *Hermetry* is a combination of *hermeneutics and geometry* that is, a Hermetry form stands for the physical meaning of geometry. Each Hermetry form has a direct and unique physical meaning (for more details see [17, 18, 26]). Each Hermetry is represented by its respective metric tensor (matrix).

No additional spatial dimensions exist in *EHT*. However, as will be outlined in Section 2.3, at each point in spacetime an internal eight-dimensional tangent space, termed Heim space H^8, is attached. This picture leads to the geometrization of physics as foreseen by Einstein [8], and provides a different approach toward unification than string theory.

2.2. Internal Space, Hermetry Forms and Fundamental Interactions

EHT is based on the following four fundamental rules, termed the *GODQ* principle. These rules cannot be derived from more basic principles or mathematical assumptions. Briefly stated: *God quantizes.* Again, these four principles cannot be proved mathematically, but their formulation is based on generally accepted observations and intends to reflect the workings of *Nature*. They simply express the underlying principles that seem to apply in the construction of the *Universe* as least, as this process is understood at the moment. Once accepted, the major physical laws and evolution of the *Universe* should unfold. Needless to say, that *EHT* has not reached this state of development, but the rules of *GODQ* have been employed as the basic guidelines.

i. *Geometrization principle for all physical interactions* that is, constructing the proper metric tensor for each physical interaction.

ii. *Optimization (Nature employs an extremum principle)* that is, physical action expressed by its proper path integral.

iii. *Dualization (duality, symmetry) principle (Nature dualizes or is symmetric and antisymmetric, bits*) that is, determining symmetry groups of both the external space, which is the spacetime field itself (M^4 manifold), and the associated internal Heim space H^8. Conservation principles follow from symmetries of both spaces.

iv. *Quantization principle (Nature uses integers only, discrete quantities)* that is, discreteness and finiteness of physical quantities as well as discrete nature of spacetime (Smolin: “atoms of spacetime” [54]).

The duality principle holds, in particular, for the *dual structure* of *universal physical* space, namely four-dimensional external spacetime (the stage for physical events) and internal Heim space H^8 (physical entities, actors, marked by their symmetry groups). Furthermore, the set of 15 Hermetry forms itself can be separated into two classes termed ordinary and non-ordinary matter, see below. Only the graviton belongs to both classes. Experimental physics has revealed that the so called vacuum of space possesses significant physical features, for instance it exhibits the *Casimir* force. Moreover, material particles can be generated out of this vacuum, so there is evidence for the existence of an underlying internal space, and all physical phenomena seem to be based on the existence of these two spaces. Is this were not the case, only geometry would exist. According to B. Heim this was the case in the early *Universe*, until the minimum area (*metron* area) reached a certain smallness, which triggered a phase transition and matter was produced. A short discussion can be found in Dröscher and Hauser [16] in the section on *Speculative Cosmology* and, of course, from Heim Vol I [29] and II [30]. This does not necessarily exclude the big bang, which might be just another name for the phase transition.

2.2.1. Internal Space H^8

For a complete physical description, the internal dynamical physical properties of spacetime need to be taken into account that is, if a general geometrodynamics approach is to be realized. To this end, in *EHT*, an internal eight-dimensional space, *called Heim* space H^8, comprising four subspaces, see Fig. **1**, is attached to each point in spacetime. The subspace structure is introduced by physical arguments. In other words, the symmetry of H^8 is broken due to this structure. This is the only time an explicit assumption on the structure of H^8 is made. This generalized concept of universal physical space S, namely the combination of four-dimensional (external) spacetime, manifold M^4 with eight-dimensional internal space H^8, is considered to account for both physical phenomena (particles, waves, interactions) and the stage on which these phenomena take place. This picture is fundamentally different from the view expressed by Veltmann [38]. From the duality principle the existence of additional internal symmetries in *Nature* is deduced, and thus such a higher dimensional internal symmetry space should actually exist, whose structure will now be presented. However, as discussed in Section 2.3, the universal physical space, termed S, external and internal, is *not* the direct sum (or Cartesian product) of $M^4 \otimes H^8$, but trough the *entanglement of internal and external coordinates*, *instead* leads to the construction of a *poly-metric tensor* as well as a set of *four symmetry groups*.

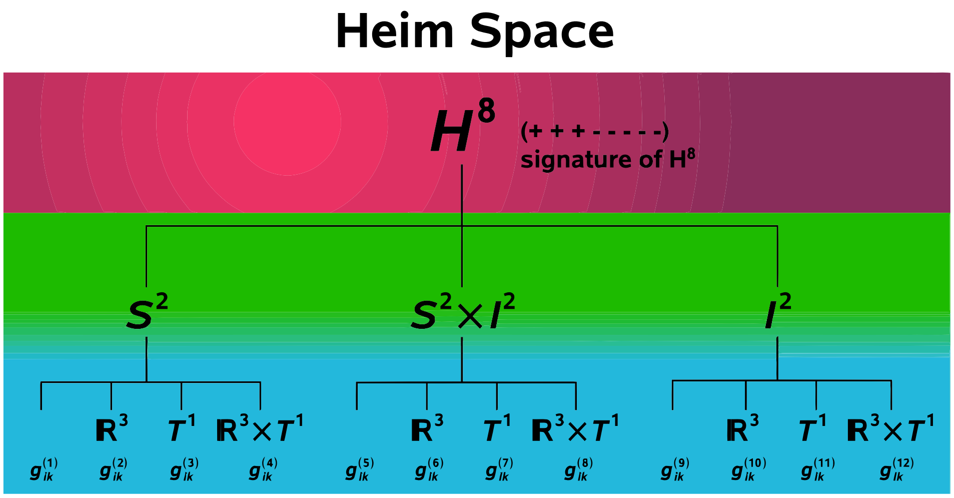

Figure 1: Each point in spacetime is associated with an additional *internal* space, termed Heim H^8 that has eight internal coordinates $\xi^a, a = 1\ldots8$. These coordinates are associated with a general 8 component quaternionic scalar field $\varphi = (\varphi^a), \varphi^a \in \mathbb{H}$, $a = 1,.,8$, and $\mathbb{H}$ denoting the set of quaternions. We refer here to the non-linear $\sigma-$ model of Jost [27], which seems to comprise the mathematical description of this physical process. This topic needs to be investigated further. The picture shows the complete set of metric-subspaces that can be constructed from the poly-metric tensor, Equation (4).

Heim space H^8 comprises four subspaces, namely manifolds R^3 (not to be confused with Euclidean space R^3), T^1, S^2, and I^2. The 8 coordinates, ξ^a, of H^8 themselves are functions of the curvilinear coordinates η^μ that is, $\xi^a = \xi^a\left(\eta^\mu\right)$ of four-dimensional spacetime, characterized by manifold M^4. Using index selection rules for the poly-metric tensor, a set of submetric tensors can be constructed. Each submetric is denoted as Hermetry form, which has, because of the selection rules, direct physical meaning (see Table **2** in [10, 26]). In order to *construct a Hermetry form, the selection rule requires that internal* space S^2 *or* I^2 *coordinates must be present*. Following this rule, directly delivers a set of 12 Hermetry forms. Internal space H^8 is a factored space that is, it is represented as $H^8 = R^3 \times T^1 \times S^2 \times I^2$. This factorization of H^8 into the internal space-like manifold R^3 and three internal time-like manifolds (signature), namely T^1, S^2 and I^2 comprises the inner structure of H^8. The four subspaces have the following physical meaning: R^3 *is responsible for ponderable mass* (*energy*), the presence of T^1 stands for c*harge in general* (*electric, gravitational, weak and color*), S^2 is representing *organization and structure of physical phenomena*, and I^2 is *accomplishing the exchange of information* among the constituents of a physical system.

Postulating the subspace structure of H^8 is equivalent to an explicit symmetry breaking. This is, however, mandatory, since the resulting subspace structure, through their symmetry group structure, is responsible for the physical events to happen. In other words, the evolution of the *Universe* starts at the very instant this subspace structure is realized, which is the beginning of physical time. As long as H^8 retains its symmetry, characterized by group $O(8,q)$, only the geometry of external spacetime exists, and thus there exists the stage only, but not yet the actors. By means of symmetry breaking, perhaps achieved through the mechanism conceived by Heim, see remarks above, the *geometric Universe turns into the physical Universe*. However, for the following discussion, the process of how symmetery breaking is actually achieved and whether a purel geometric Universe pre-existed, is not of concern. Only the fact that this process has occurred is important, *i.e.,* breaking the symmetry of $O(8,q)$ into four subgroups.

In order to geometrize physical interactions, the two principles of *SR* need to be extended, which state that

- Spacetime *is both homogeneous and isotropic* (this same principle applied to the existence of worlds hospitable to life would directly show that they should be most common), and, second,

- *Physical laws are covariant when moving from one inertial system to another*.

To summarize the discussion of above, in *EHT*, the following additional concepts are introduced:

- The third principle to be added, first conceived by Heim (for instance [28] and independently formulated by Finzi [32], states that *each physical interaction is characterized by its own Hermetry form* (metric tensor). Consequently, in order to account for all physical phenomena, instead of a mono-metric, a *poly-metric* has to be constructed. This is a *necessary, but not a sufficient condition*.

- In addition, as was already stated, four-dimensional spacetime is complemented by an *internal 8D* space, H^8 (*causing physical objects to appear on stage*), *comprising a four-fold sub*space *structure*.

- In order for any physical object to become manifest in four-dimensional spacetime, the Hermetry form of this object must include *coordinates of sub*space S^2 (*organization, structure*) *or* I^2 (*exchange of information*).

- In H^8, there exist three internal spatial-like coordinates (lower Latin characters *a, b, c* are used for summation in H^8, ranging in general from 1 to 8. Greek indices μ, ν, .. indicate summation from 1 to 4 in four-dimensional spacetime. Characters $i, j, \ldots$ indicate summation in physical space from 1 to 3.

- The first four internal coordinates ξ^1, ξ^2, ξ^3 are for space R^3, and the internal coordinate ξ^4 is used for space T^1.

- The remaining four coordinates are utilized to describing the degree of *organization* and *information* exchange as observed in *Nature*. Coordinates ξ^5, ξ^6, space S^2, denote *entelechial* and *aeonic* coordinates (organization and structure), respectively, and ξ^7, ξ^8 denote coordinates for the exchange of information in space I^2.

- With the introduction of four different types of coordinates, the space of fundamental symmetries of internal space H^8 is fixed and each subspace of H^8 is associated with a specific symmetry group. That is, the set of four symmetry groups describes all particles and fields that can exist, as will be discussed in the following section.

- In summary, the set of 15 Hermetry forms serves as a *classification scheme* for all physical objects. Hermetry form 16, *deemed to be responsible for the inertia field, is special in that it does not contain organization or information coordinates*, but lives directly in four-dimensional spacetime, and its Hermetry form is given by $H_{16}(\mathbb{R}^3 \times T)$ (it should be noted that $\mathbb{R}^3$ stands for a manifold in physical space).

2.2.2. Group Structure of Space H^8 *and Hermetry Forms*

In physics symmetries are represented by mathematical groups and through *Noether's* theorem, with each symmetry transformation a conservation law is associated. Hence, the group structure of any physical theory is of fundamental importance.

Internal space H^8 has eight internal coordinates ξ^a, $a = 1 \ldots 8$ which are associated with a general 8 component quaternionic scalar field $\varphi = (\varphi^a)$, $\varphi^a \in \mathbb{H}$, $a = 1,...,8$, and $\mathbb{H}$ denoting the set of quaternions (the reader not interested in the mathematical details can skip this section). It should be noted that the set of quaternions is used instead of the conventional set of real or complex numbers, since $\mathbb{H}$ provides the simplest non-commutative algebra, and will also allow using tensors of third rank as connections. The reason for this will be given shortly.

The subspace structure of H^8 comprising subspaces $R^3 \times T^1 \times S^2 \times I^2$ gives rise to four corresponding quaternionic symmetry groups, namely

$$O(3,q), O(2,q), O(2,q), O(1,q) \text{ with } q \in \mathbb{H}.$$

In other words, each internal coordinate ξ^a corresponds to a scalar function $\varphi(x)$ with $x = (x^\mu(\eta))$ that is $\xi^a(x) \leftrightarrow \varphi^a(x)$. It is now required that $\varphi(x)$ transforms according to $Q\varphi(x)$ with $Q \in O(n,q)$ and $n = 1,\ 2,\ 3$, similar to *QFT* as discussed, for instance, by Kaku [34], Zee [39], or Lawrie [40]. This means that internal space R^3 possesses local symmetry under $O(3,q)$, T^1 is locally invariant under $O(1,q)$, and S^2 and I^2 are locally symmetric under $O(2,q)$. The number of generators of each of these groups is 15, 1, 6, and 6, respectively. This local symmetry is underlying the principle of local gauge invariance.

The set of quaternions $\mathbb{H}$ is used in place of the set of complex numbers C, since gravitation is to be included in the Yang-Mills formalism. Complex numbers lead to gauge potentials A_μ, which are first rank tensors. Quaternions, however, result in third rank tensors for the gauge fields.

Furthermore, the 15 generators (gauge fields) of group $O(3,q)$ associated with internal space R^3 (gauge fields), stand for the 15 Hermetry forms of H^8, and thus are responsible for the physics that can occur in the *Universe*. In turn, each Hermetry form or family of Hermetry forms possess their own specific symmetry group.

The four symmetry groups describing the 15 gauge fields of the four interactions are $SU(3)$ for the 8 gluon fields of the strong interaction, $U(1)$ for the electromagnetic field, $SU(2)$ for the three fields of the weak interaction, and $SO(4)$ for the 6 fields of the gravitational interaction. The single generator of $O(1,q)$, internal space T^1 is related to the vacuum field.

Inertia is not described by any Hermetry form in H^8, but is a feature of pure spacetime and thus is described by $H(\mathbb{R}^3 \times T)$. Here spaces $\mathbb{R}^3 \times T$ denote spacetime and not the subspaces of H^8. The physical meaning of these spaces should be clear from the context. Obviously, because of the Minkowski metric, the symmetry group belonging to (also called) Hermetry form, H_{16}, is $SO(3,1)$. In other words, two types of gravitons seem to exist. The one for gravitational mass belongs to the symmetry group $SO(4)$, the other; one responsible for inertia is represented by group $SO(3,1)$. It should be noted that this fact may have major consequences, since the no-go theorem does not hold for $SO(4)$. The 6 generators of $O(2,q)$ for S^2 give rise to 6 Higgs fields (bosons) through which fermions are coming into existence (mass and charge) by the Higgs mechanism as well as the massive bosons, for instance of the weak interaction $W^\pm$, Z^0. Finally, the 6 anti-Higgs bosons of $O(2,q)$ from subspace I^2 procure mass and charge, including imaginary mass for the particles representing non-ordinary matter.

This formulation also answers the important question: what is the *origin of physical fields and particles*? This question cannot be answered by *QFT*. In the context of H^8, it is straightforward to see that it is the *structure of the 8 internal* (*generalized*) *coordinates that give rise to physical fields*. Moreover, all fields are of geometrical nature, *i.e.,* possess their proper metric.

The 15 Hermetry forms (gauge fields) represent all aspects of matter that is, *fermions and bosons as well as the six fundamental physical interactions*. This includes the two novel gravitational field quanta, termed *neutral gravitophoton*, ν_{gp}^0, (attractive and repulsive), and a repulsive particle named quintessence, ν_q, that might explain dark energy, which, together with the graviton, give rise to the three gravitational fields predicted by *EHT*. The meaning of the 15 Hermetry forms is discussed below.

1. Hermetry forms H_1 to H_8 describe ordinary matter (OM), both fermions and bosons.

2. Hermetry forms H_1 and H_9 to H_{15} are describing non-ordinary matter (NOM). For instance, neutral leptons, e^0 (believed to be in the range of 40-45 GeV mass?), should exist.

3. Hermetry forms of ponderable mass (possessing a rest mass different from zero) have to contain subspace R^3 in their metric tensor.

4. Hermetry forms carrying any charge include subspace T^1 in their metric.

5. Only the photon can interact with NOM by being converted into a neutral gravitophoton, *i.e.*, $\gamma \rightarrow \nu_{gp}^0$.

6. Hermetry forms representing field quanta (messenger particles (bosons) that are mediating forces) have to contain subspace I^2 in their Hermetry form.

7. There is one exception, namely the graviton whose Hermetry form is $H_1 = H_1(\mathrm{S}^2)$.

8. NOM particles *do not contain sub*space R^3 in their Hermetry form, and are thus believed to possess imaginary mass. They may be generated in slids, but, because of their interaction with the lattice, do not behave like tachyons.

9. There is one exception, namely the neutral leptons, which belong to NOM, but have ponderable mass.

10. For NOM, the concept of virtual particle is extended to *virtual particles possessing imaginary mass but real charge*, which are assumed to be responsible for the conversion of photons into gravitophotons, thus establishing the interaction among electromagnetism and gravitation.

11. Each Hermetry form represents a *class of physical phenomena* or *particle family*, for instance, the six quarks or the eight gluons.

12. Dark matter, $H_{14}(\mathrm{R}^3 \times \mathrm{S}^2)$, might consist of neutral leptons, presumably the neutral tau particle τ^0 , that are lacking subspace T^1, which is present in the Hermetry form of the charged leptons.

13. The set of quarks is represented by Hermetry form $H(\mathrm{R}^3 \times \mathrm{T}^1 \times \mathrm{I}^2)$.

14. Gluons are given by Hermetry form $H(\mathrm{R}^3 \times \mathrm{I}^2)$.

Hermetry forms contain numerous partial terms in their metric, and therefore, represent families of particles or fields. For example, the quark Hermetry form contains 36 partial metric terms. In how far these partial structures are able to represent the entire range of physical properties of quarks and gluons, including their quantum numbers, such as mass, charge, color charge, weak charge, flavor *etc.* is not known at present. The spin of a particle does not seem to be directly contained in a Hermetry form.

This picture of symmetry groups is different from the current approach utilized in the standard model, since it results in a hierarchical group structure. In this regard, a single group describing all elementary particles like $E(8)$, as, for instance, postulated recently by Lisi [43, 44], *should not exist* in *Nature*.

The extremal principle in physics is characterized by the Lagrange density, and, as a simple example, we consider a charged particle in an electric potential whose Lagrangian is given by $\mathcal{L} = \frac{1}{2}mv^2 - e\Phi$. Replacing classical coordinates q_i by scalar fields φ^i gives the general formulation of the Lagrangian $\mathcal{L} = \partial_\mu \phi^\dagger \partial_\mu \phi - V(\varphi^\dagger \varphi)$. The writing of this formula deserves further explanation. In general, a Hermetry form is written as $H_\ell = H_\ell(\xi^a)$, where indices a are determined from the subspaces that occur in the metric of this form. The Lagrangian $\mathcal{L}_\ell$ associated with this H_ℓ, can, however, only depend on the three component scalar function $\phi = (\varphi^1, \varphi^2, \varphi^3)$, since its corresponding $O(3,q)$ group belongs to R^3. On the other hand, the potential function V is locally invariant as long as it depends on the product $\varphi^\dagger \varphi$. Moreover, a Hermetry form causes curvature in four-dimensional spacetime, which in turn determines the equations of motion. At the same time, the equations of motion for any kind of particle can be determined from its Lagrangian, and thus this Lagrangian should reflect its dependence on φ. We believe that a description of the Lagrangians, constructed from their associate Hermetry form, in the framework of the *nonlinear* σ*-model*, as given in the next section, should provide the hitherto missing link between geometry and physics.

2.3. Double Coordinate Transformation and the Non-Linear σ – Model

Einstein introduced the principle of geometrization in physics, which successfully identified the gravitational potential by the metric tensor of spacetime. However, his attempts to geometrize the other force fields, in particular the electromagnetic field, remained unsuccessful. An extension of the Einstein mono-metric tensor to a poly-metric tensor is needed to comprise the other force fields. Since physical fields were identified with Heim space H^8, it is straightforward to surmise that the coordinates ξ^a should be involved in the construction of the poly-metric. This should be done in such a way that if space H^8 is not present, the mono-metric of ξ^a *GR* is obtained. This is achieved by the so called double-coordinate transformation as demonstrated in Section 2.3.2. In addition, there is one more step, namely to find a physical principle that associates geometry with physics that is, $\xi^a \leftrightarrow \phi^a(\eta)$, finding a relationship between internal coordinates of H^8 and a set of scalar functions that will enter into the Lagrangian. Einstein, as is discussed at the end of this section, did not have such a principle and *simply postulated curvature equals energy*. In other words, matter curves spacetime.

In the following the mathematical details of constructing such a poly-metric tensor are presented, whose roots are going back to the ideas of Heim. However, it will turn out, that it is most important to be specific about the type and dimension of the internal space being introduced as well as the inherent symmetries (group structure) this space possesses. Moreover, it is of special consideration whether the Lie algebra associated with these groups' lives in a real or complex vector space, or a different mathematical field should be employed. As the discussion in Section 2.2.2 revealed, the mathematical field of quaternions, $\mathbb{H}$, should be applied instead.

As will be shown below, the poly-metric tensor that is obtained from the introduction of Heim space H^8, gives rise to a set of 15 metric subtensors or Hermetry forms that possess physical meaning, see Section 2.3.2. The concept of an internal 8D space, comprising four subspaces, as discussed above, leads to a modification of the general transformation employed in *GR*. In *GR* there are two sets of coordinates, Cartesian coordinates x and curvilinear coordinates η, linked by a relation between their corresponding coordinate differentials, Equations (21) and (22). If Heim space were not to exist, the poly-metric collapsed to the mono-metric of *GR*.

Having constructed a poly-metric tensor and its associated set of Hermetry forms, however, is only half of the task, providing, so to speak, the left hand side (curvature tensor) of the Einstein field equations. In order to establish a connection between geometry and physics, Einstein used the energy-momentum tensor $T_{\mu\nu}$ as the right hand side of his field equations. In the same way one could add the energy-momentum tensor of electromagnetism and arrive at a set of equations that describe both gravitational and electromagnetic phenomena. This ad hoc approach does not have any deeper physical interpretation, and adding the electromagnetic energy-momentum tensor does not even have a geometrical interpretation. Therefore, Weyl, in 1918, made a first attempt to construct a unified field theory by proposing that the length of a vector changes when parallel displaced. The change in length was dependent on a four-potential, identified with the vector potential of electromagnetism. However, this gave the unphysical result in that the natural frequencies of atoms changed according to their position in spacetime.

The construction process using H^8 results in a genuine poly-metric, but still the relationship between Hermetry forms and physical fields needs to be established. In Hauser and Dröscher [24], the real part of internal coordinates ξ^a in H^8 was already identified with scalar fields ϕ^a with $a = 1,\dots,8$. However, there is a mathematical formulation termed non-linear σ-model. Comparing the double coordinate transformation with this non-linear σ - model as described by Jost in [27], and identifying coordinates ξ^a with scalar fields ϕ^a, eventually leads to a Lagrange density in the action integral S of the non-linear σ model that can be expressed through the formula of the double coordinate transformation Equation (8). In this way, each Hermetry form is endowed with its proper Lagrangian.

2.3.1. Mono-Metric Tensor of GR

In *GR* there exists four-dimensional spacetime only, comprising three spatial coordinates with positive signature (+) and the time coordinate with negative signature (-). It should be remembered that the Lorentzian metric of R^4 has three spatial (+ signature) and one time-like coordinate (- signature). Signatures are not unique and may be reversed. Numbering of coordinates was chosen such that coordinates of positive signature are numbered first. The corresponding metric is called Minkowski metric and the spacetime associated with this metric is the Minkowski space. The plus and minus signs refer to the (local) Minkowski metric (diagonal metric tensor, see Equation (21). Therefore, the squared proper time interval is taken to be positive if the separation of two events is less than their spatial distance divided by c^2. Let coordinates x^μ with $\mu = 1,...,4$ denote Cartesian coordinates $x^1 = x,\ \ x^2 = y,\ \ x^3 = z,$ and $x^4 = ct$. A general coordinate system for a spacetime manifold, M, needs to be described by curvilinear coordinates η^ν with $\nu = 1,..,4$ and $\eta = (\eta^\nu) \in \mathsf{M}$. In *GR* the equations relating the two systems of coordinates are given by $x^\mu = x^\mu(\eta^\nu)$ or $\eta^\nu = \eta^\nu(x^\mu)$ and the distance between two neighboring events with coordinates η^ν and $\eta^\nu + d\eta^\nu$ is given by the square of the line element $ds^2 = g_{\nu\mu}\, d\eta^\nu d\eta^\mu, \nu, \mu = 1,...4$ where the metric tensor is of the form

$$g_{\nu\mu} = \mathbf{e}_\nu \cdot \mathbf{e}_\mu = \frac{\partial x^\alpha}{\partial \eta^\nu}\frac{\partial x^\alpha}{\partial \eta^\mu} \qquad \textbf{(3)}$$

and $\mathbf{e}_\nu = \partial \mathbf{x} / \partial \eta^\nu$ with $\mathbf{x} = x^\mu\, \hat{\mathbf{e}}_\mu$. The vectors $\mathbf{e}_\mu$ are the curvilinear (covariant) base vectors and $\hat{\mathbf{e}}_\mu$ denote the Cartesian unit vectors.

2.3.2. Poly-metric Tensor and Double Coordinate Transformation

In this section, the set of metric subtensors obtained from the ξ^a coordinates of H^8 is constructed. In turn, each of subtensor is describing a *class* of physical phenomena (physical interaction or particles). This leads to the concept of Hermetry form, which was introduced in Section 2.1. Thus, the connection between physical space and physics (symmetries) might be established in a way foreseen by Einstein, namely by the geometrical properties of spacetime, provided an additional principle can be found that allows to *calculate the energy-momentum tensor* $T_{\mu\nu}$ *from external* spacetime *and internal* space *coordinates*. This should be achievable by employing the nonlinear σ-model that was mentioned in Section 1.4 and will be further discussed below. However, in order to reach this objective, spacetime had to be complemented by an internal space H^8 to *model its intrinsic physical properties*. Once the internal space with its set of coordinates has been determined, everything else is fixed, and Equation (4) is a direct consequence of H^8. In contrast to *GR*, now the relation between the coordinate systems (x^μ) and (η^ν) is *via* the internal space with coordinates ξ^a that is $x^\mu = x^\mu(\xi^a(\eta^\nu))$ or $\eta^\nu = \eta^\nu(\xi^a(x^\mu))$. The mathematical and physical consequences, which are substantial, are discussed in the following two sections. The approach in *EHT* is fundamentally different, since a set of 15 different 4 × 4 metric tensors is constructed that all live in four-dimensional spacetime. The existence of internal space H^8 demands a more general coordinate transformation from a spacetime manifold In the concrete case of *GR* spacetime manifold M^4 would be used M to a manifold N *via* the mapping M (locally

R^4) $\to$ H^8 $\to$ N (locally R^4). In *EHT*, therefore, a double transformation, Equation (4), involving Heim space H^8 occurs. The global metric tensor is of the form

$$g_{\mu\nu} = \frac{\partial x^\alpha}{\partial \xi^a}\frac{\partial \xi^a}{\partial \eta^\mu}\frac{\partial x^\alpha}{\partial \xi^b}\frac{\partial \xi^b}{\partial \eta^\nu} = \frac{\partial x^\alpha}{\partial \xi^a}\frac{\partial x^\alpha}{\partial \xi^b}\frac{\partial \xi^a}{\partial \eta^\mu}\frac{\partial \xi^b}{\partial \eta^\nu} \quad \textbf{(4)}$$

and

$$g_{ab}(\xi(\eta)) := \frac{\partial x^\alpha}{\partial \xi^a}\frac{\partial x^\alpha}{\partial \xi^b} \quad \textbf{(5)}$$

where indices $a, b = 1,...,8$ and $\mu, \nu, \alpha = 1,...,4$, and thus $g_{\mu\nu}$ comprises 64 components. Length being geometric is invariant under such a re-parametrization, and thus Equations (3) and (4) describe exactly the same geometric object. So it seems that nothing has been achieved by this double coordinate transformation, since, obviously, all other geometrical features of the manifold remain also invariant.

However, the associated complete metric tensor (Equation (4)) with its total of 64 terms, Equation (6), *does not have any physical meaning by itself*. The construction process for the set of the Hermetry forms is *accomplished* as follows.

Extracting a certain number of terms from the global metric described by Equation (4) employing the selection rules mentioned above, the complete set of 15 different Hermetry forms is eventually obtained.

A single component of the metric tensor belonging to one of the four subspaces is given by Equation (6). Only special combinations of the $g_{ik}^{\alpha\beta}$ reflect physical quantities, *i.e.,* Hermetry forms. Because of the double transformation, each physically meaningful metric does comprise a different subset of the 64 components. In other words, depending on the Hermetry form, *via* index selection, only specified components from the complete metric tensor in spacetime, Equation (4), are chosen. Hence, each Hermetry form is marked by the fact that *only a subset of the 64 components* is present. This subset is different for each Hermetry form. Therefore each Hermetry form leads to a different metric in the spacetime manifold, and thus describes a different physical phenomenon. In other words, this approach is equivalent to the solidarity principle of Finzi, namely each class of physical phenomena (Hermetry form) determines its proper curvature in four-dimensional spacetime [32]. This is why Equation (4) is termed the *poly-metric tensor*. It serves as a *repository for the 15 Hermetry forms*. This construction principle is different from Einstein's approach. Only in the special case of vanishing space H^8, *EHT* reduces to *GR*,

$$g_{\mu\nu}^{ab} = \frac{\partial x^\alpha}{\partial \xi^{(a)}}\frac{\partial \xi^{(a)}}{\partial \eta^\mu}\frac{\partial x^\alpha}{\partial \xi^{(b)}}\frac{\partial \xi^{(b)}}{\partial \eta^\nu}. \quad \textbf{(6)}$$

The poly-metric tensor can be written as

$$g_{\mu\nu} = \sum_{a,b=1}^{8} g_{\mu\nu}^{a,b}. \quad \textbf{(7)}$$

A single Hermetry form is given by

$$g_{\mu\nu}(H_\ell) := \sum_{a,b\in H_\ell} g_{\mu\nu}^{a,b} =: \sum_{a,b\in H_\ell} (a,b). \quad \textbf{(8)}$$

Any Hermetry form can be written as the sum of its symmetric and anti-symmetric part, where indices S and A denote the splitting of the partial metric terms into their symmetric and anti-symmetric parts

$$(a,b)_S := \frac{1}{2}[(a,b)+(b,a)] \quad \textbf{(9)}$$

and

$$((a,b)_A := \frac{1}{2}[(a,b)-(ba)]\,. \quad \textbf{(10)}$$

For instance, the Hermetry form of the first neutral gravitophoton field which decays into a graviton and a quintessence particle, $\nu_{gp}^0 \to \nu_g + \nu_q$, is represented as

$$H(\nu_g + \nu_q) = H(\nu_g) + H(\nu_q) \quad \textbf{(11)}$$

where the Hermetry forms of the graviton and the quintessence particle can be written in the form

$$H(\nu_g) = (55)_S + (56)_S + (66)_S \quad \textbf{(12)}$$

and

$$H(\nu_q) = (77)_S + (78)_A + (88)_S \quad \textbf{(13)}$$

The metric tensor representing any Hermetry form can therefore be written in general form

$$g_{\mu\nu}(H_\ell) = \sum_{a,b \in H_\ell} (a,b)_{S,A} \quad \textbf{(14)}$$

The analysis of the recent experiments by Tajmar [13] led to the conclusion that four different partial gravitomagnetic fields should have been generated, whose strengths were calculated from those metric components describing both the graviton and quintessence particles. Further details can be found in [10].

2.3.3. Asymmetric Hermetry Forms

As the experiments by Tajmar *et al.* [11-13], Graham *et al.* [14] and also the anomalous spin drift observed at Gravity-Probe B have shown, the *magnitude of the gravitomagnetic field strongly depends on the direction of rotation* that is, the *gravitomagnetic field in clockwise direction differs substantially from the counter-clockwise field* leading to some kind of parity violation.

By assigning a spin or parity value to the respective Hermetry forms, a heuristic explanation is given for the experimentally detected asymmetry in the magnitude of the clockwise and counter-clockwise gravitomagnetic fields denoted as $\mathbf{B}_{gp}^{CW}$ and $\mathbf{B}_{gp}^{CCW}$.

To this end, we associate a value of $+1$ with each symmetric term, and 0 with each antisymmetric term in Equation (12). Next, the so called *strength* value, S (not to be confused with the symmetric subscript), for each Hermetry form is introduced. It should be noted that the various terms comprising a Hermetry form are representing physical potentials. The S value of a Hermetry form is therefore a measure of the strength of this potential, and hence determines the magnitude of the gravitomagnetic fields $\mathbf{B}_{gp}^{CW}$ and $\mathbf{B}_{gp}^{CCW}$. With respect to Equation (12) one finds

$$S(H(\nu_g)) = 3 \quad \text{and} \quad S(H(\nu_q)) = 2 \quad \textbf{(15)}$$

Now the strength values $S^{CW}(H(\nu_g + \nu_q))$ and $S^{CCW}(H(\nu_g + \nu_q))$ need to be determined. The argument of S reflects that, according to *EHT*, in the experiments by Tajmar *et al.* [11-13] as well as Graham *et al.* [14], the predicted neutral gravitophoton is decaying into a graviton and quintessence particle, *i.e.*, $\nu_{gp}^{02} \to \nu_g + \nu_q$.

In addition, two parity factors are introduced, namely $P_x = \pm 1$ and $P_t = \pm 1$. P_x is associated with space inversion $\mathbf{x} \to -\mathbf{x}$ that is, $P_x^{CW} = +1$ and $P_x^{CCW} = -1$. P_t denotes the time inversion parity parameter. Values $P_t^{CW} = +1$ and $P_t^{CCW} = \pm 1$ are postulated. We do this in order to reproduce the four ratios of CW and CCW gravitomagnetic fields, measured by Tajmar *et al.* [11-13] for different combinations of materials. However, the quantitative ratio of the CW and CCW gravitomagnetic fields is *calculated from the properties of the Hermetry forms* of ν_g and ν_q. For the CCW rotation P_t^{CCW} seems to depend on the material, but at present this dependence is not known.

The strength in CW direction is given by

$$S^{CW}(H(\nu_g + \nu_q)) = P_x^{CW} P_t^{CW} \left(S(H(\nu_g) + S(H(\nu_q)) \right) = 3 + 2 = +5 \quad \textbf{(16)}$$

where the arguments of the parity parameters are the same as for the S values. In a similar way the strength in the CCW direction is calculated

$$S^{CCW}(H(\nu_g + \nu_q)) = P_x^{CCW} P_t^{CCW} S(H(\nu_g) + P_x^{CCW} P_t^{CCW} S(H(\nu_q)) = (\pm 3) + (\pm 2)\,. \quad \textbf{(17)}$$

The four numerical values are.

$$S^{CCW}(H(\nu_g + \nu_q)) = (+5, +1, -1, -5)\,; \quad \textbf{(18)}$$

forming the ratio of Equations (16) and (18), gives four relative signal strengths for the gravitomagnetic fields in the CW and CCW direction of rotation.

In the latest measurements by Tajmar *et al.* [13] three experimental configurations A, B, and C are employed. Configuration C is not considered in this analysis, since the measured uncertainties are large and sometimes of the same magnitude as the measured quantities. Configuration C is, however, discussed in [10]. Analyzing the measured magnitudes of the gravitomagnetic field and taking the measurement uncertainties into account, the above determined four values can actually reproduce the measured ratios. However, the influence of the material on the gravitomagnetic field cannot be directly deduced at present.

If the gravity-like field is considered, the factor of 3/5 needs to be used in Equation (19), since only the graviton interaction is seen, while the quintessence particle does not contribute to the acceleration.

$$-\frac{1}{2}\int \frac{\partial \mathbf{B}_{gp}}{\partial t} \cdot d\mathbf{S} = \alpha_g^{-1} \oint \mathbf{E}_{gp} \cdot d\ell\,. \quad \textbf{(19)}$$

The gravity-like force is determined by integrating Equation (19) over the surface $\mathbf{S}$ of the Nb ring where vector $d\ell$ is taken positive in the direction along curve C that encloses surface $\mathbf{S}$.

2.4. Physical Meaning of Hermetry Forms

In this section the physical importance and meaning of Hermetry forms is summarized and their physical consequences are discussed. There are 15 admissible combinations of metric subtensors (termed Hermetry form) to which physical meaning is ascribed. A Hermetry form is denoted by H_ℓ with $\ell = 1, ..., 15$. It should be noted that for a final theory an internal space H^{12} might be needed, because there should exist an additional subspace, G^4, which is believed to be responsible for the *steering of the interference of probability amplitudes*. Since the present analysis is concerned with physical fields and particles, space H^8 is deemed to be sufficient.

A set of 12 Hermetry forms can be directly constructed using the selection rules that require the presence of coordinates of spaces S^2 or I^2, see Fig. **1**. In addition, there exist three so called *degenerated* Hermetry forms that is, these forms have the subspace combinations of the photon $\left(T^1 \times S^2 \times I^2,\ H_2\right)$, and neutrino $\left(\mathbb{R}^3 \times S^2, H_6\right)$, but several of the partial terms in the metric of these particles are missing. This results in particles that do not belong to ordinary matter, and consequently this type of matter is termed non-ordinary matter (NOM). There is also a degenerated form of the quintessence particle $\left(I^2,\ H_{10}\right)$, which is part of NOM, and represents the exchange particle for a repulsive gravity field, and thus might be attributed to dark energy. Hence three additional groups of Hermetry forms exist, giving a total of 15. The complete tables of OM and NOM particles/fields are given in [10, 24]. For the following discussion only two more NOM particles are mentioned. The first one is needed in the explanation of the gravitomagnetic experiments, namely the *imaginary photon*, $\gamma_I\left(H_{11}\right)$), which is responsible for the conversion of photons into gravitophotons, *i.e.,* interaction between electromagnetism and gravitational fields. The second one is called the neutral ($\approx 1GeV$ mass), which is one of the neutral leptons $\left(e^0, \mu^0, \tau^0, H_{15}\right)$ of NOM. There are also NOM particles of imaginary mass, which are *virtual particles* in the sense that they do not occur in the initial and final states of a process.

The corresponding conversion equations play a major role in the explanation of the experiments by Tajmar *et al.* [11-13], namely converting the electromagnetic into a gravity-like force, as well as in the proposed vertical gravity-like field propulsion experiment.

It is interesting to see that a Hermetry form of space $S^2 \times I^2$ describes neutral gravitophotons $\left(\nu_{gp}^0\right)$, and a Hermetry form constructed from space $S^2 \times I^2 \times T^1$ represents photons (γ). This is an indication that, at least on theoretical arguments, photons can be converted into gravitophotons, if somehow the time dependent part T^1 of the photon metric can be canceled. Fig. **1** shows the possible Hermetry forms in *EHT*.

For instance, the Hermetry form (photon metric) comprises only coordinates from subspaces T^1, S^2, and I^2 and is denoted by $H_2(T^1 \times S^2 \times I^2)$. The neutral gravitophoton Hermetry form is given by $H_9(S^2 \times I^2)$. Since gravitophoton and photon Hermetry forms are described by different coordinates, they lead to different Christoffel symbols, and thus to different geodesic equations, see Equation (26). Furthermore, if there were a physical process to eliminate the T^1 coordinates, *i.e.*, the corresponding Christoffel symbols are 0, the photon would be converted into a gravitophoton. This is how mixing of particles is accomplished in EHT. We believe this to be the case in the experiments by Tajmar *et al.* [11-13]. The fundamental question, naturally, is how to calculate the probability of such a process, and to determine the experimental conditions under which it can take place. Hermetry forms alone only provide the potential for conversion into other Hermetry forms, but nothing is said about physical realization. In any case, if Hermetry forms describe physical interactions and elementary particles, a completely novel scenario unfolds by regarding the relationships between corresponding Hermetry forms. Completely new technologies could be developed from the conversion of Hermetry forms. Fig. **2** depicts the six fundamental forces predicted by *EHT*. From the neutral gravitophoton metric and from the forces measured in the experiments by Tajmar *et al.* it is deduced that the gravitophoton decays into a graviton $\left(H_1\right)$ and a quintessence (H_9, repulsive) particle. Fig. **1** shows the set of metric-subspaces that can be constructed.

In addition, *six Higgs fields* should exist, whose lightest particle mass should have, according to considerations from *EHT*, a mass of 182.7 ± 0.7 GeV.

2.5. Six Fundamental Interactions

In physics a question of great importance concerns the number and type of fundamental physical interactions. So far this question has not been answered theoretically, but *experimentally four physical forces* have been observed. However, with the *advent of extreme gravitomagnetic and gravity-like fields* (as was shown in [20]) additional long range force fields are needed, which should be of gravitational type. The number and type of these novel fields should be derivable from the combined structure of internal space and external spacetime. Naturally, the number and type of these physical interactions depend on the dimension and structure of internal space H^8, since its composition of four subspaces eventually determines the set of the 15 admissible Hermetry forms, Section 2.2.2, and consequently predicts six fundamental forces.

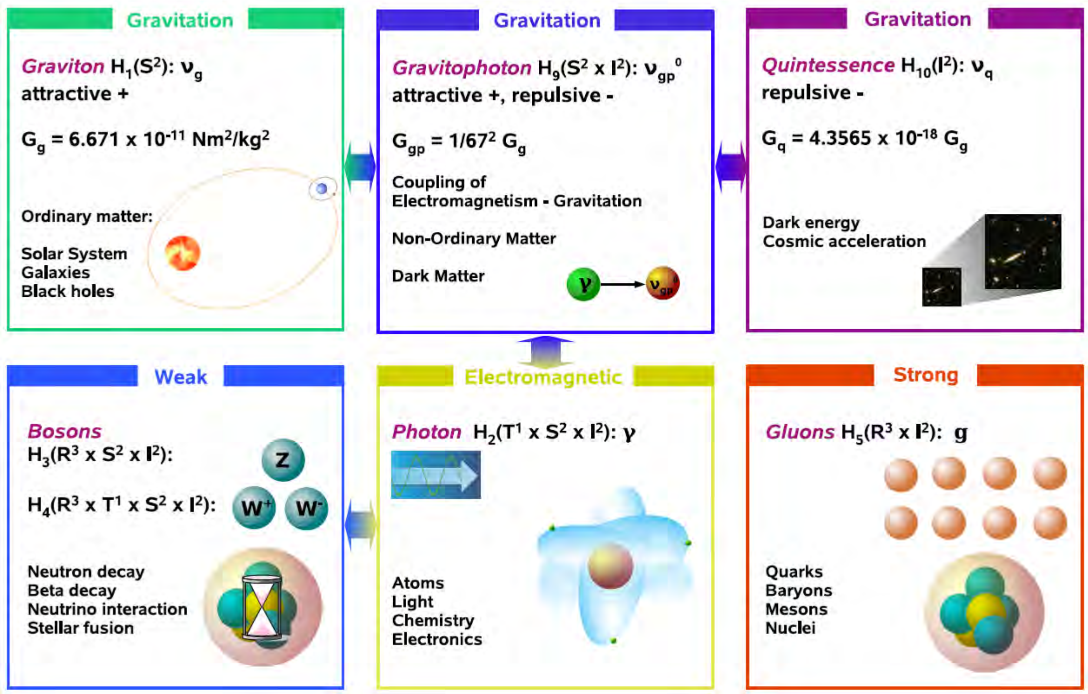

Figure 2: Six fundamental forces are predicted by *EHT*. Three of them are gravity-like fields, mediated by the graviton (attractive, upper left), gravitophotons (attractive and repulsive, upper middle), and the quintessence particle (repulsive, upper right).

Contrary to the ideas employed in *string* theory, see for example [33, 37], spacetime dimensions are not increased in *EHT*. Instead, at each point in spacetime there exists a local internal space H^8 (*internal* space *of eight dimensions*) that is responsible for the existence of all physical objects in spacetime, but is not part of spacetime. Physical spacetime is of *dual nature*, namely comprising external (four-dimensional spacetime) and internal space (Heim space H^8).

The crucial point lies in the construction of the internal space whose subspace composition has to come from basic physical assumptions, which must be generally acceptable [22]. The *coupling strengths* for the three gravitational fields, in the past, were calculated from set theory, *i.e.*, their values are obtained from pure mathematical considerations. However, a moreconvential way has been found, namely the Coleman-Weinberg potential. The arguments of a Hermetry form indicate the subspaces that are forming this metric tensor. The internal symmetry space H^8 comprises four subspaces, namely R^3 responsible for mass (energy), T^1 accounting for charge in general, S^2, for organization and I^2 for information. Hermetry forms can be converted into different forms by experimentally canceling certain subspace coordinates. Since *GR* does not possess any internal structure, it has a very limited geometrical structure, namely that of pure spacetime only. Because of this limitation, *GR* cannot describe other physical interactions than gravity, and consequently needed to be extended.

EHT in its present form without any quantization, *i.e.*, not using a discrete spacetime structure, reduces to the continuum *GR* when this internal space is omitted. The metric tensor, as used in *GR*, has purely geometrical means that is, it is of immaterial character and does not represent any physics. Consequently, the Einsteinian Geometrization Principle (EGP) is equating the Einstein curvature tensor, constructed from the metric tensor, with the stress tensor, representing energy-momentum distribution. In this way, the metric tensor field is related to a physical object whose behavior is governed by an action principle, like that of other physical quantities.

As will be presented in more detail in a forthcoming paper, but was briefly mentioned above, the non-linear σ-model, as given in the general mathematical formulation by Jost [27], can be used to construct the Lagrangian of the corresponding Hermetry form H_ℓ. In the following only the main idea is given. It should be remembered that Hermetry forms are obtained *via* index selection from the poly-metric tensor obtained by the double coordinate transformation incorporating internal space H^8. The internal coordinates ξ^a of subspaces R^3, T^1, S^2, and I^2 have physical meaning and are associated with *mass* (R^3), *general charge* (T^1), *organization* (S^2), and *information* (I^2). However, in spacetime only real physical fields of mass and charge are present. Identifying ξ coordinates with the vectorfield

$$\phi = ((\phi^1, \phi^2, \phi^3), (\phi 4), (\phi^5, \phi^6), (\phi^7, \phi^8)) \tag{20}$$

the function integral $S(\phi)$ for the corresponding Hermetry form representing a physical interaction is set up. The structure of ϕ is determined from the symmetry groups of the subspaces that are present in the respective Hermetry form.

As a consequence of internal Heim space H^8, this geometric approach predicts two further fundamental physical interaction fields, in addition to the four experimentally known ones. The nature of these two novel fields is gravity-like. The six fundamental interactions emerge in our four-dimensional spacetime and represent real physical fields carrying energy. The two additional interaction fields are identified as gravitophoton interaction (*i.e.*, the conversion of photons into a gravity-like field), and quintessence or vacuum interaction (a conversion of photons into a repulsive type of gravity-like field). The gravitophoton interaction is mediated by two massless, so called gravitophoton particles, one which is gravitationally attractive, and the other one is gravitationally repulsive. The massless quintessence or vacuum interaction particle mediates a very weak repulsive gravity-like force that is much smaller in magnitude than the gravitophoton interaction.

Now the important question poses, namely under which experimental circumstances do these interactions manifest themselves as real physical phenomena? The answer is that in the experiments by Tajmar *et al.* [11-13] Graham *et al.* [14] as well as possibly in the Stanford-NASA Gravity Probe-B experiment these novel physical phenomena might have become visible. This will be discussed in more detail in the subsequent section. Moreover, dark matter and dark energy might be interpretable as the result of the novel gravitational interactions.

Hence, according to *EHT*, the gravitational force that we experience is composed of three different fundamental interactions, having six interaction quanta, namely two different neutral gravitophotons that can decay *via* two modes. The first mode gives a decay into a graviton (the usual graviton of quantized *GR* theory) and the repulsive quintessence particle. The second mode results in two gravitophotons - one being attractive, the other one repulsive. The gravitophoton and quintessence interactions should be invariant under an SO(4) group and not SO(3, 1), see [10]. The laws of momentum and energy conservation are strictly obeyed, but both *ordinary and non-ordinary matter* must be accounted for [10].

This means that the gravitational constant G contains contributions of all three gravitational constants, termed G_g, G_{gp} and G_q, respectively. The internal coordinates of H^8 depend on the local (curvilinear) coordinates of spacetime. This is analogous to gauge theory in that a local or gauge transformation is used. In gauge theory it is the particles themselves that are given additional degrees of freedom, expressed by an internal space. Consequently in the geometrization of physics, it is spacetime *instead of elementary par*ticles that has to be provided with internal degrees of freedom.

The introduction of an internal space has major physical consequences. The structure of H^8 determines the number and type of physical interactions, and subsequently leads to a polymetric. This means that spacetime *comprises both an external and internal structure*. In general, only the external structure is observed, but it has long been known experimentally that matter can be generated out of the vacuum. This is a clear sign that spacetime has additional and surprising physical properties. Therefore, any physical theory that aims at describing physical reality needs to account for this fact. Since *GR* uses pure spacetime only, as a consequence, only part of the physical world is visible in the form of gravitation.

This idea of constructing a polymetric was first conceived by the German physicist B. Heim. A similar principle was mentioned by the Italian mathematician Finzi. The polymetric tensor resulting from this concept is subdivided into a set of sub-tensors, and each element of this set is equivalent to a physical interaction or group of particles, and thus the complete geometrization of physics is achieved. This is, in a nutshell, the strategy chosen to accomplish Einstein's lifelong goal of geometrization of physics. There is of course a second aspect, namely the quantization of the spacetime field. The general theory of Einstein was the first theory to show that fundamental symmetries should have a local character.

It must be noted that this approach is in stark contrast to elementary particle physics, in which particles possess an existence of their own and spacetime is just a background staffage [38]. In *EHT*, considered as the natural extension of *GR*, matter is a consequence of the additional internal physical features of spacetime. These two physical pictures are mutually exclusive, and experiment will determine which view ultimately reflects physical reality. It is, however, well understood that the concept of a point-like elementary particle is highly useful as a working hypothesis in particle physics.

2.6. Geometrization of Physics and the Equations of Motion

Gravity manifests itself as spacetime curvature. If this principle is accepted as the basis for all interactions in physics, a polymetric tensor needs to be constructed. The polymetric tensor describes the complete dynamics of spacetime and leads to a geometrodynamic picture of all physical interactions. In *GR* the geometrical structure of spacetime leads to a single metric that describes gravitational interaction. Einstein's pioneering efforts in the geometrization of physics revealed themselves unsuccessful [8] when more interactions were discovered, and attempts to geometrize physics were abandoned. Einstein did not succeed in constructing a metric tensor that encompassed all physical interactions.

Einsteinian spacetime [37, 42] is indefinitely divisible and can be described by a differentiable manifold. In the following derivation, which relates the metric tensor to physical interactions, this classical picture is used, though spacetime should be treated as a quantized field. The quantization of spacetime seems to play a role in the concept of hyperspace or parallel space [17].

GR can be summarized in a single sentence: *matter curves* spacetime. In curved spacetime the metric is written in the form

$$ds^2 = g_{\mu\nu} d\eta^\mu d\eta^\nu \tag{21}$$

where $g_{\mu\nu}$ is the metric tensor, η^1, η^2, η^3 are the spatial coordinates, and η^4 is the time coordinate. These coordinates can be curvilinear. Einstein summation convention is used, *i.e.*, indices occurring twice are summed over. From the strong equivalence principle it is known (for instance see [41]) that at any point in spacetime a local reference frame can be found for which the metric tensor can be made diagonal, *i.e.*, $g_{\mu\nu} = \eta_{\mu\nu}$ where $\eta_{\mu\nu}$ is the Minkowski tensor. Note that the Minkowski tensor $\eta_{\mu\nu}$ must not be confused with curvilinear coordinates η^μ. Reference coordinates are locally Cartesian $(x^1, x^2, x^3, x^4) = (x, y, z, ct)$. This is equivalent to a transformation between the two sets of coordinates, namely

$$dx^\mu = \Lambda^\mu_\nu \; d\eta^\nu \text{ and } \Lambda^\mu_\nu = \frac{\partial x^\mu}{\partial \eta^\nu} \tag{22}$$

In the free fall frame of the x coordinates the acceleration is 0, and thus the equation of motion simply is

$$\frac{d^2 x^\mu}{d\tau^2} = 0 \text{ and } ds^2 = \eta_{\mu\nu} \; dx^\mu dx^\nu \tag{23}$$

where τ denotes proper time, *i.e.*, the time registered by a clock in its own reference frame. This means the clock is stationary in this frame, and the time measured is the time shown on the clock's dial. In order to obtain the equation of motion for curvilinear coordinates η, one only needs to insert the transformation relations, Equation (22) into Equation (23), which results in the geodesic equation

$$\frac{d^2\eta^\alpha}{d\tau^2} + \Gamma^\alpha_{\mu\nu}\frac{d\eta^\mu}{d\tau}\frac{d\eta^\nu}{d\tau} = 0 \tag{24}$$

where the $\Gamma^\alpha_{\mu\nu}$ are the well known Christoffel symbols or affine connections. Rewriting the geodesic equation (24) in the form

$$\frac{d^2\eta^\alpha}{d\tau^2} = f^\alpha \text{ with } f^\alpha = -\Gamma^\alpha_{\mu\nu}\frac{d\eta^\mu}{d\tau}\frac{d\eta^\nu}{d\tau} \tag{25}$$

and comparing Equation (25) with the equation of motion for a free falling particle Equation (23), the right hand side of Equation (25) can be regarded as a force coming from a physical interaction, which has caused a curvature of the surrounding space, marked by the presence of nonzero Christoffel symbols.

The metric of the proper equation of motion is determined by the Hermetry form obtained from Equation (14). The respective Christoffel symbols denote the physical fields of this Hermetry form. In *GR* mass (matter particles) distributions are determining spacetime geometry, while in electrodynamics the electromagnetic field (waves) is connected to its spacetime geometry. However, in the microscopic world, matter-energydistribution possesses both particle and wave character, which cannot be separated from each other. The existence of the 15 Hermetry forms suggests that the structure of the Einstein field equations provides the framework of the field equations for all physical interactions. This means, Einstein's equations should be representative also for the microscopic world, transcending gravitation and electromagnetism, see Section 2.2. The left hand side of equation (25) can be written as $m_I\mathbf{a}$ where m_I denotes inertial mass and $\mathbf{a}$ is acceleration. Multiplying f^α by its proper charge results in the equation of motion for the respective physical interaction. In the case of gravity, because of the equality of inertial and gravitational mass, charges on the left and right hand sides cancel out. For all other physical interactions this is not the case. In that respect *gravity has a unique role, namely that it curves also the surrounding* space. For all other physical interactions, if pointlike charges are assumed (classical picture), space is curved only at the location of the charge.

One major point of course is that the relation $x = x(\eta)$ as used in *GR* delivers only a single metric, which Einstein associated with gravitation. The *fundamental question is, therefore, how to construct a metric tensor that gives rise to all physical interactions*. The answer lies in the fact that in EHT there exists an internal space H^8. Therefore, in *EHT* the relation between coordinates x and η is $x = x(\xi(\eta))$. In contrast to *GR*, EHT employs a double transformation as specified in Equation (4). From this double transformation a set of different metric tensors can be constructed, which, in turn, lead to a set of individual geodesic equations having the same structure as Equation (25), but depending on the specific charge and Christoffel symbols inherent to this specific physical interaction. An individual equation of motion will have the form

$$m_I\frac{d^2\eta^\mu}{d\tau^2} = e_c f_c^\mu \text{ with } \mu = 1,\ldots,4 \tag{26}$$

where e_c denotes the specific charge of the interaction and quantities f_c^μ are the associated Christoffel symbols. The equation of motion describes a particle of mass m_I with charge e_c, subjected to the respective field of this interaction, represented by its proper Christoffel symbols, *i.e.*, they stand for the curvature of space generated by this interaction. The total number of physical charges e_c is determined by the subspace structure of H^8 in concert with combination rules to constructing a metric that has physical meaning. Equation (26) describes a very difficult physical problem. First, the number of physical charges and their coupling constants need to be determined. There should exist twelve Higgs fields (two $O(2,q)$ groups) that endow physical particles (fields) with their inherent charges. Therefore, all particles of OM or NOM (as described in [9, 24]) are supposed to interact with their respective Higgs particle (field) in order to obtain their corresponding charges (*e.g.,* color, gravitational mass or electric charge *etc.*), but their inertia (energy) should come from group $O(1,q)$, which denotes a special Hermetry form, H_{16} from subspace T^1, related to energy (mass) *via* $\Delta E \Delta t = \hbar$. It is remarkable that the 15 generators of the $O(3,q)$ group define the existence of all possible particle (field) families, *i.e.,* the existence of physical phenomena in material or energetic form is fixed by this symmetry group. It should be noted that the set of 15 families comprises six fermions (quarks, electrons and neutrinos as well as neutral electron, imaginary electron and imaginary quark) in combination with the nine gauge bosons (graviton, photon, vector bosons $W^{\pm}$ and Z^0, gluons as well as imaginary gluon, imaginary photon and the additional gravitational particles, namely the gravitophotons and quintessence particle. The double transformation as given in Equation (4) represents the particle aspect and leads to eigenvalue equations whose eigenvalues have the dimension of an inverse length. In these eigenvalue equations the Christoffel symbols occur. Using the inverse of the Planck length expressed as $m_p c/\hbar$, results in a correspondence between inverse length and mass. Since particles and fields form a unity, the transformation from spacetime into internal space, $\mathsf{M} \to \mathsf{H}^8$, should represent the field aspect, because derivatives of internal coordinates $\xi^a, a = 1,...,8$ with respect to curvilinear coordinates η^μ lead to an expression $\left(e_c^a / m_I\right) h_{\mu\nu}^a$. The $h_{\mu\nu}^a$ denote deviation from the flat metric, and physically represent the tensor potential of the charge e_c^a with m_I as associated inertial mass. The metric coefficients thus assume energy character. This short discussion implies a comprehensive mathematical program, namely the determination and solution of the above mentioned eigenvalue equations as well as the derivation of the tensor potentials for the interactions. The task is not finished, but this brief discussion should have conveyed an idea how the introduction of an internal symmetry space leads to a correspondence between geometry and physical quantities. The mathematical framework to determine the charges and to obtain the correspondence between geometry and physics is quite involved. It seems that internal coordinates are described by quaternions. There is an interesting question, namely: *What is the Hermetry form of the vacuum field*? If the vacuum has an energy density different from zero, it should not be the case that its Christoffel symbols are 0. However, we feel, in order to answer this question, a quantization procedure for Equation (26) has to be established. *This approach differs substantially from GR, and should lead to the complete geometrization of physical interactions.*

2.7. Fundamental Interactions and their Field Equations

If each physical interaction causes its own spacetime curvature, the structure of the Einstein field equations should provide the mathematical frame for the description of all six forces. In the following it will be shown how, at least in principle, these equations can be constructed. In general, spacetime curvature is small, *i.e.,* except for black holes, neutron stars *etc.*, and thus the metric tensor can be linearized

$$g_{\mu\nu} = \eta_{\mu\nu} + h_{\mu\nu} \tag{27}$$

and Cartesian coordinates

$$(x^\mu) = (x, y, z, ct),\ \mu = 1,...,4. \tag{28}$$

The geometric part of the Einstein equations, that is, the part describing spacetime curvature, can be written as

$$R_{\mu\nu} = \frac{1}{2}\left(\Delta - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}\right); \tag{29}$$

$$h_{\mu\nu} = \frac{1}{2}\Omega\, h_{\mu\nu}\,, \tag{30}$$

where denotes the d’Alembertian wave operator. In a space free of matter

$$\Omega\, h_{\mu\nu} = 0 \quad \textbf{(31)}$$

and thus gravity waves should be possible. In the case of non-relativistic velocities $v << c$ and neglecting pressure as well as internal energy distributions in the energy-momentum tensor, *i.e.,* there is only one component $T_{44} \approx \rho c^2$ where ρ denotes mass density, the time-independent Einstein field equations lead to

$$\Delta\, h_{44} - \frac{1}{c^2} R\, h_{44} = 2\kappa\, T_{44} \,. \quad \textbf{(32)}$$

However, the *Einstein equations are not self-consistent*, since the energy-momentum tensor is a different physical entity, and has to be supplied from the outside, *i.e.,* does not result from the geometry of spacetime. In order *to make this system self-consistent* it is assumed that in general

$$T_{\mu\nu} = T_{\mu\nu}(g_{\alpha\beta}) \,. \quad \textbf{(33)}$$

Regarding a special Hermetry from H_ℓ the energy-momentum tensor in accordance with this Hermetry form can be formally written as

$$T_{\mu\nu} = T_{\mu\nu}(H_\ell) \,. \quad \textbf{(34)}$$

For the above mentioned special case a linear relationship is assumed in the form

$$T_{\ell;44} = k_\ell\ \rho_\ell\ h_{\ell;44} \quad \textbf{(35)}$$

where the index ℓ denotes the Hermetry form and k_ℓ is a specific constant. The quantity $m_\ell(i.e., \rho_\ell)$ describes the type of mass-energy belonging to H_ℓ. If the rest mass is different from 0, it is believed that an eigenvalue equation can be derived from geometrical principles whose spectrum gives the physically admissible particle masses, in a similar sense as already postulated by Heim. Thus a complete geometrodynamic approach would be accomplished.

3. PHYSICS AND MATHEMATICS OF EXTREME GRAVITATIONAL FIELDS

The gravitomagnetic effect as known from *GR* that is, the *Lense-Thirring* effect cannot be utilized to explain the experiments of Tajmar *et al.* [11-13], nor can it serve as propulsion principle, because of its extremely small magnitude. When the Einstein-Maxwell (the linearized Einstein field equations) equations are employed in the explanation of the extreme gravitational fields, it becomes obvious that neither the magnitude nor the sign of the acceleration field measured by Tajmar *et al.* is described correctly. A physical model that aims at providing a phenomenological framework of extreme gravitational fields cannot be based on these equations.

The conclusion is that the laboratory generated extreme gravitomagnetic fields are, because of their enormous field strength, outside *GR* and also the gravity-like fields. It is these gravity-like fields that might be usable as basis for a novel technology of energy generation as well as (space) propulsion principle. In the next section the physical model for the generation of extreme gravitational fields is outlined. One of the key issues is that gravity-like fields are produced by conversion of electromagnetic into gravitational fields, which might explain their strength. Needless to say, this requires the introduction of novel physical concepts.

3.1. Physical Principles of Gravitational Field Generation

At present, theoretical physics does not foresee an interaction between electromagnetic and gravitational fields, *i.e.*, no terms coupling the Maxwell equations with the Einstein-Maxwell equations are known. In the following, a brief discussion of the fundamental physical mechanism deemed to be responsible for the generation of extreme gravitational fields is given.

Some aspects have been discussed in [9, 20, 24], but a more comprehensive discussion will be given in a forthcoming review paper [Preprints are available through the authors]. In this article we present the set of basic equations and physical mechanisms that make up the phenomenological theory for calculating extreme gravitational fields.

First, no explanation within the framework of current physics seems to be possible. Either the recent experiments by Tajmar *et al.* [11-13] and Graham *et al.* [14] somehow misinterpret unknown disturbances as large gravitomagnetic fields, or some novel physics does exist. As a reminder, it should be noted, that despite its name, a gravitomagnetic field is a purely gravitational field. There is no magnetic component or interaction with electrodynamics. The name was derived from the similarity of the Einstein-Maxwell equations with the Maxwell equations. Gravitomagnetism represents the dynamic nature of matter.

A similar situation seems to exist regarding the strong gyro misalignment observed in the GP-B experiment. Although the NASA-Stanford University team claims that there is an electrostatic patch effect (the Nb coated quartz sphere of the gyro is not a perfect equipotential surface) there could be room for the effect seen in Tajmar's experiments. It should be noted that the torque acting on the spinning cryogenic gyros is given by $\mathbf{N}_g = \frac{1}{2}m(\omega \times \mathbf{r}) \times \mathbf{B}_{gp}$. According to *EHT*, at cryogenic temperatures the four gyros used in the GP-B experiment should produce their own $\mathbf{B}_{gp}$ field due to the same phenomenon, which in turn would be the source of a major gyro misalignment by producing a substantial torque in comparison to the small effect of *GR* frame dragging. An analysis for the GP-B experiment was performed in [20].

3.2. Conservation Principles

Physics is governed by symmetry (invariance) where each symmetry stands for a conservation law, termed Noether's principle. Momentum conservation is derived from the homogeneity of space, which means that the Lagrange function is independent of its position in space that is, invariant under translation. Therefore, its variation δL must satisfy $\delta L = 0$ for a translation from $\mathbf{x}$ to $\mathbf{x} + \mathbf{a}$ where $\mathbf{a}$ is a constant vector. Since spacetime is four-dimensional, the homogeneity in time stands for the invariance of the Lagrangian with respect to translation in time. This is expressed by the fact that the Lagrangian does not depend explicitly on time, *i.e.*, $L = L(q_k, \dot{q}_k)$.

There is a stern rule governing all classical physics and, in particular, applies to all propulsion systems: identify the physical system and wrap a closed surface, control surface (CV), around it. Check the amount of momentum going through the CV. What is going on inside the physical system is of absolutely no interest. If this amount is zero, there is no momentum change, and thus no propulsion. Time and again, this principle has been misunderstood, for instance, confusing energy with momentum (all our propulsion is non relativistic). Moreover, the definition of physical system is not always straightforward.

In *EHT*, the spacetime field itself is part of the physical system. The propulsion principle is similar to the Mossbauer effect (the large crystal absorbs the recoil momentum of the particle) that is, the momentum of spacetime is changed almost imperceptible, but the space system is accelerated. The key issue is to find a physical concept that can achieve a sufficiently strong interaction with spacetime, *i.e.,* not through frame-dragging as takes place in *GR* which is far too weak.

The present principle of propellantless propulsion *via* gravity-like fields is different from the above concept in that it involves the spacetime field itself through gravitomagnetic interaction as part of the physical system that is, there is an exchange of momentum and energy between the space vehicle and the local spacetime. The amount of this exchange is determined by the magnitude of the generated $\mathbf{B}_{gp}$ field. The spacetime field that is, electrogravitic and gravitomagnetic fields have just as much claim to reality a the original concept of momentum as electric and magnetic fields together with the charged particles, *i.e.*, gravitational (mass) and electric charge. Momentum is transferred from a charge to the field, through the field, and perhaps to other charges. Therefore, any propulsion system based on gravity-like fields is based on strong interaction, compared to *GR*, with the surrounding spacetime. The experiments at AIT have already demonstrated that these fields are about 10^{18} times stronger than those produced by movable masses. It is conjectured that the accelerated expansion of the *Universe* might be a direct consequence of universal momentum conservation that is, the physical system that comprises all masses in the *Universe* as well as spacetime field [31].

3.3. Ginzburg-Landau Theory of Extreme Gravitational Fields

First, if *one accepts the existence of gravity-like fields from the measurement by Tajmar et al.* [11-13], the question naturally arises: how are these extreme gravitational fields possible? In Section IV of [20] it is shown that none *of the four known fundamental physical interactions* can explain the nature and magnitude of these fields.

It is believed that the physics of extreme gravitational fields is a solid state phenomenon, owing to the formation of a Bose-Einstein condensate *via* a phase transition at a cryogenic temperature T_C, but caused by a new type of matter, which has similarities to superconductivity, but the underlying physical mechanism is believed to be entirely different, representing novel physics.

The analysis that we are presenting here does not aim at explaining the physics of the extreme gravitational fields in that a microscopic quantum theory is presented in the form of the BCS (Bardeen, Cooper, and Schrieffer) theory [21]. BCS theory describes the phenomena within the superconductor, *i.e.,* the physical reasoning why Cooper pairs (phonon coupling of two electrons of opposite momentum and spin) are formed, what their features are, and why they are able to move without friction through the lattice.

Instead, the physics of extreme gravitational fields is treated as an application of the Landau theory of phase transitions to superconductivity combined with the novel concepts of matter of imaginary mass and the possibility of converting imaginary electromagnetic fields (*i.e.,* their origin is from imaginary matter) into gravitational fields.

We accept the pragmatic standpoint of London, by simply saying that superconductivity is characterized by zero friction and thus Ohm's law has to be replaced, leading to a different relation between current density and vector potential. Maxwell's equations are still entirely true, but have to be complemented by the London equations. The same is assumed to hold true for the current of imaginary bosons, denoted e_I^B, formed *via* phase transition by a multiple (even number) of the imaginary electrons e_I in analogy to Cooper pairs. How this mechanism actually takes place is of no concern at the moment; neither is the calculation of the density n_I of the e_I^B bosons, nor their coupling strength or the penetration depth of the gravitomagnetic field. No attempt is made to determine the critical temperature T_C. These questions can be addressed later on, when the phenomenon of extreme gravitational fields is firmly established.

Two fundamental and completely novel physical concepts are introduced, stated below, namely

1. The existence of particles of imaginary mass, *i.e.,* the imaginary electron e_I which has the same charge as its counterpart the real electron, and the imaginary quark q_I. There is only one imaginary quark that should have the elementary charge $+e$. The q_I particle is assumed to be generated within the proton, but then there is also a fourth gluon color termed the *imaginary color* ic, and thus a *total of 15 gluons exists*. Imaginary matter is a direct consequence of the concept of Hermetry form, which is graphically represented by the four-dimensional hypercube as published in [24]. In other words, the implication of the 16 Hermetry forms is the extension of the concept of matter from real to imaginary. Imaginary matter should not be directly visible, but its presence can be deduced from the existence of the extreme gravitational fields.

2. The conversion (phase transition) from electromagnetic into gravitational fields is the key process for generating extreme gravitational fields. In order to achieve this type of hitherto

unknown conversion, the existence of matter of imaginary mass in the form of imaginary electrons e_I and quarks of imaginary mass q_I were instrumental. Imaginary matter is not directly observable, but its presence can be deduced form the existence of the extreme gravity-like fields.

Therefore, in analogy to the successful semi-classical explanation of Bose-Einstein condensates, for instance the phenomena of superconductivity, ferro-magnetism, superfluidity, or spin waves, the phenomenological mathematical description of extreme gravitational fields is based on a similar phenomenological approach in which the ideas of due to London, Ginzburg, and Landau are combined with the concept of mass of imaginary matter and the conversion of electromagnetic into gravitational fields.

That is, the generation of extreme gravitational fields is characterized by the following equations and/or physical processes

- For electrodynamic phenomena the Maxwell equations are utilized, however, modified by the London equations, similar to the case of superconductivity, to account for the phase transition,

- The gravitational field mediated by gravitons ν_g that is, Newtonian gravitation, is not described by the equations below, since it solely depends on mass (stationary or moving) and is governed by the Einstein-Maxwell equations derived from *GR*, its respective coupling constant is G_N,

- The modified Einstein-Maxwell equations of gravity (which are different from the linearized version of the Einstein field equations of *GR*) and

- The London-Einstein equations that is, the London equations employed to the gravitolelectric field $\mathbf{E}_G$ and the gravitomagnetic field $\mathbf{B}_G$, where the index G now stands for the two gravitational fields, mediated by gravitophotons ν_{gp} or the quintessence particle ν_q. The respective coupling constants are G_{gp} and G_q as given in [24].

- The Ginzburg-Landau theory in conjunction with a magnetic induction field $\mathbf{B}$ whose presence leads to the *asymmetric potential* as shown in [24]. In the Heim experiment such a field is generated by the external current in the coil.

- The assumption of a phase transition responsible for the conversion of the imaginary electromagnetic vector potential into a gravitophoton field, *i.e.,* $e0.328\alpha_{gp}\mathbf{v}\cdot\mathbf{A}_{e_I} + m_p\mathbf{v}\cdot\mathbf{A}_{gp} = 0$ with the conversion factor $\alpha_{gp} = 1/212$ calculated from the Coleman-weinberg potential as derived by Kaku [34],

- When the phase transition occurs, no symmetry breaking is taking place and instead imaginary particles are produced, *i.e.*, imaginary electrons e_I and imaginary quarks q_I, because of the asymmetric shape of the potential curve. These particles are not tachyons, because of their electromagnetic interaction with positive charges of the crystal lattice.

The following sets of equations are utilized. The Maxwell equations in differential form are given by

$$\mathbf{E} = -\nabla\Phi \text{ and } \mathbf{B} = \nabla\times\mathbf{A} - \frac{\partial\mathbf{A}}{\partial t} \qquad \mathbf{(36)}$$

$$\nabla\cdot\mathbf{E} = \frac{1}{\varepsilon_0}\rho \qquad \mathbf{(37)}$$

$$\nabla\cdot\mathbf{B} = 0 \qquad \mathbf{(38)}$$

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{j} \quad \textbf{(39)}$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t} \quad \textbf{(40)}$$

where the electric displacement current $\partial \mathbf{E} / \partial t$ was neglected in Ampere's law Equation (39) and $\varepsilon_0 \mu_0 c^2 = 1$, $\mu_0 = 4\pi \times 10^{-7}\, N/A^2 = 1.256 \times 10^{-6}$ Vs/Am, and $\varepsilon_0 = 8.854 \times 10^{-12}$ As/Vm.

Now we consider the Einstein-Maxwell formulation of linearized gravity that possesses a certain similarity to the mathematical form of the electromagnetic Maxwell equations. In analogy to electromagnetism there also exist gravitational scalar and vector potentials, denoted by Φ_G and $\mathbf{A}_G$, respectively [35].

$$\mathbf{E}_G = -\nabla \Phi_G \quad \text{and} \quad \mathbf{B}_\text{G} = \nabla \times \mathbf{A}_\text{G}. \quad \textbf{(41)}$$

If the original Einstein field equations are expanded up to first order, see for instance Thorne [36], and introducing the corresponding gravitoelectric and gravitomagnetic fields, one obtains the following set of equations for Newtonian gravitation:

$$\nabla \cdot \mathbf{E}_{G_N} = -4\pi G_N \rho \quad \textbf{(42)}$$

$$\nabla \cdot \mathbf{B} G_N = 0 \quad \textbf{(43)}$$

$$\nabla \times \mathbf{B}_{G_N} = -\frac{16\pi G_N}{c^2} \mathbf{j} \quad \textbf{(44)}$$

$$\nabla \times \mathbf{E}_{G_N} = 0 \quad \textbf{(45)}$$

where $\mathbf{j} = \rho \mathbf{v}$ is the mass flux and G_N is Newton's gravitational constant. The field $\mathbf{E}_{G_N}$ describes the gravitational field from a stationary mass distribution, whereas $\mathbf{B}_{G_N}$ describes the gravitomagnetic field produced by moving masses.

The linearized version of Einstein's equations of *GR*, Equations (43) and (45), have been cast in a mathematical form that resembles the Maxwell equations of electrodynamics, but there are two major differences.

First, it can be seen that there is *no equivalent equation to Faraday's induction law*, since the term $-\partial \mathbf{B}_{G_N} / \partial t$ is absent because the expansion is of first order in terms of v / c only. Including second order terms would restore this term, but also *would lead to additional terms* in the other equations, thus clearly changing the Maxwellian character of the Einstein-Maxwell equations.

Second, comparing the signs of the Maxwell and Einstein-Maxwell equations, there is a minus sign in the source term of the first Einstein-Maxwell equation, which causes Newtonian gravity to be always attractive. Equation (45) is the result from *GR* and therefore the index G_N is used. Comparing the stationary Maxwell and Einstein-Maxwell equations, they can be given exactly the same structure, if $\mathbf{E}_{G_N}$ and $\mathbf{B}_{G_N}$ are multiplied by -1 and redefined as new gravitoelectric and gravitomagnetic fields.

However, the Einstein-Maxwell equations *cannot be employed* in describing gravitomagnetic phenomena caused by gravitophotons. To distinguish the gravitomagnetic field generated by gravitophotons it is denoted as $\mathbf{B}_{gp}$. Because of the phase transition that is responsible for the bosons of imaginary mass that are generating an imaginary supercurrent, the source term $\mathbf{j}_{gp}$ for the extreme gravitomagnetic field $\mathbf{B}_{gp}$ is large, and therefore the term $\partial \mathbf{B}_{gp} / \partial t$ from gravitophoton interaction could become large and thus must appear in the equations. In the equation that is analog to Ampere's law, the term $\partial \mathbf{E}_{gp} / \partial t$ might play a role, but for the Heim experiment it is set to 0 . Since the masses in both the Heim and Tajmar experiments are exceedingly small, the divergence for the $\mathbf{E}_{gp}$ is set to 0 . The *const* in the gravitational Ampere law still needs to be determined. The mass flux from the spinning disk is also negligible that is, the gravitomagnetic field $\mathbf{B}_{G_N}$ generated from *GR* can be safely neglected as well. Therefore, the mathematical form of the equations describing the generation of extreme gravitomagnetic fields, the Einstein-Heim-Maxwell (EHM) equations, expressed as a set of partial differential equations, are assumed to have the form

$$\nabla \cdot \mathbf{E}_{gp} = 0 \tag{46}$$

$$\nabla \times \mathbf{E}_{gp} = -\frac{1}{2}\alpha_g \frac{\partial \mathbf{B}_{gp}}{\partial t} \tag{47}$$

$$\nabla \times \mathbf{B}_{gp} = const\ \mathbf{j}_{gp} + 2\alpha_g^3 \frac{1}{c^2}\frac{\partial \mathbf{E}_{gp}}{\partial t} \tag{48}$$

$$\nabla \times \mathbf{B}_{gp} = const\ \mathbf{j}_{gp} \tag{49}$$

$$\nabla \cdot \mathbf{B}_{gp} = 0 \tag{50}$$

It should be emphasized that the source in the rotation of the gravitomagnetic field $\mathbf{B}_{gp}$ is coming from the current of the imaginary bosons (phase transition), and thus is of electromagnetic origin. As a final remark, because of the assumed coupling of electromagnetism and gravitation, there should be coupling terms occurring in both the Einstein-Heim-Maxwell equations that are of electrodynamic origin, and maybe (not known at present) in the Maxwell equations that are of gravitophoton origin. Since the current density of imaginary bosons formed by the electrons of imaginary mass,

$$\mathbf{j} = -\frac{n_{e_I}^B (e_I^B)^2}{m_{e_I}^B}\mathbf{A}_{e_I}$$

as given in the London equation, is considered to be responsible for the gravitomagnetic field, it seems reasonable to insert this term as current density in the respective Einstein-Heim-Maxwell equation. Since a mass current density is needed for dimensional reasons, the electromagnetic current density has to be multiplied by a factor like m_p / e and also the coupling strength has to be determined.

The London equations are simply derived from the fact that in the superconducting phase the Cooper pairs move without any friction through the lattice of the solid. This means that Ohm's law $\mathbf{j} = \sigma\mathbf{E}$ is no longer valid. In other words, using Newton's law for electrons moving in a lattice

$$m_e \frac{d\mathbf{v}}{dt} = e\mathbf{E} + \frac{\mathbf{v}}{\tau} \tag{51}$$

and omitting the friction term $\mathbf{v} / \tau$, the first London equation is nothing else but the well known Newton law. Introducing particle density n and charge current density $\mathbf{j} = \rho\mathbf{v}$ one obtains the first London equation

$$\mathbf{E} = \frac{m_e}{ne^2}\frac{d\mathbf{j}}{dt} \tag{52}$$

The first London equation is quite different from Ohm's law, since now the electric field $\mathbf{E}$ is proportional to the time derivative of the current density $\mathbf{j}$, and no longer to $\mathbf{j}$ itself. Forming the curl of this equation and inserting this expression into Faraday's induction law, one directly derives the second London equation

$$\nabla \times \mathbf{j} = -\frac{ne^2}{m_e}\mathbf{B}. \quad \textbf{(53)}$$

which reflects the experimentally well known fact that there is no magnetic induction field $\mathbf{B}$ inside a superconductor and is essential to explain the Meissner-Ochsenfeld effect.

Hence, a rotating superconductor with velocity $\mathbf{v} = \omega \times \mathbf{r}$ where ω is the angular velocity of the rotating ring and current density $\mathbf{j} = \rho\mathbf{v}$ as well as electric charge density $\rho = ne$ generates a magnetic induction field, the so called *London moment*, given by

$$\mathbf{B} = -\frac{2m_e}{e}\omega. \quad \textbf{(54)}$$

The Lagrange densities before and after phase transition for the conversion from the imaginary electromagnetic into the real gravitomagnetic potential are assumed to be related in the following way,

$$0.328\, ie\alpha_{gp}\mathbf{v}\cdot\mathbf{A}_{e_I} + m_p\mathbf{v}\cdot\mathbf{A}_{gp} = 0 \quad \textbf{(55)}$$

where the factor 0.328 comes from the radiation correction (Coleman-Weinberg potential), e is the positive charge of the quark of imaginary mass and $\mathbf{v}$ is the velocity of the rotating disk above the coil. The decay of the imaginary photon into the neutral gravitophoton of the first type, *i.e.*, $\gamma_I \to \nu_{gp}^{01}$ with coupling strength α_{gp} leads to the real gravitophoton potential $\mathbf{A}_{gp}$. From the above equation a constraint on the direction of the resulting is obtained, which is of the form

$$\mathbf{B}_{gp} = \gamma\mathbf{B}_{e_I} + \beta\mathbf{v}\times\mathbf{B}_{e_I}. \quad \textbf{(56)}$$

This is the most general solution. Immediately it can be seen that in the experiments by Tajmar *et al.* [11-13] $\mathbf{B}_{gp}$ is parallel to $\mathbf{B}_{e_I}$, since there is a coupling between velocity $\mathbf{v}$ and the imaginary field $\mathbf{B}_{e_I}$ that is, $\mathbf{B}_{e_I}$ is parallel to the axis of rotation of the disk. Because of this coupling, $\beta = 0$ and this is actually seen in the experiments of the gravity-like field. Therefore the resulting acceleration field always is in circumferential direction in this type of experiment. In the Heim experiment we need to have

$$\mathbf{B}_{gp} \sim \mathbf{v}\times\mathbf{B}_{e_I}, \quad \textbf{(57)}$$

which means that, if the $\mathbf{B}_{e_I}$ of the London equation is directed along the z-axis, the resulting $\mathbf{B}_{gp}$ is pointing in $\hat{e}_r$ direction, if cylindrical coordinates are used.

For the extreme gravitomagnetic field to be generated - two types of decay occur - first the photon is converted into an imaginary photon $\gamma \to \gamma_I : \alpha$. Then the neutral gravitophoton is produced according to $\gamma_I \to \nu_{gp}^{01} : \alpha_{gp} = \sqrt{\lambda}$. The coupling constants of these decays are the fine structure constant α and the gravitophon coupling constant α_{gp}, determined from the Coleman-Weinberg potential, respectively. This is an extraordinary fact, since it seems that the process of gravitomagnetic field generation is governed by quantum electrodynamics, *in contradiction to our earlier assumption* where coupling constants were calculated from number theory, see [30]. In other words, once the *existence of fermions with imaginary mass* is accepted, *i.e.*, the concept of matter has been extended; the basic machinery of current physics seems to apply.

In the experiments by Tajmar *et al.* [11-13] cryogenic temperature are needed to produce this spontaneous symmetry breaking, similar to superconductivity. According to the physical model, derived from *EHT*, the symmetry breaking is generating imaginary bosons e_I^B that are moving without interaction through the lattice of the disk that is, there is no friction and the e_I^B do not participate in the rotation of the disk. Therefore, the form of London equation for these bosons is given by, assuming $\nabla\cdot\mathbf{v} = 0$,

$$\mathbf{j} = -\frac{n^2}{m_e}\mathbf{A} \tag{58}$$

which means that the current density $\mathbf{j}$ is obtained from a vector potential $\mathbf{A}$. The question is which type of potential does generate such a current density? The phase transition that occurs at cryogenic temperature leads to a current of imaginary bosons with charge e_I^B that results in an imaginary vector potential $\mathbf{A}_{e_I}$. Utilizing the structure of the London equation, Equation (58), the gravitophoton current density that would be obtained from the imaginary vector field $\mathbf{A}_{e_I}$ is

$$\mathbf{j} = -\frac{n_{e_I}^B (e_I^B)^2}{m_{e_I}^B}\mathbf{A}_{e_I} \tag{59}$$

The combination of London equation and Maxwell equation leads to

$$\left(-\nabla^2 + \frac{1}{\lambda^2}\right)\mathbf{B}_{e_I} = 0 \tag{60}$$

where the wavelength

$$\lambda = \left(\frac{m_{e_I}^B}{(e_{e_I}^B)^2 n_{e_I}}\right)^{1/2}.$$

It should be noted that λ is an imaginary wavelength since the mass $m_{e_I}^B$ is imaginary.

However, since eventually a gravitomagnetic field $\mathbf{B}_{gp}$ is observed, it is the respective gravitomagnetic vector potential $\mathbf{A}_{gp}$ that needs to be used in the calculation of the gravitomagnetic current density $\mathbf{j}_{gp}$. In the experiments of Tajmar *et al.* [11-13], however, a *real gravity-like field is observed* that is, the potential in Equation (59) should be the *gravitational potential*. On the other hand, this gravitational potential cannot be generated by moving masses. The rotating disk has a mass of about 400 g, while, according to *GR*, the *mass of a white dwarf* would be necessary.

It is the coupling between electromagnetism and gravitation triggered by the phase transition that eventually leads to a gravitational field by converting the imaginary vector potential $\mathbf{A}_{e_I}$ into the real gravitophoton potential $\mathbf{A}_{gp}$. In this process, the Lagrange densities before and after the conversion going from the imaginary electromagnetic into the real gravitomagnetic potential are assumed to be related according to Equation (55), since energy needs to be conserved. The corresponding gravitomagnetic field $\mathbf{B}_{gp}$ is given by Equation (56). It should be noted that *these two vector fields may have different directions*. In general, the Heim experiment, which should produce a axial gravity-like field, the relation between the gravitomagnetic and the imaginary vector field is given by Equation (57). We therefore formally write

$$\mathbf{j}_{gp} = -M^2\mathbf{A}_{gp} \tag{61}$$

where M is some kind of generalized or effective mass. The value of λ cannot be used to calculate the effective mass, since it belongs to the virtual charges *i.e.,* the imaginary current. This would mean that the gravitomagnetic field $\mathbf{B}_{gp}$ cannot penetrate into the disk, except for a thin sheet, because of the exponential decay of the field in the interior of the disk. This is true if M is real.

It seems as if the gravitophoton, ν_{gp}^{02}, in the Tajmar experiment, has gained mass. If one does not know about the cryogenic rotating disk, then there must exist a background field interacting with the $\mathbf{B}_{gp}$ field, and the resulting exponential damping virtually is reducing the range of the otherwise infinite range of the gravitophoton interaction. This is the so called Higgs mechanism and the background field that cannot be perceived, is the Higgs field. Instead, one assumes that the mediator boson has gained mass.

In the particle picture, the conversion of the fields is realized by the conversion of the imaginary photon γ_I into the neutral gravitophoton of the first type ν_{gp}^{01} (Heim experiment) or the second type ν_{gp}^{02} (Tajmar experiments) that leads to the real gravitophoton potential $\mathbf{A}_{gp}$. The details for calculating the corresponding extreme gravitomagnetic field $\mathbf{B}_{gp}$ are presented in Section 3.4. In Tajmar *et al.* [11-13] experiments we need to distinguish two different sets of experiments. In one set, Tajmar *et al.* generated extreme gravitomagnetic fields. Any material body that is moving in such a field is subject to the Lense-Thirring effect, except that the Tajmar effect (*i.e.,* the force acting on the moving body) is outside *GR*, but the force law itself remains unchanged. In the second set of experiments, Tajmar *et al.* accelerated or decelerated the rotating disk by changing its angular velocity (the rpm), which led to the circumferential gravity-like field, described above.

According to *QED*, the gauge theory with its hidden symmetry leads to a profound consequence, namely, if the electron is accelerated, then, the gauge field itself is actually emitted as a quantum particle. In other words, if an electron initially has a momentum $\mathbf{p}$ and an acceleration is applied changing the electron into a state with momentum $\tilde{\mathrm{p}}$, a photon of momentum $\mathbf{p}-\tilde{\mathrm{p}}$ is produced. The gauge field, formerly unobservable, has become a physical entity in form of the photon (in the field picture: a combination of electric and magnetic fields) that is observable in spacetime. It seems that an accelerated electron has generated a real photon (gauge particle of *QED*) with its proper momentum and energy. Light is therefore emitted from accelerated charges.

In the following a series of questions is posed and addressed that are crucial in conceiving gravitomagnetic and gravity-like field experiments, trying to work out the essential features of these fields.

- How is imaginary matter being generated, where is it generated, and what eventually happens to it?
- How do the physical conversion mechanisms differ in the Tajmar and the Heim experiments? That is, why is there a gravity-like field acting in the circumferential direction in the experiments by Tajmar and an axial gravity-like field in the Heim experiment.
- What is the exact energy conversion mechanism from electromagnetic into gravitational fields?
- What happens to energy conservation and momentum conservation?
- Where does the energy and momentum come from that a spacecraft needs to travel without propellant?
- What are the governing equations for gravitational fields? Since there exist gravitons, gravitophotons, and quintessence particles, three different types of gravitational fields should exist.

3.4. Evaluation of Gravitational Field Experiments

Tajmar *et al.* [11-13] were the first reporting the generation of extreme gravitomagnetic fields in the laboratory, which are denoted as $\mathbf{B}_{gp}$, since they are assumed to result from gravitophotons and not from gravitons. It should be noted that the existence of these fields was postulated by the authors before these experiments became known, see for instance [17] that is, theory and experiments were developed independently of each other. Even if these experiments could not be confirmed, extreme gravitomagnetic and gravity-like fields should be producible based on theoretical reasons.

It is important to distinguish between the gravitomagnetic field in the experiments by Tajmar *et al.* [11-13] and the proposed Heim experiment. These two fields are different and subsequently lead to different types of forces.

Modanese *et al.* [19] have tried to explain the Tajmar effect by employing the linear Einstein-Maxwell equations, but have come to the same conclusions as the authors, namely that these equations do not even reproduce the correct sign of the gravity-like field (acceleration field) that was observed by Tajmar *et al.* [11-13] when the angular frequency of the cryogenic ring was subject to change, *i.e.,* the ring was accelerated. The other problem of course is that the $\mathbf{B}_{gp}$ field measured is up to 18 or 19 orders of magnitude larger than predicted by *GR*.

Without further discussion, it should be mentioned that the often cited ratio of the gravitational and the electromagnetic force, which for proton and anti-proton is in the range of 10^{-38}, can no longer be used to justify the negligibility of gravitational effects. This value only holds for Newtonian gravitation. Furthermore, there is a most interesting hypothesis found in the recent book by Zee [39] (pp. 516), which states that gravity could be the square of Yang-Mills theory that is, gravity $\sim$ Yang-Mills $\times$ Yang-Mills or in more mathematical terms $M_{gravity} \sim \mathrm{M}_{gauge} \times M_{gauge}$. In other words the spin 2 field of gravitation might be comprised of two spin 1 fields of the Yang-Mills type. The coupling constant of Newtonian gravitation is 10^{-38}, therefore the coupling constant of the two Yang-Mills fields is 10^{-19}, which comes close to the Tajmar effect and could be a hint that additional gravitational fields indeed exist. However, this idea so far has not been investigated in how it could be used to provide an explanation for the extreme gravitomagnetic fields.

The observed gravity-like field *follows a Lenz type rule*, *i.e.*, it is opposing its origin. This exhibits an electromagnetic behavior and contradicts the sign of the Einstein-Maxwell equations. The use of the non-linear equations of *GR* cannot change this picture, since the gravitational fields observed are weak enough to fully justify the linear approximation.

The *Tajmar effect* cannot be explained from *GR*, which becomes clear in comparing the GP-B experiment with Tajmar's experiments. In GP-B, which was orbiting the *Earth* for more than 10 months at an altitude of about 640 km, the predicted Lense-Thirring precession of the gyro spin axis (inertial frame dragging by the rotation of the mass of the *Earth*), initially pointing at a guide star (locked by a telescope), is some *42* milli-arc seconds/year. This value is small compared to the already tiny geodetic effect (spacetime curvature caused by the mass of the *Earth*) of *6.6* arc seconds/year. The geodetic precession occurs in the orbital plane of the satellite; while the Lense-Thirring effect causes a precession of the gyro spin axis in the same direction the *Earth* is rotating (the gyro is assumed to be initially in free fall along the axis of rotation of the *Earth*). For the GP-B experiment an inertial frame was required with non-gravitational acceleration less than 10^{-13} *m/s*. Compared to Tajmar's equipment, his gyroscopes definitely are not capable to detect accelerations that small. One of the major challenges of the GP-B experiment was to provide such a drag-free (weightless) satellite. It is therefore impossible that Tajmar has observed any effect related to *GR*. His effect must therefore be outside *GR*, pointing to a new class of gravitational phenomena, provided, of course, *that his measurements are correct*. This were an indication that the standard picture of gravity as manifested in Einstein's 1915 *GR* does need an extension that goes beyond the picture of gravity of simply being the result of the curvature of four-dimensional spacetime. Therefore, the two additional gravitational fields as postulated in *EHT*, represented by gravitophotons and the quintessence particle, are at least qualitatively supported. In other words, the nature of gravity is more complex than represented by *GR*. All predictions of *GR* are correct, but it seems that it is *GR* which is not complete instead of *QM* (quantum mechanics). Moreover, the geodetic and Lense-Thirring effects show that an interaction between spacetime and massive bodies exist. This could mean that the *Tajmar effect, being many orders of magnitude larger, should have a much stronger interaction with its surrounding* spacetime. This is exactly what is needed for propellantless propulsion, which can only work if there is an intense *exchange of energy and momentum among* space vehicle *and* spacetime, see the discussion in Section 3.2.

In order to explain the *Tajmar effect*, an additional assumption has to be made in order to characterize the phase transition that obviously seems to accompany all extreme gravitomagnetic phenomena. As known from superconductivity the heuristic *London equations*, representing the material equations, in combination *with the Maxwell equations* are essential to calculate both the qualitative and quantitative aspects of superconductivity in a heuristic way.

Therefore, from a physical point of view it is clear that the Einstein-Maxwell equations alone cannot describe the gravitomagnetic experiments of Tajmar, in the same way the Maxwell equations cannot account for the phenomenon of superconductivity.

- The magnitude of the extreme gravitomagnetic field points to an electromagnetic origin, being the only other long range field with sufficient coupling strength.

- Therefore, the London equations will be employed to complement the Einstein-Maxwell equations.

- Moreover, there should be a physical mechanism that converts an electromagnetic into a gravitomagnetic (or gravity-like) field modelled by a phase transition of Ginzburg-Landau type.

- Such a mechanism is not conceivable within the framework of the four fundamental interactions which cannot incorporate additional gravitational fields along with their additional interaction bosons. The standard model cannot accommodate these additional particles and thus needs to be extended.

- For energy and momentum to be conserved, the interaction of the matter of the rotating disk (ring) with the surrounding spacetime field must be accounted for.

- In the Tajmar experiments the gravity-like field of the accelerated ring is acting in the plane of the rotating ring, opposing its origin. In the proposed Heim experiment, the gravity-like field of the disk, rotating at constant angular velocity, is calculated to be directed along the axis of rotation. Therefore, these two experiments seem to be based on two different physical mechanisms.

- The first neutral gravitophoton, indicated by ν_{gp}^{01}, which is deemed to be responsible for the Heim effect, should decay into the positive (attractive) ν_{gp}^{+} and negative (repulsive) ν_{gp}^{-} gravitophotons. The resulting gravity-like field is supposed to be pointing in axial direction.

- The second neutral gravitophoton, indicated by ν_{gp}^{02} decays only if the ring is being accelerated, and the resulting gravity-like field is in circumferential direction, and thus this decay route is believed to occur in the experiments by Tajmar *et al.* [11-13], denoted as Tajmar effect.

- From a technological point of view the axial gravity-like field is the one that could provide the enabling technologies for propellantless propulsion and novel air and land transportation systems as well as green energy generation *etc.* At present, it does not seem possible to fully assess the technological consequences of the existence of such a field.

- The two experiments for circumferential and axial gravity-like fields are fundamentally different, but in both cases a conversion from electromagnetic to gravitational fields seems to take place, triggered by the generation of imaginary electrons, see NOM cube in the 4D hypercube of [24].

In the framework of the current paper a full discussion of the implications of imaginary matter cannot be given, but the basic facts of the conversion mechanism will be presented.

It seems that not only particles and their anti-particles, but, under certain conditions, also particles and their ghost or shadow particles (*i.e.,* imaginary mass) particles exist, or, at least, can be created under special experimental conditions.

At temperatures low enough for the respective phase transition to occur, it seems that the imaginary electrons being produced are forming bosons comprising six imaginary electrons e_I. The imaginary current due to these sextets is deemed to result in an imaginary vector potential $\mathbf{A}_I$ whose interaction with the imaginary quarks q_I (protons) in the rotating disk is eventually leading to a real physical interaction which appears in the form of gravity-like fields. The physical mechanism is complex, but, as can be seen from the experimental setup of Tajmar *et al.* [11-13], the generation of the circumferential gravity-like field is surprisingly simple. The same should hold true for the axial gravity-like field experiment.

Any propellantless space propulsion technology therefore would be substantially simpler and efficient than currently used chemical propulsion, and also inherently safer as well as far more economical.

The experiment for the axial field (Fig. **3**) comprises a cryogenic disk comprised of a given material, denoted as M_D having a diameter of about 0.2 m, rotating at circumferential velocity $\mathbf{v}$. Below the disk a superconducting coil is placed, made of material M_C, that comprises N turns. The disk may also reside inside the coil. It should be noted that disk and coil material need to be complementary. In the experiments by Tajmar *et al.* [11-13] a Nb ring and an Al sample holder seem to give the best results. The third part is a simple device to ensure that the current of imaginary electrons is coupled into the coil. In order to achieve this, the wire of the coil is cut through and a non-superconducting disk of about 1 mm thickness is introduced. The Cooper pairs cannot tunnel through this layer, since its thickness far exceeds the 10 Å of the Josephson effect. However, the Compton wave length of the imaginary electrons is much larger, because of the small limit velocity c_I in solids for particles of imaginary mass, and thus the e_I should be capable of tunneling through, leading to the imaginary current I_I that gives rise to the imaginary vector potential $\mathbf{A}_I$ [It is not known if the direct imaginary current is superimposed by a high frequency alternating imaginary current as observed for Cooper pairs in the Josephson effect].

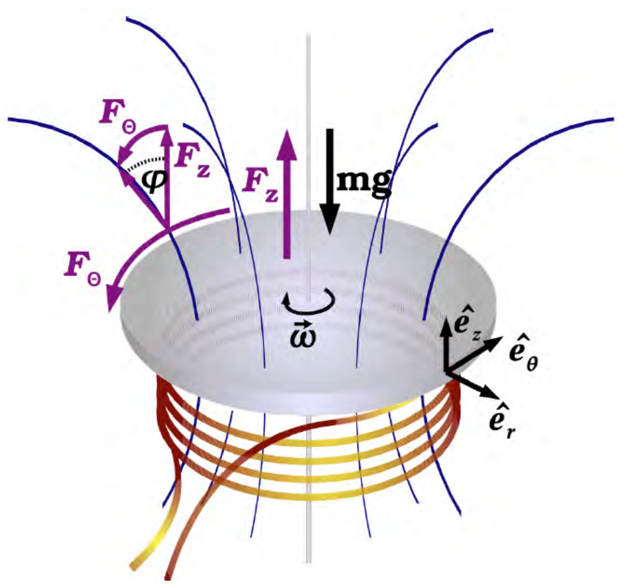

Figure 3: Heim experiment: in this gravity-like field experiment generated should be directed along the axis of rotation. The second component is in the azimuthal direction and should accelerate the ring or disk. Therefore, energy does not need to be supplied to keep the angular velocity of the ring or disk constant. The experimental setup could serve as field propulsion device, if a non-divergence free field were generated (the physical nature of the gravity-like field is not with certainty known at present). It should be noted that in order to produce the gravity-like field the current of the bosons of imaginary mass needs to be induced in the coil, which is supposed to be achieved *via* the Josephson Effect.

The gravitomagnetic mechanism of *GR* clearly is not the mechanism that occurs in the Heim experiment and also in the experiments by Tajmar *et al.* [11-13]. As these experiments demonstrate, the process is a solid state phenomenon, depending on a phase transition, triggered by temperature. Therefore, the generation of the gravitomagnetic field follows a totally different mechanism different than *GR*. Hence, the gravitomagnetic field denoted $\mathbf{B}_{gp}$ must be calculated by a different physical model. According to *EHT*, in the Heim experiment,

- The gravitomagnetic field $\mathbf{B}_{gp}$ is generated by new types of bosons, termed gravitophotons $\nu_{gp}^{\pm}$,
- The origin of the $\mathbf{B}_{gp}$ is the electromagnetic field,
- Conversion from electromagnetism to gravitomagnetism seems to follow the reaction chain starting from photons $\gamma \to \gamma_{IR} \to \gamma_I \to \nu_{gp}^{01} \to \nu_{gp}^{+} + \nu_{gp}^{-} \to \nu_g + \nu_q$,
- The ν_g gravitophoton confers the momentum to the space vehicle, the ν_q gravitophoton provides negative momentum to the surrounding spacetime which therefore expands, the total momentum of the physical system remains unchanged, *i.e.*, zero.

As additional material equations for gravitophoton interaction, in analogy to superconductivity, the London equations are employed in determining the magnitude of the $\mathbf{B}_{gp}$ field in conjunction with the conversion mechanism, *i.e.*, its magnitude is determined by the underlying physics of the conversion process. It is well known that in the superconducting case a real super current is generated by electron Cooper pairs, formed by a phase transition at critical temperature T_C, described by the heuristic London equation

$$\mathbf{B} = -\frac{2m_e}{e}\omega \tag{62}$$

where $\mathbf{B}$ is the magnetic induction field caused by the Cooper pairs. In the experiments by Tajmar *et al.* [11-13], as discussed in Section 1, an extreme gravitomagnetic field is generated. For the explanation of these experimental results as well as for the Heim experiment, it is assumed that the current of the superconducting electrons (Cooper pairs) causes a current of imaginary electrons. Imaginary particles are formed *via* the Higgs mechanism, for instance, as described by Kaku, [34] Chapter 10, further details are also given in [10]. Due to the interaction of the imaginary particles with OM in the crystal lattice, they should not behave like tachyons. For the Heim experiment, the imaginary current *needs to be coupled into the superconducting coil by some kind of tunnel effect* as stated above. The Cooper pair current is not important by itself, it only acts as the source for the accompanying imaginary current that is

$$\mathbf{B}_{e_I} = -i\,\alpha\frac{6m_e}{e}\omega_\mathbf{I} \tag{63}$$

where ω_I denotes the angular frequency of the imaginary bosons formed by the coupling of the e_I. The magnitude of the imaginary mass m_{e_I} is believed to be $6m_e$ (The charge of the imaginary electron e_I and electron $-e$ are the same). Therefore, this value is used in the above equation. It is important to ensure experimentally that an imaginary current is flowing in the coil, *i.e.*, an *experimental mechanism must be provided to couple this current into the coil*, once the real super-current sets in. It should be mentioned that the chain of formation of the three types of photons $\gamma \to \gamma_{IR} \to \gamma_I \to \nu_{gp}^{01}$ takes only place below a certain critical temperature. The question arises how to couple the electromagnetic energy to the gravitational energy. The value of the coupling constant $\alpha_{gp} = \sqrt{\lambda} \approx 1/221$ is related to the radiative correction of the Higgs field, described by the parameter λ in Kaku [34] (p.353), *via* $\sqrt{\lambda} \approx \alpha_{gp}$. Here, *Kaku* is discussing the use of the Coleman-Weinberg potential to calculate λ and is treating the Higgs field as radiative correction of the electromagnetic field. This has the following meaning. The interaction potential Φ contains a fourth order term with coefficient λ, which was inserted by hand to account for the symmetry breaking, *i.e.,* to model the phase transition process that generates charged particles of imaginary mass.

Therefore, no relation between the two parameters *m* and λ could be specified. For instance, if λ changes sign, according to the theory Landau, a symmetry breaking will take place. This kind of phase transition that is governed by the quasi symmetry breaking, is supposed to take place in the form of generation of particles of imaginary matter. Kaku then shows (see Figs. **10.4** and **10.5** in [34]) that if the so called radiative correction is used that is, in order to calculate the effective potential by summing up over all one loops in the Feynman diagram, a relationship between the fine structure constant $\alpha = w_{ph}^2 = e^2 / 4\pi\epsilon_0\hbar c$ and the value λ can be established. The following relation was calculated

$$\lambda = \frac{33}{8\pi^2}\alpha^2 = \frac{33}{8\pi^2}\frac{1}{16\pi^2\epsilon_0^2}\frac{e^4}{\hbar^2 c^2}. \quad \textbf{(64)}$$

The coupling constant in quantum electrodynamics is the well known fine structure constant, which has the value $\alpha = 1/137 \approx 7.3\times10^{-3}$, which is small. The factor $6m_{eI}$ is obtained when an imaginary instead of a real mass is considered.

It should be noted that $\mathbf{A}_{e_I}$ is the imaginary vector potential that belongs to Equation (63). Thus the resulting gravitomagnetic field is

$$\mathbf{B}_{gp} = 0.328\,\mathbf{v}\times\alpha\alpha_{gp}\frac{6m_e}{m_p}\omega_{\mathbf{I}}. \quad \textbf{(65)}$$

As mentioned above, the Lorentz equation also holds for the gravitophoton force (it should be noted that the Maxwell equations and the Einstein-Maxwell equations are similar, and the fully nonlinear equations Einstein field equations are only of interest in the direct neighborhood of black holes or for distances comparable to the diameter of the *Universe*). From the

$$\mathcal{L} = \frac{1}{2}mv^2 + e\Phi + \mathbf{v}\cdot\mathbf{A}_{e_I} \quad \textbf{(66)}$$

it is obvious that the gravity-like force is given by

$$\mathbf{F} = m\,\mathbf{v}\times\mathbf{B}_{gp} \sim m\,\mathbf{v}\times\left(\mathbf{v}\times\mathbf{B}_{e_I}\right), \quad \textbf{(67)}$$

which means that the resulting force is in the direction of the $\mathbf{B}_{e_I}$ field, which, in the *Heim experiment is the axial direction*. In the Heim experiment the neutral gravitophotn is supposed to decay according $\nu_{gp}^{01} \to \nu_{gp}^{+} + \nu_{gp}^{-} \to \nu^{g} + \nu_q : \alpha_g, \alpha_q$, where α_g and α_q are the respective coupling constants that correspond to the graviton, ν_g, and the quintessence particle ν_q. As discussed in the section on conservation principles, Section 3.2, since the spacetime field does exchange energy and momentum in all experiments of extreme gravitomagnetic fields, the force exerted by the gravitons acts on the rotating disk or ring and the force by ν_q is locally pushing against the spacetime field, acting as a repulsive force that in principle leads to an acceleration of the spacetime field, though, most likely, the effect cannot be measured. There are no ideas at present what causes the inertia of the spacetime field and how large it is. The gravitophoton g_{gp}^{+} acceleration acting on the rotating disk or ring then has the form

$$g_{gp}^{+} = 0.328\alpha\alpha_{gp}\alpha_g\frac{6m_e}{m_p}\frac{v^2}{c}\omega_I \quad \textbf{(68)}$$

with

$$\alpha_g = \left(\frac{G_N}{G_{gp}}\right)^{1/2} = 67\,.$$

Since $\mathbf{v}$ is the circumferential speed of the rotating disk, the average velocity of the particles in the disk is given by

$$v_A^2 = \frac{1}{3}v^2 \qquad \textbf{(69)}$$

and therefore the axial acceleration is

$$g_{gp}^{+} = 0.328\alpha\alpha_{gp}\alpha_g \frac{2m_e}{m_p}\frac{v_A^2}{c}\omega_I. \qquad \textbf{(70)}$$

The new variables appearing in the following equation are specified in the numerical example below. The final form for the magnitude of the gravitomagnetic acceleration in z-direction (vertical) is

$$g_g = 0.328\alpha\alpha_{gp}\alpha_g^2 \frac{2_{m_e}}{m_p}\frac{\rho_D}{\rho_{0D}}\frac{A_D}{A_{0D}} N \frac{A_C}{A_{0C}}\frac{v_A^2}{c}\omega_I \qquad \textbf{(71)}$$

As an example for a laboratory experiment to producing a sizable axial field a disk of $d = 0.2m$ diameter together with the following parameters is used:

$$\frac{m_e}{m_p} = \frac{1}{1836}\,\mathbf{;}\ \frac{\rho_D}{\rho_{0D}} = 0.19\,\mathbf{;}\ \frac{A_D}{A_{0D}} = \frac{10^3}{36}\,\mathbf{,}$$

where ρ_{0D} and A_{0D} are reference density and reference area of the disk, and $N = 50$ is the number of turns of the coil. A value of $A_C / A_{0C} = 5$ is chosen, where A_C and A_{0C} are the cross section and the so called reference cross section of the coil, respectively. The circumferential speed of the disk is $v = 50\ ms^{-1}$ and $\omega_I = 10^5 s^{-1}$. Inserting these values results in

$$g_g = 67^2 \times \frac{1}{212} \times \frac{2}{1836} \times 0.19 \times \frac{10^3}{36} \times 50 \times 5 \times \frac{2500}{3\times10^{-8}} \times 10^5 \times \frac{1}{9.81} g = \mathbf{1.8\times10^{-2}}\,g \qquad \textbf{(72)}$$

where g denotes the acceleration of the *Earth*.

In summary, in the Heim experiment the following conversion takes place: Electromagnetism $\rightarrow$ gravitation + spacetime. Gravitation and spacetime form some kind of unity that is, there is not only the gravitational acceleration from Equation (71) but also spacetime should be locally subject to acceleration mediated by the quintessence particle. With g_g fields matter is accelerated, with g_q field there will be an interaction with spacetime and momentum conservation, in order to be satisfied, need to be applied to both.

For the limit of the real current I_L one finds

$$I < I_L = \frac{2\pi R}{\mu_0}\left(\frac{A_C}{A_{0C}}\right)\frac{6m_e}{e}\omega_I \approx 10\ A. \qquad \textbf{(73)}$$

4. CONCLUSIONS AND FUTURE ACTIVITIES

Since 2002, ideas for a geometric approach of describing physical interactions, termed *EHT* (Extended Heim Theory), have been published. This approach predicts two additional physical interactions in the form of gravity-like fields; see for instance [10, 17, 20, 26, 50]. A popular description of this research may be found in [46-49].

Numerous experiments, carried out by Tajmar *et al.* [11-13] since 2003 and first published in 2006, report on the generation of gravitomagnetic (spacetime twisting) and gravity-like fields (acceleration) in the laboratory. Provided that the experiments of Tajmar and Graham are correct, a similar effect should have been observed in the Stanford-NASA Gravity Probe-B experiment. The comparison of predictions from *EHT* with measurements are given in a recent paper comparing gravity-like field experiments with calculations from *EHT* [20].

Therefore, present situation is characterized by the fact that numerous experiments were performed over a period of more than four years, employing very different measurement techniques, but showing highly similar, but totally unexpected results. These experimental results, if confirmed, are outside *GR*. Since complete electromagnetic shielding took place, none of the four known interactions can generate these extreme gravitomagnetic fields that are of long range. The experimental data, from the completely unrelated experiments by Tajmar *et al.* [11-13] and Graham *et al.* [14], have seen physical effects that are approximately 18 orders of magnitude larger than predicted by *GR*. On the other hand, the Lageos and GP-B experiments (to be finished in fall 2009) have clearly demonstrated that the inertial frame dragging effect, even from celestial bodies, is extremely small and within *GR*. These facts provide evidence for *novel physics in the form of additional fundamental forces*.

Gravity-like fields most likely would lead to novel technologies in the general field of transportation, and thus should be of major interest to the public and, in particular, to industry.

The geometrization concept of *EHT* presented is based on the existence of an eight-dimensional internal symmetry space, which is attached to each point of conventional four-dimensional spacetime. This concept leads to exactly *six fundamental physical interactions*, three of them gravity like, but gravity can now be both attractive and repulsive. The non-linear σ -model has been mentioned as the principle to connect the Hermetry forms resulting from the double coordinate transformation to Lagrangian densities that is, providing the link between geometry and physics. From the subspace structure of internal space H^8 the symmetry breaking of the associated group $O(8,q)$ follows, which gives rise to the assumption of six fundamental forces. Because of the twelve Higgs fields, 12 charges are proposed; four of them should be of gravitational nature. In addition, there seems to be second group $O(8,q)$ that describes the 15 particle families, which result from the $O(3,q)$ subgroup associated with space R^3. This leads to the assumption that there are three colors from quarks and a fourth color from the imaginary quark. This short discussion shows that there are numerous open questions and many more topics to discuss, but, on the other hand, for instance, the predicted existence of 15 gluons and 4 gravitational as well as 2 electric charges shows that physics might be much richer than currently anticipated.

From the ideas presented here, *admittedly speculative* and supported only by the (not yet confirmed) existence of extreme gravitomagnetic and gravity-like fields as measured by Tajmar *et al.* [11-13], it is surmised that these additional gravitational interactions have the potential to provide the physical principle for *propellantless propulsion* and also allow for green energy generation. For instance, in [24] it was suggested to investigate whether the the fusion plasma in a magnetic mirror can be stabilized by axial gravity-like fields and the mirror be closed.

Needless to say, control of gravity would lead to completely new technologies, comparable to the advent of electricity and magnetism in the 19th century.

Concerning the development of advanced space propulsion concepts, the ones described in Section 1 need to be pursued further, but breakthrough space propulsion does need to be based on a *research program to look for fundamentally different propulsion principles* based on the physical ideas presented in this article that is, the existence of novel gravity-like fields.

In how far the concept of geometrization of physical interactions, if it turns out to be true, might also lead to a modified *Weltbild* of physics [53] cannot be decided at present.

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