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Reality of gravity-like fields? Part I: Recent experiments that challenge current physics

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Abstract

In this paper a set of recent experiments/observations is presented that seem to indicate the existence of novel physics outside general relativity as well as the standard model of particle physics and the standard model of cosmology. The approach chosen in the present paper is unique, since the existence of new physics is based on various experiments reported from widely different areas, and not a priori on the introduction of novel physical concepts. If confirmed, new concepts might be required and drastic extensions to current physics would become necessary, for instance, in form of novel gravity-like fields. Such fields could provide the basis for propellantless propulsion that is, gravitational field propulsion might become a possibility. A total of eleven experiments both from cosmological observations and high particle physics has been identified that seem to require an extension of general relativity and also might contradict key predictions of the so called advanced physical theories like string theory, supersmmetry, or quantum gravity. The paper also discusses in how far the existence of additional extreme gravitomagnetic and gravity-like fields outside general relativity together with novel types of matter is supported by experimental facts based on the results of three recent experiments that might have measured these extreme gravitomagnetic fields (see the in depth analysis of these experiments in the accompanying paper by J. Hauser in this special issue).

Keywords

Eleven experiments that challenge current physics; Three experiments for extreme gravitomagnetic fields and gravity-like fields in the laboratory and in space; Interaction between electromagnetism and gravity at cryogenic temperature; Three different types of gravitational fields; Novel experiments for gravity-like fields; Gravitational engineering.

INTRODUCTION TO NOVEL PRINCIPLES OF PROPULSION PHYSICS

Propulsion systems of today are based on the reaction principle, and thus rely on fuel, as already envisioned by W. von Braun in 1952 in his famous Collier's Magazine article[1]. Nothing has changed since that time. As a consequence fuel mass is much larger than payload mass, if high thrust levels are required. For instance, in chemical propulsion, payload is only about 1% of the total mass. So called advanced propulsion techniques, like solar sails or antimatter propulsion are subject to severe physical limitations, and, though the physical principle of these techniques has been known for more than six decades, no practical propulsion system has come out of it. This holds true also for fission reactors to be used for space propulsion. Fusion is known for eight decades, but if the recent article by Moyer[2] turns out to be correct, the future of fusion as an unlimited energy source is highly questionable.

In general the combined mass of fuel and propulsion structure is much larger than the payload, and thus all these systems are severely limited by basic physics. Any space vehicle launched must overcome the gravitational field of the *Earth*, whose governing law was already established by Isaac Newton in 1687[51].

To achieve the goal of game changing technology and/or green energy generation, *novel physical laws in* *the form of additional long range forces will be needed*, based on new, additional fundamental scientific principles by extending, but not by overthrowing, established physical theories. The experiments of the extreme gravitomagnetic fields that could provide the physical basis of such a novel propulsion scheme are discussed in[10]. Both, the present paper and the companion paper, are excerpts of our forthcoming book entitled *Introduction to Physics and Astrophysics of Gravity-Like Fields*[3] that will deal in detail with the physics of gravity-like fields as well as their impact on both the standard model of particle physics and cosmology as well as on novel technology in the form of gravitational engineering.

Earlier experimental results on the existence of gravitational shielding, in particular those by a Russian scientist, could not be substantiated. However, in 2006, experimental results published by Tajmar et al.[4] then at AIT (Austrian Institute of Technology), claimed the generation of laboratory produced extreme gravitomagnetic and gravity-like (acceleration) fields. In the following years, numerous additional experiments were published by Tajmar et al.[5-7] and in 2007 an experiment by Graham et al.[8] was also published. However, in November 2011 Tajmar[9] presented additional experiments with data that were only about 1% of the previously measured gravitomagnetic field strengths, and thus fell in the noise level of the gyroscope. Driven by a *lack* of physical explanation for the substantial reduction in signal strength, M. Tajmar re-interpreted *all* of his results as acoustic vibrations (but did not recant or retract any of his measurements as was *incorrectly* claimed by a U.S. scientist). By contrast, the CERN superluminal neutrino data[11,12] *had* to be retracted in 2012, because of measurement errors. In addition, Graham et al. classified their results as null results, because of insufficient statistics. In the following, these experiments will be re-evaluated, and physical arguments, based on the existence of extreme gravitomagentic fields will be presented, in order to consistently explain these hitherto contradictory observations.

The physical ideas of a classification scheme for all particles and interactions that exist in physics, termed *Extended Heim Theory* (*EHT*), are briefly presented (see also[14], for details see[3]) and subsequently utilized to analyze these experiments as well as to explain their physical implications[52].

An excellent non-mathematical introduction to extreme gravitomagnetic and gravity-like fields as well as their technical implications can be found in the recent book by *G. Daigle*[13].

EHT gives rises to six fundamental forces, three of them are of gravitational nature, and thus could lead to a novel type of propulsion without propellant, termed *field propulsion*, a term already coined in 1960 by Corliss. The field responsible for propulsion would be a gravity-like field, produced through an interaction of electromagnetism and gravity. The gravitational particles produced in this interaction are supposed to impact both the space vehicle and surrounding spacetime. It should be understood that spacetime is directly connected with the dark energy field, i.e., dark energy is assumed to be produced *exclusively in conjunction* with the dynamic evolution of the spacetime lattice as discussed in[3] and also in[14]. In other words, there is no spacetime without dark energy and vice versa. Hence spacetime (i.e., the combination of spacetime and associated dark energy) can be considered an active physical field that carries both momentum and energy (perhaps also angular momentum), and thus is capable of interacting with a space vehicle. This means that in field propulsion the combination of rocket mass and fuel mass is *replaced* by interaction of the novel gravity-like fields (postulated by *EHT* which, however, are clearly outside *GR*), of space vehicle and spacetime, but conservation laws are strictly obeyed.

One of the hopeful aspects of the new gravitomagnetic field experiments would be that until recently gravitation could only be observed, but not experimented on in any controlled fashion. In gravitomagnetic experiments, gravity-like (acceleration) fields might be producible in the laboratory. In other words, there could be experimental evidence that long-range force fields other than Newtonian gravitation and electromagnetic fields might exist.

The technology of gravitational engineering would be far superior compared to chemical propulsion, not only because it is propellantless, but the level of technical complexity would be much lower, leading to substantially safer and more efficient propulsion as well as huge cost savings. Once the underlying physics is understood, gravitational engineering could become a market of almost no limits.

In addition to the gravitomagnetic experiments, in order to demonstrate that current physics is far from being complete, a set of eleven recent experiments has been identified, presented in the next section, that challenge the fundamental assumptions of modern physics and cosmology. For instance, these experiments sometimes seem to confirm *GR* (general relativity), while sometimes there seems to be a contradiction. Furthermore, there are recent experimental data that indicate that the more advanced concepts in physics like string theory, quantum gravity, and supersymmetry are not compatible with these experimental findings. Hence, there could be room for new physics, in particular, regarding the existence of gravity-like fields, which would be outside *GR*.

RECENT EXPERIMENTS CHALLENGING CURRENT PHYSICS

This section comprises a detailed discussion of the set of eleven recent experiments/observations mentioned above that seem not to confirm established physical theories, including, to some extent, Einstein's *SR* and *GR*. In particular, the extensions of the standard model of particle physics, which are based on the concepts of supersymmetry and superstring theory are apparently at odds with several of these experiments. Moreover, current models of quantum gravity, the alternative to string theory, probably also are not in accordance with recent ESA Integral satellite measurements.

Most important, LHC (the Large Hadron Collider at CERN) so far did *not* find any of the many new particles predicted by string theory and supersymmetry, for instance see Quigg[15]. Furthermore, the theory of supersymmetry seems to have been *invalidated* by recent LHC measurements (November 2012). In turn, this would have major implications for the Higgs field, which is a scalar field, predicted by the standard model of particle physics. The Higgs particle was found in LHC data (July 2012), and has a mass of about 126 GeV[53].

Also, the cornerstone of astrophysics, the standard model of cosmology, is in difficulty, since observations indicate that dark matter is absent (at least no gravitational effect of dark matter was observed) inside galaxies as measured by Bidin et al. in 2012[16]. In addition, the debated MOND (MOdified Newtonian Dynamics)[17,18] hypothesis has been confirmed by the recent measurements of S. S. McGaugh[19,20]. This lack of accord should have also consequences for other advanced physical concepts, such as the existence of multiverses and theories requiring spaces of ten or eleven dimensions. These constructs have been central to many mainstream ideas in theoretical physics and cosmology, developed over the last four decades. They may need to be relegated to the realm of pure mathematics, if the *Universe* is found to be constructed in a different way. Finally, the extensive computer simulations (considered to be experiments) of Loll, Ambjorn et al.[22-24] seem to indicate a *de Sitter topology*[25-28] for the *Universe*, and thus, for instance, the cherished concepts of *space travel by wormholes* are removed from physics and are now in the realm of science fiction. Obviously, not all mathematically admissible solutions of *GR* are actually *realized* by *Nature*.

This short discussion, in a nutshell, elucidates several of the major *fundamental* problems with current physics, and the criticism expressed in several recent publications, for instance see[29-32], namely that physics eventually is an experimental science, and not a collection of *non-falsifiable* mathematical constructs, should perhaps be taken seriously. In other words, things have to be measured to be true.

As mentioned above, the LHC at CERN, operating since 2008, is intensively searching for the many theoretically predicted novel particles, but so far has *not detected* any of these particles up to the mass range of about 800 GeV (spring 2014)[33]. The present mass limit of the LHC for novel particles is about 1,000 GeV, so there is *not* much room left. Whether the remaining energy range of the LHC will deliver any new particles remains to be seen, but the probability, however, does not seem to be high.

Moreover, despite the best theoretical efforts since the 1970s, gravitation still cannot be unified with quantum theory, but even within established quantum field theory, as was just discussed, there are theoretical results that clearly do *not* match experiment. This problem was not counted as experiment number twelve, because this fact has been known since the beginning of quantum field theory.

There is therefore *no* reason whatsoever for claims, as made by some physicists, that the fundamental problems in physics have been solved, and the rest are details. These remarks are not *even wrong*, but are expressing a complete lack of understanding. In almost all respects, the study of physics has *hardly begun*. The *Universe* abounds with mysteries, and the most profound discoveries are yet to be made. *Hopefully*, extreme gravitomagnetic fields are part of these discoveries.

Next, the details and implications of the controversial experiments are listed below.

MOND: Newton's law violated and the missing dark matter[54]

The recent measurements by S.S. McGaugh[19,20] have shown without doubt that the MOND[17,18] formula is correct on the galactic scale, and the Newton (Einstein) formulation of gravity does not apply, unless huge amounts of extra invisible dark matter inside the galaxy exist to account for the larger central force (or some other hitherto unknown force is present). On the cosmological scale Newton (Einstein) gravitation seems to be correct according to observations by Reyes et al.[21] as long as the combined masses of both visible and dark matter are inserted into Einstein's field equations. Moreover, these measurements show that the interaction between dark and visible matter must be governed by Newton's law of gravitation. On the other hand, the latest observations by ESO, Bidin et al.[16], leave little room for the presence of dark matter inside galaxies, i.e., observations require dark matter be *largely or completely absent*, and thus seem to have put an end to this hypothesis. However, the very reason for postulating the existence of dark matter inside a galaxy by Caltech astronomer Zwicky in the 1930s was to explain the observed orbital velocities of stars about the center of their galaxy, as recently confirmed by S. S. McGaugh. In other words, the basic reason for which the concept of dark matter was invented, just most likely proved to be *incompatible* with recent observations. Thus, there seem to be two *irreconcilable* scenarios.

- *GR* is confirmed on large galactic and cosmological scales, provided dark matter is accounted for.
- On the other hand, without dark matter being present within galaxies, *GR* (Newton) cannot be applied to describe the movement of stars about their galactic center, at least not without making further drastic physical assumptions. However, as discussed by J. Hauser in the accompanying paper[10], Newton's law seems to hold also for extremely small accelerations, since the Gravity Probe-B experiment provided an almost completely drag free satellite.

The only other type of matter presently foreseen comes in the form of dark energy, whose existence was postulated in 1998 to account for the (accelerated) expansion of the *Universe*.

Dark energy should be present throughout space that is, also inside galaxies. At present, no theory exists that explains the nature of dark energy and how it could have been created. A (tentative) physical model will be given in[3]. One can prove that distances within galaxies do *not* seem to be subject to the expansion of space[3], i.e., the stars within a galaxy are not moving apart from each other. Inside a galaxy the mass density is in considerable excess compared to the density (utilized) in the derivation of the Friedmann equation, i.e., the density of intergalactic space. Could it therefore be that dark energy plays a different role in areas of high concentration of visible matter? Unless a completely unknown physical phenomenon is responsible for the anomalous rotation curves of galaxies, dark energy is the *only* alternative remaining. Again, the experimental facts seem indeed to contradict each other:

- On the one hand, *GR has been confirmed* by Reyes et al. on cosmological distances as well as by Ciufolini[41] and, to some extent, by GP-B[42] on planetary distances, confirming the Lense-Thirring effect (1918) of *GR*.
- At the same time, there is irrefutable experimental evidence for a force law *incompatible* with *GR* as shown by McGaugh on the galactic distance scale.

This does not mean that *GR* is incorrect, but there may exist additional gravitational phenomena outside *GR*, and thus gravitation may not be completely described by *GR*.

Extreme gravitomagnetic fields

Gravity and electromagnetism are the two-long range interactions of current physics. The major difference between the two forces is that electromagnetic fields can be generated in the laboratory, while gravity cannot be engineered. In other words, gravitational fields can only be generated by large masses, e.g. planets or stars. However, during the last two decades several experiments have been reported on the generation of extreme gravitomagnetic or gravity-like (acceleration) fields in the laboratory.

In Einstein's *GR* one needs to distinguish between two different types of gravitational fields. Static masses are generating the so called gravitoelectric[55] field $\boldsymbol{E}_{G_N}$ (in analogy to the electric field $\boldsymbol{E}$ in Maxwell's electrodynamics), which is nothing but the well known Newtonian gravitational law. The second type of gravitational field, the gravitomagnetic field BGN $\boldsymbol{B}_{G_N}$ (G_N is Newton's gravitational constant), follows from the motion of gravitational charges (matter), in the same way as moving electric charges are generating the magnetic induction field B. Gravitomagnetic fields B_{G_N} do not exist in Newton's theory and are the (relativistic) product of *GR*, i.e., they are due to relativistic effects, and hence their magnitude is extremely small. They are far too weak to be measured in a laboratory on *Earth*.

Extreme gravitomagnetic fields are denoted by B_{gp} and might have been generated in the laboratory. They are clearly outside *GR* and are not generated by the motion of large gravitational masses. In *EHT* their existence is explained by a new boson, termed gravitophoton ν_{gp}, which is the mediator particle between electromagnetism and these novel gravity-like fields[3,14]. These fields should be many orders of magnitude stronger than the relativistic effects of *GR* and, if confirmed, could form the basis for a new technology of gravitational engineering.

A present there exist (possibly) three independent experimental sources for extreme gravitomagnetic fields, namely from Tajmar et al. and Graham et al., who carried out carried out their experiments in the laboratory as well as the NASA-Stanford University Gravity-Probe B (GP-B) experiment, launched into a 640 km LEO (Low Earth Orbit) in 2004. The detailed analysis of these experiments will be the subject of the accompanying paper in this special issue by J. Hauser[10].

- For several years Tajmar and his group published numerous papers about this novel gravitational effect, but in 2011 Tajmar et al. re-interpreted their results, attributing the measured effects to some kind of acoustic noise. The reason for this re-interpretation was that newer experiments, using modified equipment, measured gyroscope signals about two orders of magnitude lower compared to their earlier results. Since Tajmar et al. could not find a *physical explanation* for the reduction in signal strength, their conclusion was that most likely *acoustic effects* must have mimicked the presence of gravitomagnetic fields. As will be discussed in the second part of this review on novel experiments[10], the decay of the gyroscope signal strength observed in their latest experiments (Setup D and E)[9] in November 2011 can be explained by *EHT*[14], and is assumed to be caused by the different *thermal environments* the extreme gravitomagnetic field B_{gp} encountered before it was measured by the gyroscope. From a theoretical point of view this behavior is to be *expected*, and definitely is not a sign or proof for having recorded artificial signals or acoustic vibrations in the earlier experiments (i.e., those experimental configurations termed Setup A and B in the publications by Tajmar et al.).
- The experiments by Graham et al.[8], performed in 2007, might have seen a gravitomagnetic signal too, and, depending on the interpretation of the results, could serve as a basis of providing experimental evidence for the existence of extreme gravitomagnetic fields, which are *outside the range of GR*. However, the experimentalists themselves claim not to have measured any extreme gravitomagnetic phenomena.
- The four gyroscopes in GP-B, which are Nb coated quartz spheres operating at the temperature of liquid He, reported unforeseen large spindrifts that were first analyzed in[44] and are re-evaluated in[10]. According to this analysis, extreme gravitomagnetic fields, similar to the ones reported by Tajmar et al., might have been generated in orbit, which could have been responsible, at least partly, for the large reported gyro(roscope) misalignments. However, there is also an explanation from the Stanford team in form of an electrostatic patch effect that was used to calculate the misalignments. In practice, both effects could have been present.

In summary, there exist clear hints from experimental data for the generation of extreme gravitomagnetic fields outside *GR*, but a definite confirmation is still lacking. Hence, in order to present convincing evidence, novel experiments are needed to clarify the situation (see the section *Gravitomagnetic Interference with Neutrons* in the second part of this review[10]).

Latest extreme gravitomagnetic field experiment by Tajmar et al.

The recent paper of Tajmar (November 2011)[9] is of great importance, since, as the subsequent analysis will reveal, it may provide additional evidence for the existence of laboratory generated gravity-like fields, despite the fact that much weaker signals were generated than in the previous experiments. According to theoretical considerations extreme gravitomaagnetic fields should exhibit a strong temperature dependence, i.e., the field becomes strongly diffusive at temperatures higher than the critical temperature T_C, as can be seen from the measurements. The experimental verification of the dependence of the gravitomagnetic field strength on cryogenic temperatures follows from the fact that the signal strength in the latest experiments (Setup C, D, E) is substantially lower than in the previous experiments (Setup A, B), which was the major reason that Tajmar eventually re-interpreted his earlier experiments as artifacts caused by acoustic vibrations.

In comparison to Tajmar's earlier papers, for instance[6], the gravitomagnetic field strength measured in his latest experiments[9] is reduced from ≈ 3-4 × 10^{-8} by a factor of about 100, which means the value of the so called coupling factor is now C_R = 2.0 × 10^{-10} (see Eq. 1) where the suffix *R* in the coupling factor indicates the rotating Nb ring (mass about 4 × 10^{-1} kg), and suffix *gp* in the gravitomagnetic field is used as a reminder that this field is supposed to have been generated from the interaction between electromagnetism and gravitation by the novel particle called *gravitophoton* (see above, also[35-37,44]). In the experiments by Tajmar et al. and Graham et al. the value of the dimensionless coupling constant *CR* (see Eq. 1) is employed in the subsequent discussion in order to characterize the experiments, and is determined both experimentally and theoretically. It is the ratio of the strength of the gravitomagnetic field B_{gp} (dimension: 1/s) and the angular velocity ω of the rotating cryogenic Nb ring (Tajmar et al.) or the Pb disk (Graham et al.).

LHC, massive particles, and supersymmetry

LHC (spring 2014) so far did not find any novel particles at higher energies (above about 126 Gev)[48], i.e., there is no experimental basis for supersymmetry and superstring theory. Only the Higg particles was found at around 126 GeV. It is now suggested by some theoreticians, that these particles might be found in the energy range above 1,000 GeV, which is clearly beyond the operational limit of the LHC. However, though this possibility cannot be ruled out (requiring a new Super-LHC, ready perhaps by 2050), it seems to be highly unlikely. Theoreticians were fairly *sure* that the LHC would lead to a new era of particle physics, see, for instance, C. Quigg[15], and therefore the present null results cannot justify a request for the next Super-LHC. Instead, the LHC results should be interpreted as a sign for *major deficiencies at the fundamental level of physics*. For instance, as was already discussed in[14,35-37], there could be *three different gravitational fields*, see also the gravitomagnetic field experiments discussed under topic three. If this were the case, *additional field quanta* in the form of new bosons must exist. Furthermore, different types of matter should exist, leading to a major revision of particle families. In addition, recent LHC measurements presented a blow to supersymmetry, which seems to be in clear contradiction with regard to the recent LHC results of November 2012.

ESA integral satellite

The ESA Integral satellite data of 2011[38] proved false the predictions by quantum gravity, namely that the speed of light *c* should depend on frequency ν that is $c = c(\nu)$. A measurement that was deemed impossible (at least by the theorists)!

Flyby anomaly

In the recent article in *Physics Today*, October 2009[39] the (unresolved) *Earth* flyby anomaly is discussed. It should be noted that the *Pioneer* anomaly is *no* longer an anomaly. It was found by computer simulation that thermal radiation is causing the trajectory deviation, and thus any (postulated) novel cosmological quantum effect can be excluded. Thus, all the theoretical explanations in form of new physics have become obsolete.

Causal dynamical triangulation MC simulation

Recently Monte Carlo computer simulation experiments performed by Ambjorn, Loll, Jurkiewicz et al.[22-26], show that spacetime possesses (exactly) four-dimensions at a length scale above the Planck length

$$\ell_P = \sqrt{\hbar G_N / c^3} = 1.62 \times 10^{-35}\,\mathrm{m}.$$

Space time topology seems to be spherical (de Sitter), and thus no wormhole travel etc. will be possible. Most important, without Einstein's cosmological constant Λ (repulsive gravitational force) these computer experiments have shown that no structured spacetime lattice will evolve.

Cosmological principle violated

Most recent observations, see for instance *La Science&Vie*, April 2013[40], have shown the cosmological principle, as formulated by Einstein, to be violated. The cosmological principles states that, at a large enough spatial scale, the *Universe* is homogeneous and isotropic. A group of quasars was detected in the form of 73 galaxies, termed U1.27, of the size of 40,000 milky way galaxies with a luminosity of about 3.4×10^{18} times that of the sun, extending over a spatial range of some four billion light years. This massive structure should simply not exist, and is obviously not compatible with the assumption of a homogeneous and isotropic *Universe*. Moreover, if one such structure has been detected, there is a certain probability that it is not unique. So far, no consequences have been drawn from this phenomenon, but eventually the standard model of cosmology may turn out to be insufficient.

NATURE OF GRAVITATIONAL FORCES

The geometrization of physics was the major scientific objective of Einstein upon having published his theory of general relativity, which, however, was never satisfactorily realized. Einstein also introduced the cosmological constant Λ in his equations to arrive at a steady state *Universe*. However, this step was much *more* than just introducing a constant in the field equations. It meant that Einstein had modified Newtonian gravity and added a second type of gravity, which is repulsive with respect to spacetime. That is, Einstein was actually using two different types of gravitational forces.

Newtonian gravitation is attractive between baryonic matter which comprises about 4.9 % of the *Universe*. Repulsive gravitation is due to a field in spacetime called dark energy *acting* on spacetime. Dark energy accounts for about 68.3% of the energy in the *Universe* (Planck satellite data 2103). The remaining 26.8 % are attributed to dark matter. The cosmological constant is associated with the dark energy field that is ubiquitous in the *Cosmos*, but there seem to be other physical processes capable of producing a repulsive gravitational force, i.e., expanding spacetime (locally)[56]. We feel that the experiments by Tajmar et al. most likely need to be explained in this way[36,37]. As a result, physical processes producing a local or global repulsive gravitational force should contribute to the accelerated expansion of the *Universe*.

In addition, the hypothesis of the existence of different gravitational fields is supported by recent computer simulations, called *Causal Dynamical Triangulation* (*CDT*), see Ambjorn, Jurkiewicz, and Loll (see above)[22-26], since in these simulations spacetime, as it is experienced (i.e., as a four-dimensional manifold), will only evolve if a positive cosmological constant, Λ, is added to the original Einstein field equations, representing a novel, globally repulsive gravitational field. Since Einstein's *GR* is the prototype of a local gauge theory, i.e., possessing local symmetry with respect to general coordinate transformations, where the gravitational field itself is acting as the gauge field, it is logical to assume that the cosmological constant $\Lambda = \Lambda(x,t)$ to retain the property of local gauge symmetry.

Gravitational forces and galactic dynamics

In this section a discussion is presented whether the existence of additional gravitational laws outside Newton (Einstein) in the form of novel gravity-like fields and/or special types of matter can be supported by experimental facts. The following recent observations have been reported:

1. The Modified Newtonian Dynamics (MOND) hypothesis, which alters Newtonian gravity for small accelerations, was recently confirmed by the measurements of S. S. McGaugh for 47 gas rich galaxies. An attempt for an explanation of the MOND hypothesis is given in[3], employing the physical concepts of *EHT*, i.e., by postulating two additional gravity-like fields as well as novel particles in the form of fermions and bosons.
2. No dark matter seems to reside within galaxies (ESO observations, Bidin et al. June 2012), relegating dark matter to the galactic halo. On the other hand, the deviation from Newton's law has been experimentally verified by McGaugh (February 2011). In order to resolve this conundrum a novel interaction of dark energy with visible matter, which takes place inside the galaxy, is postulated. This alternative should account for the modification of Newton's gravitation law. Since the MOND hypothesis (not based on any physical model so far) seems to give the correct numerical value, any derivation needs to reproduce its numerical value. As the measurements by Reyes and also galactic gravitational lensing have shown, both visible and dark matter are subject to Newton's gravitational law.
3. As strong gravitational lensing is observed, galaxies must possess dark matter in their halos. Therefore, the *physical mechanism for galactic halo formation* has to be found, while, at the same time, the *non-existence of dark matter inside galaxies* must follow from the the same physical concept, and, finally, the correct value of the MOND acceleration has to be produced. So far, no physical theory exists. Therefore, the attempt is

undertaken to apply the novel concepts of *EHT* to try not to solve, but to shed some light on this riddle.

4. According to the computer simulations of Causal Dynamical Triangulation (which is the Monte Carlo simulation of the path integral for the action of *GR*, or summation over geometries (universes)) *omitting* the cosmological constant, $\Lambda > 0$, does not result in a four-dimensional spacetime in the classical limit. In other words, a repulsive gravitational force is mandatory for the *Universe* to enfold, and thus the assumption of the existence of dark energy is supported also by this computer simulation.

Mond acceleration formula

One of the greatest riddles in current (astro) physics is the MOND formula. It seems to give the correct acceleration values, but the physical reason for its success is unknown.

It is known that within a galaxy, cosmic expansion does not take place[3]. Instead, an additional acceleration field, a_0, the so called MOND acceleration, directed *toward* the center of the galaxy is present. As a consequence, the orbital speed of stars about the center of a galaxy is *larger* than predicted by Newton's gravitational law. This has been known for about eight decades, but was confirmed only recently beyond doubt by the observations of McGaugh (Sec. II).

At present, there is *no* physical theory that can explain the existence of a_0. In the following, a few thoughts will be presented that might shed some light on the physical origin and magnitude of this mysterious acceleration as well as the halo formation of galaxies (a more comprehensive discussion is given in[3]). Of course, the following remarks should not be mistaken for a physical model.

Since, according to recent observations, dark matter *cannot* be present inside galaxies[16], and therefore only dark energy remains, unless a deviation from Newton's law is postulated (with regard to the GP-B experiment this assumption does not seem to be justified[10]), as the cause for MOND. From the basic group structure of *EHT* (and thus this is *not* a postulate per se), the existence of a second type of dark energy particle, which is attractive (i.e., contracting spacetime), is postulated.

That is, dark energy comprises a composition of two dark energy particles, denoted by ν_{de}^{-} and ν_{de}^{+} that either expand or contract spactime, respectively (dark energy is a field and thus, according to second quantization, is characterized by particles). The dark energy field in the sense of Einstein may be described by a (fictitious) particle, denoted by ν_{de}, representing the cosmological constant Λ, and thus actually is the result of the combined interaction of the two dark energy particles. In intergalactic space the value of Einstein's cosmological constant Λ is extremely small that is, the contributions of ν_{de}^{-} and ν_{de}^{+} almost cancel each other. The question arises, how the large density of ordinary matter inside a galaxy - remember that dark matter cannot be present -does affect the distribution of these two types of dark energy particles, i.e., the (spacetime expansion) ν_{de}^{-} and (spacetime contraction) ν_{de}^{+} particles that are deemed to be ubiquitous throughout the *Cosmos* (because dark energy cannot be separated from the spacetime lattice)?

The result is known, namely, inside a galaxy, an acceleration $a_0 = 1.2 \times 10^{-10}\text{m/s}^2$ pointing toward the galactic center must be obtained, which seems to be a global value that is, it is the same for all galaxies. If dark energy is responsible for this acceleration, the value of Λ inside a galaxy must change, and Einstein's cosmological constant must be promoted to a cosmological function $\Lambda(x,t)$. Obviously, this can only be caused by the presence of the second field, the ν_{de}^{+} dark energy field (possessing negative energy density that is, contracting spacetime), whose interaction with visible matter inside the galaxy, however, should lead to a repulsive gravitational force, substantially reducing the number of ν_{de}^{+} inside a galaxy. The only difference between intergalactic space and the space inside galaxies is the density of visible matter, where the density is about 10^7 times larger. For the two different types of dark energy there are two corresponding cosmological constants that, in accordance with Einstein's cosmological constant Λ, are denoted by Λ_- (labeled negative, since it causes spacetime to expand, but possessing positive energy density) and Λ_+ (labeled positive, since it causes spacetime to contract, but representing negative energy density). In general, there should be a complete symmetry between Λ_+ and Λ_- that is, Einstein's cosmological constant Λ should be zero - in a *Universe without* matter. In intergalactic space, because of the (small) presence of matter, this *symmetry is broken* and $\Lambda > 0$ results in the current era. Consequently, because of the presence of large amounts of visible matter inside galaxies (compared to intergalactic space), the value of Λ is supposed to change drastically.

In the present era $|\Lambda_-| > |\Lambda_+|$ (note that $\Lambda_- > 0$, $\Lambda_+ < 0$), because an expansion of spacetime is observed (note that the expansion or the arrow of time is similar to symmetry breaking, since a preferred direction exists on the cosmic time scale, and thus might be responsible for special physical phenomena, which, of course, are not present on the time-symmetric scale, valid for all fundamental equations of physics[3]). Therefore, Einstein's cosmological constant is given by $\Lambda = \Lambda_- + \Lambda_+$, which, even in *GR*, should be a function of time that is, in this era $\Lambda = \Lambda(t) > 0$. The value of Einstein's cosmological parameter currently is $\Lambda \simeq 10^{-51}$ 1/m^2, deemed to be responsible for spacetime expansion. It should be noted that for the pressure of the vacuum (intergalactic space) the equation

$$p = -\rho_\Lambda \sim -\Lambda$$

holds, that is, the current value of Λ exerts a negative pressure, and thus causes an expansion of the spacetime lattice (*Universe*). However, since in physics no singularities exist (one of the fundamental principles of *EHT*), $\Lambda(t)$ will have to change sign, owing to the expansion process itself, when the *Universe* has reached a certain size (see Sec. *Ising Model for the Spacetime Lattice* in[3]). Since the energy density of negative dark energy is counted positive (Λ_-, ν_{de}^-), visible matter and negative dark energy *attract* each other. For positive dark energy (Λ_+, ν_{de}^+), the opposite effect occurs that is, visible matter and positive dark energy *repel* each other. The boson mediating that force, which follows from the *EHT* particle classification scheme, is termed quintessence particle, ν_q.

Since Λ is extremely small, the two different types of dark energy, each being large by itself (from quantum physics), Λ_- and Λ_+, almost cancel each other in intergalactic space. The Einstein value of Λ is valid in intergalactic space only, where matter density is very low, and the polarization effect due to the presence of visible matter can be almost neglected, but this quasi-equilibrium is changed in the presence of visible matter, i.e., inside galaxies. Of course, the volume of all galaxies in the *Cosmos* compared to the volume of the *Cosmos* itself, is negligible, and thus Einstein's cosmological constant Λ is valid on the cosmological scale, but not (locally) on the galactic scale.

Employing this model, it is predicted that Λ substantially changes inside galaxies, because of strong polarization, which is weakening the Λ_+ field, and thus causing an acceleration toward the galactic center. Moreover, Λ can also be changed by the local presence of extreme gravitomagnetic fields (laboratory generated), and therefore in general $\Lambda = \Lambda(\mathrm{x},t)$ is needed.

The effect of Λ_+ (spacetime is contracted), being repulsive with regard to the visible matter inside the galaxy (because of its negative energy density) is largely neutralized inside a galaxy, and therefore inside the galaxy only the attractive gravitational effect of Λ_- on ordinary matter remains. The reason why the Λ_+ is neutralized inside a galaxy, is due to the fact that a galaxy contains a large amount of ordinary matter, i.e., both visible matter inside the galaxy and dark matter that resides in the halo, with about 80% of the matter in the halo. The surplus of Λ_- cannot cause an expansion of spacetime, because it is prevented by Newtonian gravitation of the visible mass inside the galaxy.

To understand the qualitative physical mechanism of dark matter halo formation, consider a sphere filled with positive electric charges. It will repel particles arriving from outside the sphere that are of like charge, while attracting particles of negative electric charge. The ν_{de} particles (whose existence follows from the symmetry groups[14] of internal gauge space H^8), representing the Λ_- field, are attracted by the visible galactic matter, and thus are collected mainly inside a galaxy and in its halo, where matter density is larger. Inside a galaxy, the dark energy particles ν_{de}^+ (representing the cosmological Λ_+ field) are being repelled by the visible galactic matter, and thus are screened to a certain extent (i.e., there is a polarization effect for dark energy). Thus, a surplus of ν_{de}^- particles is collected in the halo and, to a lesser extent, inside the galaxy, resulting in an acceleration acting toward the center of the galaxy, which is known as MOND acceleration. In this way, dark energy *in combination* with the dark matter halo seems to be responsible for the observed MOND acceleration. The dark matter in the halo is deemed to be responsible for the effect of gravitational lensing.

In order to provide an estimate for the magnitude of the MOND acceleration (but *not* a real physical explanation), we are using several hand-waving arguments, but this does *not* amount to a real derivation. The acceleration due to the dark energy field is given by the well known equation

$$a = \frac{1}{3}\Lambda c^2 r$$

where r is the distance from the center of the galaxy. It is assumed that this equation is valid up to the finite distance R_U. Assuming that the polarization effect generates an opposite acceleration outside the galaxy (consider a simplified *Universe* filled with dark energy particles, ν_{de}^- and ν_{de}^+, but which contains only a single galaxy), the MOND acceleration a_0 can be calculated as the average acceleration, i.e., averaged over the entire *Universe* (the radius of the galaxy is negligible), and one obtains

$$a_0 = -\frac{1}{cT_U}\int_0^{R_U=cT_U} \frac{1}{3}\Lambda c^2 r dr.$$

The numerical value is given by

$$a_0 = -\frac{1}{cT_U}\frac{c^2}{6}\frac{1}{R_U^2} = -\frac{c}{6T_U} = -1.15\times 10^{-10}\,\mathrm{m/s^2},$$

where the minus sign was chosen to indicate an acceleration toward the galactic center, R_U denotes the Hubble radius, T_U = 13.82 × 10^9 years is the the age of the *Universe*, and $\Lambda(T_U) = \frac{1}{R_U^2}$, i.e., the amount of dark energy depends on the age of the *Universe*. This is an approximation only, since the expansion of the *Universe* is deemed to reach a turning point in finite time[3], and the *Universe* will change from an expansion to a contraction mode. The combined acceleration inside a galaxy is calculated as

$$a = a_{G_N} + a_0.$$

Since Newtonian gravitational fields possess the property of self-coupling (for instance, like the Higgs field), and, if we assume that the dark energy field does *not couple* to itself, the square of the above equation can be written as

$$a^2 = a a_{G_N} + a_{G_N}\, a_0.$$

Now the gravitational accelerations resulting from visible (dark matter only in the halo) and dark energy inside a galaxy can be calculated. Inside the galaxy two zones need to be distinguished. Solving the above equation for the total acceleration a and considering the two special cases of interest, one obtains the following two equations:

1. $\frac{4a_0}{a_{G_N}} << 1: \qquad a_1 = a_{G_N}.$

The second case is given by the equation

2. $\frac{4a_0}{a_{G_N}} >> 1: \qquad a_2^2 = a_{G_N}\, a_0,$

which is the case of the MOND acceleration that is, this is the correct equation for the orbital speed of stars at a distance large enough from the center of the galaxy. From this equation, by forming the square of the formula for centrifugal acceleration $a = \frac{v^2}{r}$, the following relation is obtained

$$\frac{v^4}{r^2} = G_N \frac{M_{G_N}}{r^2} a_0,$$

where M_{G_N} denotes the gravitational mass of the star. Solving for v^4, we eventually obtain the well known MOND relation, i.e.,

$$v^4 = G_N M_{G_N} a_0 = const,$$

that is, the rotational velocity of a star about the center of the galaxy remains independent of distance r. The above equation is exactly the relation for the observed *fast rotation* of the stars about the galactic cores, which is different from classical Newtonian rotation.

It should be *emphasized* that the above remarks should not be seen as a derivation of the (mysterious) MOND equation, since no consistent physical basis was presented (there are, however, ideas that eventually might lead to such a basis).

EXTREME GRAVITOMAGNETIC FIELD EXPERIMENTS

Since 2006, in a completely different type of *gravitational experiments*, which are carried out in the *laboratory*, Tajmar et al., in a series of papers[4-7,9], are reporting on the measurements of *extreme gravitomagnetic fields* produced by rotating cryogenic Nb rings or disks, having small masses of about 400 g. The strength of these fields, if confirmed, would be *up to 18 orders of magnitude* larger than predicted by *GR*. These experiments are in clear contradiction to the GP-B experiment. In GP-B the *Earth* was used as the test body and measuring time was about 10 months, since the frame-dragging effect (Lense-Thirring 1918) accumulates over time. According to *GR*, it is impossible to measure this effect in the laboratory.

On the other hand, Tajmar et al. are using a Nb ring of some 15 cm diameter and the measuring time is a few seconds only. According to *GR* their observed gravitomagnetic field is equal to the one produced by a white dwarf. Furthermore, in 2007, gravitomagnetic fields generated by a rotating cryogenic lead disk were measured by Graham et al.[8]. Though these measurements were not conclusive (the accuracy of the laser gyroscope was not sufficient to produce a standard deviation small enough) their measurements also saw the same (strange) phenomenon, reported earlier by Tajmar et al., termed parity violation that is, gravitomagnetic fields produced by the cryogenic ring or disk vary *substantially* in their field strength and also change sign, depending on their sense of rotation, i.e., clockwise or counter-clockwise.

The GP-B experiment also reported an *anomaly* in form of a large misalignment of its four gyroscopes, once they were in orbit. In GP-B, Nb coated quartz spheres are rotated at cryogenic temperatures to use the London effect (i.e., a rotating superconductor is generating a magnetic induction field $\boldsymbol{B}$ along its axis of rotation) to provide a coordinate system in space, oriented toward a fixed star. There were two gyro pairs, with a gyro separation distance of a few centimeters. When we were analyzing the GP-B experiment in 2008[42,44], employing the concept of extreme gravitomagnetic fields, it turned out that an *interaction between the gyros in each pair* should have occurred, since the gravitomagnetic field generated by one sphere would be acting on the other one and vice versa, leading to a noticeable *spindrift anomaly*. In this case, a rotation of the gyro axis in the plane *perpendicular to its orbital plane* should have occurred. The spindrift magnitude is given by 1/2 $B_{gp}\ sin(\psi)$, where ψ is the gyro misalignment angle of the gyroscope (the gyroscopes are initially oriented toward the guide star IM Pegasi, see Part II[10]). If a spinning sphere (gyroscope) does generate an extreme gravitomagnetic field of similar magnitude as observed by Tajmar et al., this should be leading to an observable torque, causing a substantial frame-dragging effect, resulting in a spindrift. The second effect that should have occurred, would have caused a gravitomagnetic force in tangential direction, *slowing down one sphere and accelerating the other*[44]. This, in principle should have led to an effect much larger than the Lense-Thirring effect produced by the rotating *Earth*. From the GP-B data, however, it cannot be presently concluded that this theoretical effect actually occurred, though there might be room for it. The Stanford scientists attributed the misalignment to an electrostatic patch effect, i.e., the surfaces of the Nb spheres, not being perfectly spherical, would have exhibited slight deviations from an equipotential surface, thus leading to electrostatic forces.

If the experiments by Tajmar et al. can be confirmed, they would serve as proof for the existence of additional gravitational fields of *non-Newtonian character* that is, gravity-like fields *not* generated by the movement of large gravitational masses, pointing to a much more complex nature of gravitation. Furthermore, these gravitational fields should not be spin 2 fields, but spin 1 fields. As has been demonstrated in the GP-B experiment, measuring gravitomagnetic fields poses extreme difficulties. Tajmar et al. measure for a few seconds only, and therefore should not be able to detect any signal at all. Independent of the magnitude of their signal, as long as they are measuring any gravitomagnetic field at all, it must be *outside GR*.

Introduction to the experiments of Tajmar, Graham, and GP-B

The statement by Soren Kierkegaard, providing two opposite alternatives (below), exactly characterizes the present situation with respect to the existence of novel extreme gravitomagnetic fields.

One is to believe what isn't true: The author could be biased by the physical model of *EHT*, which is predicting this type of field, and hence is interpreting the results of the experiments by Tajmar et al., Graham et al., and GP-B by means of the presence of extreme gravitomagnetic fields, in order to provide experimental validation for a fancied physical model. In other words, experimental artifacts are interpreted as physical reality to confirm novel (but false) physical ideas. For instance, remember cold fusion, the fifth force, detection of magnetic monopoles, and lately, superluminal neutrino speed etc.

The other one is to refuse to believe what is true: The experimentalists themselves, arguing from the apparently save basis of established theories of general relativity and quantum physics, interpret their unexplainable results as acoustic noise, null results, or electrostatic patch effects, rejecting the idea of extreme gravitomagnetic field. In other words, the situation is reminiscent of the attitude of the Cardinal who refused to look through the telescope of Galileo, for fear of getting a headache. Hence, the gates of heaven remained closed.

At the moment, it is not easy to decide which view is the correct one. Since physics is an experimental science, additional experimental data are needed to be absolutely sure about the existence of extreme gravitomagnetic fields. At present, we will be content to come forward with plausible physical arguments, obtained from recent experiments, in favor of the existence of these fields. *That is it*.

If we want more, then those novel experiments based on the interference of matter waves and modified torsion balance should be considered that is, experimentalists need to find out if the *Gedanken experiments*, termed gravitational Aharonov-Bohm effect as presented by J. Hauser in Part II in[10], can be converted into real experiments. For instance, the outcome of the suggested neutron interference experiment should provide an unmistakable answer in the form of a *yes-no* decision.

In 2006 Tajmar et al. published a series of experiments claiming to have observed extreme gravitomagnetic and gravity-like fields that would be outside *GR*.

In 2007, a similar experiment was published by Graham et al. utilizing a rotating cryogenic lead disk[8]. These measurements were *not* conclusive (the accuracy of the laser gyroscope was not sufficient to produce a standard deviation of five sigma necessary to claim to have measured a novel effect). The authors reported a null experiment.

However, their measurements also saw the same (strange) phenomenon, reported earlier by Tajmar et al., termed parity violation that is, gravitomagnetic fields produced by the cryogenic ring or disk vary *by order of magnitude* in their field strength, depending on their sense of rotation, i.e., clockwise (CW) or counter-clockwise (CCW). Furthermore, the gyroscope signals recorded by Graham et al. were not entirely random. A similar trend in accordance with Tajmar's observations could be observed. Relaxing the five σ requirement, their experiment possibly observed an effect similar to Tajmar et al.

Moreover, we mention a third experiment, termed Gravity-Probe B, whose gyroscopes were subject to anomalies in the form of large unexpected misalignments.

Tajmar and Graham carried out their completely different type of *gravitational experiments* in the *laboratory*, while GP-B measurements were taken in orbit around the *Earth* at 640 km altitude.

Tajmar et al.[5-7] initially reported on the measurement of *extreme gravitomagnetic fields*, produced by rotating cryogenic Nb rings, having small masses of about 4×10^{-1} kg. The strength of these fields was *up to* 18 *orders of magnitude* larger than predicted by *GR*.

In November 2011 Tajmar published a further paper[9]. He had repeated his experiments using two different experimental configurations, termed Setup D and E. The signal strength was now reduced by about two orders of magnitude compared to his earlier experiments, termed Setup A and B[57]. Since no physical explanation for the reduction in signal strength could be found by M. Tajmar, he eventually re-interpreted his earlier results (but not recanted, i.e., the measured values stand as they are, which is important for the discussion in the accompanying paper by J. Hauser[10]). It should be noted that there is a major difference between recanting of experimental results and re-interpretation. The CERN neutrino velocity measurements had to be recanted (retracted), because they were wrong. No re-interpretation of their earlier data would have been possible. The most likely interpretation at present is, according to Tajmar, that artifacts, caused by the experimental equipment itself, are responsible for the strong signals of Setup A and B, and *not* the presence of extreme gravitomagnetic and/or gravity-like fields, as claimed in earlier publications.

In 2004 the NASA-Stanford Gravity Probe-B was launched after almost fifty years of preparation. The aim was to test the prediction of *GR*, namely that any rotating massive body is dragging its spacetime around (also called frame-dragging), twisting the metric of the surrounding spacetime, or, in other words, producing a gravitomagnetic field $\boldsymbol{B}_{G_N}$. This effect is, however, extremely weak, and thus requires a large test mass (planet or star) and long measuring times. The evaluation of the GP-B data required great care and took almost six years, see the project report from December 2008[42] and the final report of 2011[43]. The major problem was the existence of large, unforeseen gyroscope misalignments many times larger than the predicted effect, requiring complex mathematical procedures to extract the frame-dragging data. It is questionable whether the lengthy and sophisticated mathematical algorithms employed to reconstruct the desired signal are unique and completely reproducible. In the end, the envisaged accuracy could not be obtained, and *GR* was confirmed within about ±15 %. However, a somewhat more accurate result was obtained by Ciufolini in 2006[41] using the data of the Lageos satellites. We feel that the gyroscope misalignment, or at least part of it, could be attributed to the generation of extreme gravitomagnetic fields, and thus the GP-B experiment possibly might not have been well designed to measure the frame-dragging effect of *GR*, but, instead, may have recorded entirely novel phenomena, resulting from the generation of extreme gravitomagnetic fields in orbit. Here the word *extreme* is used with reference to mass, i.e., comparing the mass of the quartz spheres (gyroscopes used in GP-B) with the mass of the *Earth*.

The recent paper of Tajmar (November 2011)[9] is of great importance, since, as the subsequent analysis will reveal, it seems to provide *further evidence* for the existence of laboratory generated gravity-like fields as well as a hint of their dependence on cryogenic temperatures, since the signal strength in these later experiments (Setup C, D, E) was substantially lower than in previous experiments (Setup A, B). The reason for these differences will be explained in Part II[10].

Compared to Tajmar's earlier papers, for instance[6], the gravitomagnetic field strength measured in his latest experiments[9] is reduced from $\approx 3 - 4 \times 10^{-8}$ by a factor of about 100, which means the coupling factor is

$$C_R := |\mathbf{B}_{gp}| / \omega = 2.0 \times 10^{-10}, \qquad (1)$$

where the suffix R in the coupling factor indicates the ring, ω denotes the angular frequency of the rotating ring or disk, and suffix *gp* in the gravitomagnetic field is used as a reminder that this field might have been generated from the interaction between electromagnetism and gravitation by a novel particle called gravitophoton that was already mentioned in several of our earlier publications[35-37,44].

The GP-B experiment reported an *anomaly* in form of a large misalignment of its four gyroscopes, once they were in orbit. In GP-B, Nb coated quartz spheres are rotated at cryogenic temperatures to use the London effect (i.e., a rotating superconductor is generating a magnetic induction field $\boldsymbol{B}$ along its axis of rotation) to provide a coordinate system in space oriented toward a fixed star. The experimental environment of the quartz gyroscopes is similar to the one used by Tajmar et al. and therefore, if Tajmar has seen an extreme gravitomagnetic field, it should have also appeared in the GP-B experiment. In addition, an interaction between the Nb coated quartz spheres at cryogenic temperature should have taken place. Unfortunately, the extreme gravitomagnetic field produced by the small quartz spheres would have interfered with the very weak gravitomagnetic field of the rotating *Earth*, according to *GR*, and thus would have fundamentally compromised the accuracy of the (one billion $) GP-B experiment, since a much larger effect constantly (i.e., during the measuring period of ten months) would have been overlaying the tiny signal from the *Earth*. This was indeed observed, but was interpreted by the Stanford team to be the result of an *electrostatic patch* effect, as will be discussed below.

If the experiments by Tajmar et al. can be confirmed, they would serve as proof for the existence of additional gravitational fields of *non-Newtonian character* that is, gravitomagnetic and gravity-like fields *not* generated by the movement of large gravitational masses, referring to a much more complex nature of gravitation. As has been demonstrated in the GP-B experiment, measuring gravitomagnetic fields poses extreme difficulties. By contrast, Tajmar et al. measure for a few seconds only, and therefore should not be able to detect any signal at all. Independent of the magnitude of their signal, as long as they are measuring any gravitomagnetic field at all, it must be *outside GR*.

Results of gravitomagnetic experiments by Tajmar and Graham

In this section, the experimental results from the experiments by Tajmar et al. and Graham et al. are presented. The in orbit experiment Gravity Probe-B is discussed in Part II[10]). It is different from the laboratory experiments, since its intention was not to search for new physics in the form of extreme gravitomagnetic fields, but to provide a testbed for classical *GR* by measuring the predicted frame-dragging effect as accurate as possible. The main results of the laboratory experiments, i.e., the gravitomagnetic experiments by Tajmar et al. and Graham et al. are summarized in the form of two tables, subsuming the measured values of the gyroscope output and presenting a comparison of measured and calculated values for the so called parity violation. The evaluation and interpretation of the results together with an explanation of the observed unusual phenomena are given in the following three sections.

Comparing the gyro results as shown in TABLE 1, it is obvious that there are substantial differences for the clockwise gyro signals for different materials, and it also might seem that there are inconsistencies in the measured counterclockwise signals. However, as shown in the rightmost column, the ratio of the CW/CCW signals, within their specified measured uncertainties, always assumes one of the integer values *1, -1, 5, and -5*. These values should occur according to *EHT*, and are derived from the partial terms of the corresponding Hermetry forms. However, at present, it is not understood theoretically under which experimental conditions a specific ratio is seen.

The last row (green) shows the results by Graham et al.[8]. Results of Graham were obtained by utilizing the high precision ring laser gyro, operated by the Canterbury Ring Laser Group that has dimensions 21.0 m × 39.9 m. In this experiment, due to its size, the gyro is operated *outside* the cryostat at ambient temperature, and therefore any influence of evaporating helium causing acoustic vibrations, as claimed by Tajmar, on the measuring equipment can be excluded. The change in sign (compared to results of Tajmar et al.) of the $\boldsymbol{B}_{gp}$ field can be explained from the fact that the ring laser gyro saw the downward component of the (dipole) gravitomagnetic field vector, which is a polar vector (according to *EHT*, the Tajmar experiment in Setup A measures the magnitude of an axial vector), since the measurement location was outside the disk.

In Setups B and C of Tajmar et al. the angular frequency was limited to ω = 100 rad/s, instead of ω = 420 rad/s in Setup A (see TABLE 1). Comparing the results of Setups B and C, it is obvious that there is a substantial difference in the magnitude of the gyro signals. Furthermore, if the 5σ rule is employed, in order to have a *valid gyro signal*, i.e., the measured signal magnitude must be at least *five times larger than the standard deviation*, only the measured results of the first red row would qualify as valid signals. In addition, even the CCW value in this row might have to be considered a null signal. From[6] all uncertainties are restricted to one digit accuracy, no information is available on the second digit. Applying the same rule to the yellow measurements, all *measured results should be disqualified*, except perhaps the first value in the first row. However, if the uncertainty were about 10 % larger than specified, this result also would have to be considered a *null result*. Since the uncertainties in Setup C are already one order of magnitude less than the ones in Setup B, it is not clear how accurately they could be determined. In other words, it could be that *all results in Setup B and C need to be discarded*. There is substantial uncertainty in interpreting the signals of Setup C in such a way that only the rotating liquid helium is responsible for the signal, while the gravitomagnetic signals of the Al-Al and Nb-Al are counted as null. If the casing of Setup C works similar to a gravitomagnetic cage, all signals are drastically reduced. However, as depicted in the rightmost column, the ratio of the CW/CCW signals, within their specified measured uncertainties, does assume one of the integer values *1, -1, 5, and -5* as already shown in TABLE 1.

Phenomena observed in the three gravitomagnetic field experiments:

- Tajmar et al.: The measured CCW signals for Setup A in TABLE 1 reveal a change in sign compared to CW signals.
- Tajmar et al.: The noise levels in Setup A (see TABLE 1) are in the range of the largest signal measured in Setup C (TABLE 2).
- If the 5σ rule is strictly applied, the results in TABLE 2 would have to be discarded and the same holds true for several further measurements of TABLE 1.
- On the other hand, the gyros *do* report sign changes in the signals, i.e., they actually seem to *see* a signal, which is *not* random in nature. The gyros are *able* to distinguish between rotations in the CCW and CW directions, even for these smaller signal strengths.

TABLE 1 : The three (yellow) rows depict the measured values for Setup A1, compiled from[5] and the following four (red) rows show the gravitomagnetic field measurements for a slight variation, termed Setup A2. In both cases a Nb ring was used. Depicted is the so called *coupling factor* × 10^8 (see Eq. 1), defined as gyro-signal per angular frequency (rad×s^{-1}/ω) (as reported in Tajmar et al.[6]). The temperature ranges from T = 4 - 6 K. The last row, in green, shows the measurements obtained from Graham et al., where a Pb disk was used, and measurements were done *outside* the cryostat employing a large ring laser. Note that this experiment does not satisfy the five σ rule in order to be able to claim a conclusive set of measurements. As can be seen, the magnitudes of the measured B_{gp} field strangely depend on the direction of rotation (the index *gp* was used to indicate a gravitomagnetic field, supposed to be generated by an interaction involving the postulated gravitophoton ν_{gp}. Because of the magnitude, the B_{gp} field cannot be attributed to Newtonian gravitation). The last column shows the gyroscope signal ratio, denoted CW/CCW, as calculated from *EHT*, for rotations in clockwise and anti-clockwise directions. The theoretical results are in agreement with measured results from columns CW and CCW when measurement uncertainties are considered.

Gravitomagnetic Measurements for Setup A1 and A2 by Tajmar et al.					
Material	*Sample Holder*	*Geometry*	*CW*	*CCW*	*CW/CCW*
Nb	Al	ring	3.2 ± 0.5	-0.4 ± 0.3	-5
YBCO	Al	ring	5.3 ± 0.2	-1.2 ± 0.1	-5
Al	Al	ring	3.8 ± 0.2	-0.7 ± 0.3	-5
Nb	Al	ring	5.7 ± 0.4	4.8 ± 0.5	1
YBCO	Al	ring	3.1 ± 0.4	0.3 ± 0.4	5
Teflon	Teflon	ring	3.1 ± 0.4	-0.5 ± 0.5	-5
-	-	no sample	-0.1 ± 0.2	-0.3 ± 0.1	-
Pb	Pb	disc	-5.3 ± 8.5	37.7 ± 13.2	-5

TABLE 2 : This table is similar to TABLE 1, except that two different experimental setups were utilized, namely Setup B (similar to Setup A), see Part II[10]. The three (red) rows of the table show the *coupling factor* × 10^8 at temperatures T = 4 - 6 K for Setup B as reported in Tajmar et al.[6]. The following three (yellow) rows depict the measured values for Setup C, compiled from[5]. It is clearly recognizable that the signal strength is weakened significantly by the transition from Setup A to Setup C. This trend is even further exacerbated in the transition to Setup E, so that the signals now are in the noise level of the gyroscope, and so it seems that the gravitomagnetic field has disappeared. The green row shows measured results at the temperature of liquid nitrogen, which are effectively null results.

Gravitomagnetic Measurements for Setup B and C by Tajmar et al.					
Material	*Sample Holder*	*Geometry*	*CW*	*CCW*	*CW/CCW*
St.-Steel	St.-Steel	ring	3.4 ± 0.5	-4.7 ± 0.9	-1
Al	Al	ring	2.1 ± 0.8	-2.2 ± 0.5	-1
Al	-	disc	0.3 ± 0.1	-0.3 ± 0.1	-1
Al	Al	He cup fins	0.17 ± 0.03	0.01 ± 0.09	-1
Al	Al	ring	-0.03 ± 0.03	-0.04 ± 0.04	1
Nb	Al	ring	-0.12 ± 0.05	-0.12 ± 0.08	-1
YBCO L_2N_5 T = 77 - 90 K	Al	ring	0.0 ± 0.01	0.01 ± 0.01	-

CONCLUSIONS

The twentieth century has seen substantial progress in physics, but gravity is still a mysterious force. The last fifty years were dominated by particle physics, where space and time are not playing a major role. The twenty-first century therefore needs to *re-establish the dominant role of spacetime*, if the true nature of the gravitational force and its implication on technology are to be revealed.

Any breakthrough in propulsion or energy generation, in order to become a real game changer, needs to be functioning *without fuel*. This insight is not new, and was already discussed in the book on space propulsion by Corliss, 1960, termed *field propulsion*, and was actively researched in industry and academia at that time.

The only propulsion technology currently available results from the physics of classical momentum conservation, applied to a physical system comprising the *rocket and its fuel*. This concept has fundamental limits as expressed by Tsiolkovsky's rocket equation of 1904, i.e., the achievable final rocket velocity at the instant of burnout is given by the equation,

$v_f = v_e ln \frac{m_i}{m_f}$, where v_e is the velocity of the gas at the rocket nozzle exit, resulting from the combustion of fuel (LH) and oxidizer (LO), which is simply given by the chemical energy stored in both LH and LO, and today is in the range of 4,500 m/s. The exit velocity is limited by the physics of the atom shell (10 eV), and thus cannot be overcome by any technical refinement. The other, severe limiting factor is the *logarithm of the ratio* of the initial rocket mass m_i on the launch pad and the final rocket mass m_f at burnout.

A *novel physical principle* for spaceflight as well as energy generation is needed *first*, then everything else will fall into place, i.e., the proper technology will follow from this principle.

What could this new physical principle be? Obviously, it has to do with both *gravitation and spacetime*.

To this end, a set of recent *eleven experiments* was identified that, in some way or another, contradict established physical theories. The existence of novel gravitational laws might also be supported by the *Modified Newtonian Dynamics* (*MOND*) hypothesis, which alters Newtonian gravity for small accelerations. So far MOND has not been motivated by any underlying physical model or theory.

In numerous experiments, first published in 2006, Tajmar et al.[4-7,9] reported on the measurements of *extreme gravitomagnetic fields* produced by small rotating Nb rings at cryogenic temperatures that are up to 18 orders of magnitude larger than predicted by *GR*.

It is postulated that an interaction between electromagnetism and gravitation at cryogenic temperatures exists, as surmised already by Faraday in the 19th century. In addition, drastic extensions with regard to the types of matter that are existing in the *Universe* might become necessary, requiring additional types of matter of both negative and imaginary mass. Moreover, the experimental results of the extreme gravitomagnetic field experiments, if verified, would, according to *EHT*, require an increase of the fundamental forces from four to six, where the two additional interactions (between electromagnetism and gravity in conjunction with spacetime and dark energy) are gravity-like fields (laboratory generated) that can be both attractive and repulsive.

If extreme gravitomagnetic fields are accepted as the physical cause for the anomalous experimental effects, they are obviously outside both *GR* and the standard model of particle physics.

In the the two other gravitomagnetic experiments, namely the measurements by Graham et al. *no* acoustic noise could have been generated, since the laser interferometer used by Graham et al. has a footprint of about 20 m × 40 m. Furthermore, there are additional anomalous effects in the Gravity Probe-B experiment unexplainable by acoustic noise, i.e., the spindrift and the tangential accelerations of the four gyroscopes (which are Nb coated quartz spheres). These topics will be discussed in detail in the accompanying paper by J. Hauser[10].

However, there is as yet *no* firm experimental basis for the existence of extreme gravitomagnetic fields. On the other hand, the experimental situation seems to be *better* than for the so called advanced physical theories that either cannot be falsified (string theory), and/or are predicting particles not found by the *LHC*. Even worse, quantum gravity and supersymmetry (which is an extension of the standard model of particle physics) seem to contradict the latest experimental findings. Moreover, current observations from space science missions would demand huge amounts of dark matter to be present inside galaxies, in order to avoid the MOND (Modified Newtonian Dynamics) hypothesis; whereas recent satellite observations *only* seem to allow dark matter in the halo of galaxies, i.e., these measurements exclude the presence of dark matter within galaxies, as discussed in the text. Gravity, therefore, might have a multifaceted nature, and Newtonian gravitation might represent just one feature.

As it turns out, entirely novel technologies would be possible in form of *gravitational engineering* if gravity-like fields existed. Laboratory generated gravity-like (acceleration) fields might become a reality, similar to the generation of electromagnetic fields, which would give rise to a *revolution* in propulsion as well as energy generation. It would bring a new level to almost all kinds of technology, lowering the cost of transportation and energy production by orders of magnitude, providing a simple but safe and highly efficient technology, only requiring the handling of liquid helium, and thus resembling a technology from MacGyver land.

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[51] A. Einstein's general relativity (GR) of 1915 has not changed this picture.

[52] *EHT* is not Heim theory, despite the similarity of the names. The name *EHT* was *selected to honor* B. Heim's idea of internal gauge space. The concept of internal space in *EHT* is reminiscent of B. Heim's initial six-dimensional approach, but otherwise the two approaches are employing different physical concepts and there are no further relationships, except, of course, for the name.

[53] *Note*: We are inaccurate here, following the customary use. Actually the mass of a particle is given by E/c^2, where E denotes energy and c is the speed of light.

[54] Not everybody is convinced that dark matter and dark energy exist. Recently field medalist *C. Villani*[34] expressed his doubts about the existence of dark matter and dark energy.

[55] *Note*: Despite the names *gravitoelectric* and *gravitomagnetic* these fields are *pure* gravitational fields. The terms electric and magnetic are used to emphasize the similarity between the linearized Einstein field equations of *GR*, known as Einstein-Maxwell equations and the Maxwell equations of electrodynamics. The corresponding charge of course is the gravitational mass. However, the extreme gravitomagentic fields do *not* follow from the Einstein-Maxwell equations, but are described by the so called Einstein-Heim equations[3].

[56] *Note*: it is necessary to distinguish how dark energy interacts with the spacetime field and with visible or dark matter.

[57] *Dr. E. Davies*, Institute for Advanced Studies, Austin, TX, in an e-mail to Prof. J. Hauser (30 January 2013), stated that Tajmar had *recanted* his results. In an e-mail to J. Hauser, Prof. M. Tajmar rejected this claim. He did *not* recant, but has re-interpreted his results.