48th AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit
29 July -1 August 2012, Atlanta, Georgia

AIAA 2012-3915
Revised Version 22 July 2012

On the Reality of Gravity-Like Fields

Walter Dröscher [1], Jochem Hauser [2] *

At present all space propulsion systems as well as jet engines rely on the reaction principle, and thus need a substantial supply of fuel. In general, fuel mass 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. Hence, any breakthrough in propulsion, in order to become a real game changer, needs to be functioning without propellant, and thus has to be able to produce its own gravitational field, strong enough to overcome planetary gravitation. However, if gravity were completely described by Newton's law, as current physics proposes, there is no possibility in achieving this goal. Any breakthrough in propulsion does require a breakthrough in gravitational physics (but not in particle physics). The paper therefore discusses the reality of the existence of novel gravity-like fields, both experimental and theoretical. To this end, a set of eleven experiments was identified that contradict established physical theories. In addition, a theoretical approach is presented, termed Extended Heim Theory (EHT), that predicts six fundamental forces, three of them of gravitational origin as well as the existence of an interaction between electromagnetism and gravitation. As a result, entirely new gravitational laws should exist. This view might be supported, for instance, by the Modified Newtonian Dynamics (MOND) hypothesis, which alters Newtonian gravity for small accelerations. It implies that the relation between the Newtonian gravitational force and acceleration differs from Newton's second law for very weak accelerations, which is typical for large scale structures like galaxies. So far MOND has not been motivated by any underlying physical model or theory. Therefore an attempt is made to explain the physics of MOND employing the novel physical concepts of *EHT*. In addition, recently S. S. McGaugh has demonstrated the validity of MOND for 47 gas rich galaxies. The experimental situation seems to be contradictory, since Cifuolini in 2006 and the NASA-Stanford Gravity Probe-B experiment in 2007 confirmed the Lense-Thirring effect as predicted by *GR* (gravitomagnetic fields generated by a rotating massive body, i.e. *Earth*) within some 10-15%, validating the predictions of *GR*. The experimental situation seems to be irreconcilable, because in numerous experiments, first published in 2006, Tajmar et al. 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*. In this overview paper a non-mathematical account is given in order to reveal the underlying physics of MOND and to try to clarify the multi-faceted physical nature of gravity. Most important, it turns out, that entirely novel technology might be possible in form of gravitational engineering, that is, laboratory generated gravity-like fields might be producible, similar to the generation of electromagnetic fields, which would give rise to a revolution in propulsion as well as energy generation.

Keywords: MOND, three Different Gravitational Fields, Ordinary and Non-Ordinary Matter, Generation of Gravity-Like Fields in the Laboratory, Interaction between Electromagnetism and Gravitation.

*1 Senior Scientist, Institut für Grenzgebiete der Wissenschaft, 6010 Innsbruck, Austria
*2 HPCC-Space GmbH, Hamburg and Faculty H, Ostfalia Univ. of Applied Sciences, Campus Suderburg, Germany

I. Introduction

Propulsion systems of today are based on the reaction principle, and thus rely on fuel. This has the consequence that fuel mass is much larger than payload mass, if high thrust levels are required. For instance, in chemical propulsion, payload is about 1% of the total mass. So called advanced propulsion techniques, like solar sails are subject to severe physical limits, 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.

The 40th anniversary of the Moon landings has come and gone, but the future of humans going back to the Moon looks grim, not even considering a Mars mission, which seems next to impossible. The problem *is* inadequate propulsion. Space propulsion is stuck with the technologies developed in the 50s and 60s of the last century, and the vision portrayed by von Braun in his famous article in Collier's magazine, entitled *Man on the Moon* in 1952,[4] did not become a reality. The same holds true for the generation of energy. Therefore, if no new physical laws can be found that allow for **propellantless propulsion**, genuine progress in space propulsion will not be possible. In order to progress, emphasis must be given to **novel physics with regard to the nature of gravity**, and not on the refinement of existing technology.

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.

It was much of a surprise when, in 2006, more credible experimental results became known than those published in the preceding decade on the generation of laboratory produced extreme gravitomagnetic and gravity-like fields. One of the hopeful aspects of these experiments is that until recently gravitation could only be observed, but not experimented on in any controlled fashion. It seems now that, with the advent of these new gravitomagnetic experiments, gravity-like fields might be producible in the laboratory. In other words, there seems to be experimental evidence that long-range force fields other than Newtonian gravitation and electromagnetic fields might exist.

Since then, numerous new experiments have been published and novel observations as well as measurements were reported that lead to the conclusion that the picture of the four forces in physics might need to be extended, in particular concerning the nature of gravity. Sometimes these experiments seem to confirm *GR* (general relativity), and sometimes there seems to be a contradiction. In addition, there are measurements that seem to indicate that some of 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*. An excellent non-mathematical introduction to extreme gravitomagnetic and gravity-like fields as predicted by Extended Heim Theory (*EHT*) as well as its technical implications can be found in the recent book by *G. Daigle*.[5]

Therefore, in this paper the attempt will be made to identify these experiments, and to discuss their possible consequences as a source for novel propulsion principles as well as energy generation.

In addition, an introduction to the novel physical ideas of *EHT*) will be given, which will be utilized to analyze these experiments, and to explain their novel physical facts. *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 gravitation, while spacetime is considered to be an active physical field that carries both momentum and energy as well as angular momentum, interacting with the space vehicle.

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 simpler, 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.

II. Experimental Anomalies of the Dynamical Laws of Gravitation

In the following a non-mathematical account of the current experimental situation with regard to dynamical gravitational laws is given, revealing possible entirely unforeseen aspects of gravity from these seemingly contradictory experiments / observations with respect to the phy- sics of present gravitational dynamical laws. In particular, there are two recent experiments that seem to be in contradiction to Einstein's general theory of relativity (*GR*).[1] However, it will be shown that it might be possible that *all of these experiments are on solid ground, representing different, but hitherto unknown facets of gravity*, which might serve as the basis for the above mentioned technology of gravitational engineering.

In general, it is believed that only in the microscopic world of particles and high energies *GR* could be inadequate as outlined in the recent review article by Clifton et al.[2] However, the recent experimental findings of McGaugh seem to invalidate this belief. Moreover, the experiments by Tajmar et al. (see below), if confirmed, would reveal a completely novel feature of gravity, which presents irreconcilable differences with existing *GR*.

Could it be that these experiments are providing hints of a more subtle nature of gravitation as displayed by simple Newtonian attraction for ordinary matter?

In the following, qualitative arguments, derived from the set of the eleven experiments or observations, are given discussing the validity of both the prevailing concepts and dynamical laws of physics, with special emphasis to the laws of gravitation. The ensuing analysis based on conclusions drawn from these, apparently unrelated experimental results, instead of utilizing currently favored advanced theoretical concepts like string theory, supergravity, supersymmetry, or quantum gravity, seems to require the introduction of two additional gravity-like interactions. It also indicates that the current standard model of physics might not contain the sufficient number of particles.

The recently found Higgs boson (July 2012) at CERN, is *only* a confirmation of a theory dated back to 1964, namely how elementary particles might obtain mass, i.e. gain gravitational charge, and thus is not new at all, but is part of the standard model of particle physics, established in the 1970s. However, in *EHT*, there is not a single charge field, but a total of twelve charge fields should exist, providing electromagnetic, weak, and strong charges as well. Not too surprising, the analysis of these experiments also seems to indicate that the so called advanced physical theories might not be adequate in explaining these experimental results. In particular, Newtonian gravitation and its extension, general relativity (*GR*), seem to be at odds with those experimental findings. This does, of course, *not* mean that *GR* has become incorrect, but should be interpreted such that gravity might be a much more complex, multifaceted phenomenon. There may be physical phenomena beyond the range of *GR* or the cosmological standard model as well as the standard model of particle physics. In particular, none of the advanced concepts has foreseen or predicted *any* of the results observed/measured in these experiments.

The set of the eleven, widely different, experiments, provided that all of these measurements can be confirmed, would require a major revision of the fundamental ideas with regard to the workings of *Nature*, that is the number of six fundamental forces, existence of four lepton families, imaginary quarks and imaginary electrons, which are virtual particles of ephemeral nature, a dual spacetime of symmetry SO(4) etc., and would also question or even invalidate numerous advanced concepts beyond the standard model of particle physics. Ideas on the nature of gravity and the number of physical interactions, in an attempt to reconcile the apparently contradictory experimental findings, will be introduced below.

In the present paper, the experiments are presented, discussed, and to some extent analyzed. Furthermore, it will be argued that the contradictions between experimental data and predictions from current physical theory cannot be resolved at the level of the *four* known physical interactions. First, the experiments of interest are listed and their main references are provided. Next, remarks will be provided concerning the apparent deviation of experimental results from established theory. Then, xxperimental results will be analyzed, and their physical consequences will be pointed out. Moreover, several comparisons of calculations from *EHT* and actual observations will be presented. It will be shown that the resulting contradictions cannot be resolved within the framework of current physics, necessitat-

ing the introduction of the novel physical concepts mentioned above. Preliminary conclusions will be reached together with a listing of the open questions.

As will be seen, those novel physical ideas require substantial modifications of established theoretical concepts, in particular regarding the nature of gravity and the types of matter.

Below a brief description of the main topics of the selected experiments that question current and advanced physics is presented:

1. Rotation speeds of stars about galactic centers, McGaugh, 2011[1,3] ,

2. ESO observations on missing dark matter inside ga- laxies, Bidin et al. 2012[12] ,

3. Gravity Probe-B experiment, Stanford University final report 2008,[10] for a different interpretation of the observed gyroscope misalignments in agreement with the experiments of Tajmar et al. see Dröscher, Hauser 2008[17] ,

4. Extreme gravitomagnetic fields, 2006-2011, Tajmar et al., Graham et al.[27,28,30,32] ,

5. Gravity-like fields, 2008, Tajmar et al.[30] ,

6. Superluminal neutrino speed, CERN OPERA team, 2011-2012[21] ,

7. Spacetime simulation by Causal Dynamical Triangulation (CDT), e.g., Loll et al.[40,42,43] ,

8. Large Hadron Collider particle detection, e.g., compare La Science&Vie (2011)[13] and Quigg (2008),[14]

9. ESA Integral Satellite on the energy dependence of the polarization of high energy photons, ESA 2011[11] ,

10. The *propagation speed of gravity*, as discussed by van Flandern[15] might have two different values, depending on the circumstances that is, one velocity is associated with the speed of change of the gravitational potential, as, for instance, in the motion of planets around the central star. In other words, the change of location of a massive body seems almost instantaneously be felt by any other massive object, e.g., both sun and planet interact without any time delay. This speed seems to be about 2.5×10^{10} c, and hence can be considered as almost infinite. On the other hand, gravitational waves or the warping of spacetime, i.e. sending out energy which propagates through spacetime, should travel at c, the speed of light in vacuum.

11. The existence of *non-local fields*, i.e. the instantaneous communication of the state of a system, has been verified experimentally for more than three decades. For instance, in 1981, A. Aspect experimentally verified that the state of an entangled system is communicated quasi instantaneously by measuring the state of polarized photons moving in opposite directions. The communication for non-local fields cannot take place by mediator bosons. No particles can be associated with these fields, i.e. they cannot be quantized.

Topic ten, has been analyzed by van Flandern, and recently by Rowlands,[16] and thus will not be discussed here. The problem with the speed of gravity seems to be analogous to the instantaneous collapse of the wave function, and the experimentally verified phenomenon of entanglement. However, in our spacetime, which is subject to the Lorentz group $SO(3,1)$, i.e. without regarding the phenomenon of tunneling, signals (i.e. sending information or energy) moving faster than the speed of light do not seem to be possible. Therefore, there seems to exist a dual spacetime with symmetry group *SO(4)* for non-local fields.

The following remarks seem to be in place on the impact of the selected experiments.

- The first two experiments seem to imply contradictory results, since McGaugh observes orbital velocities of stars about galactic centers, which differ from Newton's law,

- while observations seem to rule out the existence of dark matter inside galaxies, deemed to be the very cause for the deviation from Newton's law.

- The third experiment, GP-B, confirms *GR* on the planetary scale (Lense-Thirring effect), but also has reported very large, unforeseen misalignments of their four cryogenic Nb coated spherical quartz gyroscopes,

- similar to those effects seen in the experiments by Tajmar et. al and Graham et al., which are, however, performed in a laboratory on *Earth* at cryogenic temperatures. Moreover, Tajmar et al. not also report on the generation of extreme gravitomagnetic fields, but also seem to produce a circumferential acceleration field (gravity-like field).

- Experiment six deals with superluminal neutrino sp-eeds, as measured by the CERN OPERA team, that, however, suffered from two mishaps, and thus is not conclusive. This experiment will be repeated in the second half of 2012. Independent observation from a supernova explosion might, however, support the CERN measurements The supernovae data of 1987 have shown that neutrinos arrived three full hours before light from the explosion reached *Earth*, but further confirmation is needed. Moreover, the CERN Icarus experiment reports on subluminal neutrino speeds. Thus, the experimental situation is not clear at present, and no final conclusion on the neutrino speed issue is possible, though *SR* cannot be given up lightly.

- The experiments by Loll et al. are not measurements or observations, but represent computer simulations. They reveal most astonishing facts. Only if causality (arrow of time) and a repulsive force with respect to the spacetime field in form of Einstein's cosmological constant are present in the gravitational action of the Feynman path integral (Monte Carlo simulation), does the common four-dimensi- onal spacetime of the *Universe* develop. Furthermore, classical *GR* seems to hold down to the Planck length scale, and a two-dimensional spacetime (but no spacetime foam) is observed at smaller length scales. Perhaps 4D quantum gravity is not needed?

III. Novel Dynamical Gravitational Laws

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.

III.A. Types of Gravitational Forces

Newtonian gravitation is attractive between baryonic matter which comprises about 4 % of the *Universe*. Repulsive gravitation is due to a field in spacetime called dark energy *acting* on spacetime, which is responsible for about 73% of the energy in the *Universe*. The remaining 23 % are attributed to dark matter. The cosmological constant is associated with this dark energy field that is ubiquitous in the *Cosmos*, but there seem to be other physical processes capable of producing a repulsive gravitational force against spacetime (locally) [a] that is, the experiments by Tajmar et al. most likely need to be explained in this way.[36,38] 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 confirmed by recent computer simulations, called Causal Dynamical Triangulation (*CDT*), see Ambjorn, Jurkiewicz, and Loll,[40–44] since in these simulations spacetime, as it is experienced (four-dimensi- onal 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. Again, this is the impact on the spacetime field, not the gravitational interaction between different types of matter, e.g. visible and dark matter, which is attractive. In general, $\Lambda = \Lambda(t)$. This indicates that *the Lagrangian in the gravitational path integral, constructed from the original Einstein field equations, seems to be incomplete without such a repulsive field* and, consequently, our *Universe* with its four-dimensional spacetime cannot develop in time without it. In gen-

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

eral, there could be a local dependence also that is, $\Lambda(x)$ where $x = (x^\mu)$ denotes the four-spacetime vector. For instance, there might be a difference inside and outside galaxies. The importance of the *CDT* computer simulations cannot be overestimated:

1. Spacetime above the Planck length is four-dimensional (i.e. there are no higher dimensions).
2. The evolving spacetime possess a **de Sitter topology**, i.e., is spherical (that is, no wormholes and no time travel etc.).
3. There is **no multiverse**. From the superposition of the various paths in the Feynman path integral all other universes cancel out.
4. Monte Carlo simulation leads to exactly one universe, namely the one we are living in.

Furthermore the following conclusions can be drawn from the MC simulations:

- The path integral employed uses Lorentzian invariance, which most likely renders quantum gravity theories as well as variations of *GR* that predict deviations from this principle, unphysical.
- However, a **repulsive gravitational force** in combination **with causality** is needed in all computer experiments, otherwise the simulated spacetime becomes unphysical, i.e. has an infinite number of dimensions.
- Causality (second law of thermodynamics, which governs the direction of possible processes, while symmetries determine the respective conservation laws) simply means that one cannot go back along the time coordinate (that is $t_n > t_{n-1}$) while in space all directions are possible.
- As it seems, CDT only makes fundamental assumptions that is, *none* of the concepts of the so called advanced theories like strings, loops, branes, higher dimensions, multiverse are necessary, nor are there any additional symmetries involved.

III.B. Ordinary and Non-Ordinary Matter in Physics

Since **Einstein already had two different types of gravitation** one could have asked what are the particles (bosons) that mediate these forces? One, of course would be the graviton, ν_g, but the second one, responsible for repulsive gravitation, ν_q, is unknown and is termed quintessence in this article. As cosmological data show, there should be three types of matter in the *Universe*: ordinary matter m_g, dark matter m_{DM}, and dark energy m_{DE}.

Therefore, based on these grounds, one might tentatively assume that there are also **three different types of gravitational forces**: attractive ν_g, repulsive ν_q, and attractive-repulsive associated with the so called gravitophoton, via the decay mode $\nu_{gp} \rightarrow \nu_g + \nu_q$, responsible for the attractive interaction between dark and Newtonian matter.

The three different types of matter give rise to three different gravitational constants, G_N, G_q, and G_{gp}. The three different versions of gravitational interaction, are termed graviton (ν_g, Newtonian gravitation, attractive), which is both a spin 1 and spin 2 field in *EHT*, (ν_{gp}, gravitophoton gravitation, dark matter, attractive) which is a spin 1 field, and (ν_q, quintessence particle, repulsive, dark energy) also a spin 1 field. The laws of Newton and also the *GR* of Einstein are applicable only to ordinary matter (OM) (visible and dark as long as gravitation is concerned) or Newtonian matter, represented by m_g. As soon as experimental situations are encountered where NOM is involved and interaction between OM and NOM takes place, these laws cease to be applicable, and deviations from the dynamical laws of Newton (Einstein) should be expected.

The experiments by Tajmar et al. are more involved, since the effect is depending on a (cryogenic) threshold temperature. Second, the extreme gravitomagnetic fields reported cannot be caused by moving masses, since the masses of the ring or disk are small (several hundred grams).

Therefore, it is assumed that a phase transition occurs at a specified cryogenic temperature, eventually followed by symmetry breaking. Since extreme gravitomagnetic fields are measured (with regard to *GR*), it is postulated that an interaction between electromagnetism and gravitation takes place that is, a magnetic induction field $\mathbf{B}$ is finally converted into a gravitomagnetic field $\mathbf{B}_{gp}$, requiring the conver-