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Physics of Axial Gravity-Like Fields

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Only with *novel physical principles*, providing the proper engineering principles for propellantless propulsion, can the limits of classical propulsion be overcome. The concept of gravitational field propulsion represents such a novel principle by the capability of building devices for the generation of gravity-like (i.e. acceleration) fields in a way similar to electromagnetism. In other words, gravity fields should be technically controllable. Since a propulsion system based on gravity-like fields has to function in empty space, it has to interact with the spacetime field itself. At present, physicists *believe* that there are four fundamental interactions: strong (nuclei, short range), weak (radioactive decay, short range), electromagnetic (long range), and gravitational (long range). As experience has shown over the last six decades, none of these physical interactions is suitable as a basis for novel space propulsion. Furthermore, none of the advanced physical theories, like string theory or quantum gravity, go beyond these four known interactions. On the contrary, recent results from causal dynamical triangulation simulations indicate that wormholes in spacetime do not seem to exist, and thus, even this type of exotic space travel appears to be impossible. However, there seems to be genuine evidence of novel physical phenomena, based on both new theoretical concepts as well as recent experiments that may have the potential to leading to propellantless space propulsion technology, utilizing two novel fundamental long range gravity-like fields that should be both attractive and repulsive, resulting from the interaction of electromagnetism and gravity. The theoretical concepts for the axial gravity-like field and the respective experimental realization pertaining to the physics of gravity-like fields are presented together with a derivation for the magnitude of the axial gravity-like field and , according to the equations derived, it is shown that an axial gravity-like field acting may be producible, which should be strong enough for propulsion purposes. The basic experimental setup along with respective technical requirements as well as the resulting acceleration are given.

Nomenclature

ν_{gp}^0	= two types of neutral gravitophotons (gravitational gauge boson)
ν_{gp}^+, ν_{gp}^-	= positive (attractive) and negative (repulsive) gravitophotons (gravitational gauge bosons)
ν_g	= graviton (gravitational gauge boson, attractive)
ν_q	= quintessence particle (gravitational gauge boson, repulsive)
ω_I	= angular velocity of imaginary electrons
$\mathbf{B}_G$	= gravitomagnetic field vector from real moving masses
$\mathbf{B}_{gp}$	= observed gravitomagnetic field vector
$\mathbf{E}_G$	= gravitoelectric field vector from stationary masses
$\mathbf{E}_{gp}$	= gravitoelectric field vector from gravitophotons
F	= Helmholtz Free Energy $F = U - TS$
G	= gravitational constant comprising three parts, G_N, G_{gp}, G_q
G_N	= Newtonian gravitational constant, (mediated by graviton, attractive force)
G_{gp}	= gravitational constant for gravitophoton interaction = $\frac{1}{67^2}G_N$, this type of gravitation is both attractive and repulsive
G_q	= gravitational constant of quintessence interaction, repulsive, $10^{-18} \times G_N$

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$g_{\mu\nu}$	= component of metric tensor as in *GR*, $\mu,\nu = 1,2,3,4$
$g_{\mu\nu}(H_\ell)$	= metric tensor of Hermetry form $H_\ell, \ell = 1,...,16$
g_{gp}	= gravitophon acceleration (in contrast to gravitational acceleration by gravitons)
H^8	= Heim space, eight-dimensional internal space attached to each point of spacetime
H_ℓ	= Hermetry form (metric subtensor from double coordinate transformation), $\ell = 1,...,16$
m_e, m_p	= electron and proton mass, respectively
k_B	= Boltzmann constant
R^3 , T^1 , S^2 , I^2	= subspaces of internal space H^8
S	= entropy
T	= temperature [K]
U	=internal energy
v	= circumferential velocity of disk in axial field experiment

Abbreviations

CV	Control Volume (momentum conservation)
CMB	Cosmic Microwave Background Microwave, present value 2.7 K
EGP	Einstein's Geometrization Principle
EH	Einstein-Heim Equations
EHT	Extended Heim Theory
EM	Einstein-Maxwell Equations
ESA	European Space Agency
GR	General relativity
GP-B	Gravity Probe B experiment, NASA-Stanford Univ.
LHC	Large Hadron Collider at CERN, Geneva
NOM	Non Ordinary Matter (particles subject to gravitomagnetic or quintessence interactions)
OM	Ordinary Matter (particles subject to Newtonian gravitation)
QED	Quantum Electrodynamics
QFT	Quantum Field Theory

I. Introduction to the Propulsion Science of Gravity-Like Fields

A. Remarks on Practical and Theoretical Aspects of Field Propulsion

As has been discussed for about a decade in a series of papers[1–14] , if spaceflight as envisaged by Wernher von Braun is going to take place, a **paradigm shift in space propulsion** is needed. The rocket program initiated by von Braun in the late 50s served well its purpose in landing a man on the moon, but is not adequate for sustained space travel, and, very recently, the manned space flight program of the U.S. was discontinued. As was shown in a recent book chapter[14] , chemical propulsion presently is the only means to lift a space vehicle from the surface of the *Earth*. As long as physics is knowing only the four fundamental forces of Newtonian (Einsteinian) gravitation (attractive) and electrodynamics (Maxwell), which are of long range, as well as the weak force (radioactive decay) and the strong force (atomic nuclei), there is **no possibility to escape the coercion of a propulsion technology requiring fuel**.

As a consequence, any propulsion system is more or less a flying fuel tank. Obviously such a system is characterized by *low reliability, high cost, complex technology, small payload, low velocity, limited range, extreme flight time*, and, as experience has shown, carries *substantial risk if to be used for manned space flight*. However, the problem is not with the engineering, which is highly skilled, but lies in the fundamental physics that is the cause of all these limitations. Considering most of the so called advanced propulsion systems they are not really advanced, since all of their physics is known since the 1930s. Technically, none of the advanced systems has been realized, and most of these ideas are technically not feasible (worm holes, warp drives etc.).

Regardless what the efforts are, this problem can only be solved if **novel physical laws in the form of long-range interactions** can be found that provide the means of propellantless propulsion.

It is straightforward to decide what features these novel fields should have. Any propulsion technology in use today is based on the combined momentum of space vehicle and its fuel. The combined momentum, when the vehicle with its fuel inside, is sitting on the launch pad is zero, and because of momentum conservation, always will remain zero. In other words, the sum of vehicle momentum and fuel momentum adds up to zero.

The performance of any existing propulsion system can be judged immediately by placing a closed control surface

(CV) around the vehicle and verifying the amount of momentum entering or leaving through this *CV*. Regardless of what is going on in the interior of a space vehicle, for instance, how much energy is being generated or the type of mechanism being used to moving parts inside, only the momentum through the *CV* counts. If there is no momentum change with respect to time through the *CV*, the velocity of the space vehicle cannot change. This fact follows simply from Newton's second law (all space vehicles at present are flying at speeds of several kilometers per second and clearly are non-relativistic) $\frac{d(m\mathbf{v})}{dt} = \mathbf{F}$, which means if there is no change in momentum, there will be no force that can accelerate the space vehicle.

The often cited propellantless propulsion is clearly **not achievable with the physical principle of classical momentum conservation**. There is, of course, a different method that is well known, which has been used since the beginning of spaceflight. This technique is called field propulsion or *gravity assist*. A space vehicle enters the gravitational field of a planet and is being accelerated through Newton's gravitational law. This type of field propulsion, however, is extremely limited, because it depends on the presence of a planet or star to modify the trajectory of the vehicle, and thus cannot serve as an independent propulsion principle.

B. Propellantless Space Propulsion

Naturally, a propulsion system based on the generation of gravity-like fields, i.e., working without propellant, would be far superior over any existing propulsion technology, while its base technology might be substantially simpler and cleaner than chemical, fission, or fusion rockets. Such a system has to work in empty space and therefore, for the requirements from energy and momentum conservation, would need to **interact with the spacetime field itself**, i.e., any analysis based on the conservation principles has to consider the physical system formed by the space vehicle and its surrounding spacetime. This topic is discussed in more detail in Sec. II. There is, of course, insufficient knowledge at present, both theoretical and experimental, *to guarantee the technical realization of such a device*, but **there is sufficient evidence both from experiment and theory** to invest both in the design and prototype construction of a device for generating an axial gravity-like field, see Sec.IV.

C. Gravity-Like Fields, GR, Particles, and Recent Experiments

The recent book by G. Daigle with the title *Gravity2.0*[16] provides a non-mathematical overview of the present status of gravity-like field research. In the following only several novel topics are highlighted, which are discussed in more detail in the subsequent sections and are deemed to be responsible for the totally unexpected gravitational phenomena observed. These phenomena are in **defiance** of the assumption of *four fundamental interactions* as *postulated*[17] in current physics as well as the leading physical theories (supersymmetry, string theory, quantum gravity, parallel worlds etc.).

1. Apart from the mysterious *dark matter* and *dark energy* whose existence is in contradiction to both *GR* and the *Standard Model* of particle physics, there are several recent fundamental experiments contradicting *GR* and/or leading particle theories:

2. McGaugh (Newtonian gravitation, rotational speed of stars)[18,19] , experiment in contradiction to *GR*,

3. Tajmar et al. (generation of extreme gravitomagnetic fields)[49–51,53–55] , in contradiction to *GR*: extreme gravitomagnetic field $\mathbf{B}_{gp}$ about 18 orders of magnitude larger than $\mathbf{B}_g$ of *GR*,

4. Gravity-Probe B[39] (?) (strong gyro misalignment, perhaps partly caused by extreme gravitomagnetic fields (?), see the discussion in[7] . If an extreme gravitomagnetic field was generated by the four cryogenic Nb coated quartz spheres, an effect similar to the experiments in Tajmar et al. should have been observed, causing major gyro misalignment,

5. LHC experiments up to an energy of 700 GeV have not detected any new particles (June 2011), in contradiction to *all theories* that propose an extension of the Standard Model of elementary particles,

6. ESA *Integral* satellite results (30 June 2011)[21] are placing stringent limits on the size of atoms of space and time,[38] in contradiction to all theories predicting a dependence of the speed of light c in vacuum on frequency ν (e.g., string theory, quantum gravity etc.).

Provided that the above experimental evidence stands the test of time, and there is good reason to believe so, the experiments 1-4 would call for an extension of *GR*, while experiments 5-6 would rule out current versions of string theory, quantum gravity, supersymmetry etc.

Hence, perhaps the *present situation in theoretical physics might be better characterized* by a **Theory of No Such Thing** instead a **Theory of Everything**[17] . Moreover, it should be noted that all of the experimental evidence, except the LHC null results, does not come from the field of particle physics, but is from condensed matter physics or astrophysics. This clearly shows the heightened importance of condensed field theory and cosmology not only for fundamental physics, but also for advanced technology.

When calculating the magnitude of the extreme gravitomagnetic fields of the Tajmar et. al, Graham et al., Gravity-Probe B experiments, it was amazing to see the numerical accuracy of the coupling constants derived from a Coleman-Weinberg potential, see M. Kaku's treatise on quantum field theory (QFT)[41] Chap. 10, once an interaction between electromagnetism and gravity is assumed.

There is also the interesting idea that gravity might be Yang-Mills squared (it is mentioned in our forthcoming review article), as discussed in A. Zee in his second edition on QFT[42] . This his far reaching consequences, but is far from being understood. It is assumed in *EHT* that the extreme gravitomagnetic fields are spin 1 fields.

The acceleration of the *Universe* seems to be a consequence of energy and momentum conservation. Spacetime is asummed to be a discretized **physical field** and in the extreme gravitomagnetic field experiments **it becomes part of the physical system**. It should be noted that there are three types of gravitational coupling assumed to exist, based on the concept of Hermetry form[8,9,13] , namely Newtonian (OM, graviton ν_g), gravitomagnetic (ν_{gp}, electromagnetism-gravitation interaction) and quintessence (ν_q, interaction of particles of dark energy of mass 10^{-33} eV with the space-time field), represented by Hermetry form $H_{16}(\mathsf{R}^3\ ,\ \mathsf{T}^1\ )$ see[8,9,13] . In the following we discuss several key physical aspects supposed to occur in the experiments for generating gravity-like fields. From the concept of Hermetry form, the existence of particles of imaginary mass and the existence of an imaginary photon, γ_I, can be derived, characterized by the so called *hypercube* of ordinary and non-ordinary matter[8,9,13] .

1. The imaginary photon γ_I has the same Hermetry form as the photon γ, but several of the partial terms are missing (i.e. all terms (4,5) ...(4,8)). If, however, the term (4,4) is deleted (subspace coordinates T^1 are not present) in the Hermetry form of the photon, it is changed into a gravitophoton γ_{gp} [a]. In other words, the gravitophoton particle is created, which is given by the Hermetry form of the photon γ without the T^1 partial terms. The interaction between electrons of imaginary mass is mediated by the imaginary photon γ_I. The interaction between the real electrons e and imaginary electrons e_I is by the particle γ_{IR} which contains more partial terms than the imaginary photon γ_I, but some of the T^1 terms are missing, which makes the difference to the photon γ. Therefore, if physical experiments can be set up that lead to a conversion from photons into gravitophotons, a coupling between electromagnetism and gravitation would be established. It is argued that such a type of coupling does occur in the gravitomagnetic experiments by Tajmar et al. as well as in the proposed Heim experiment.

2. Modanese[43] is coupling the Higgs field (Landau-Ginzburg potential) to the vacuum fluctuations (represented by the cosmological term), which is no longer a constant but a function in space. He assumes that by vacuum fluctuations locally a much larger Λ term can be constructed that in turn is leading to large interaction. In contrast to Modanese, we are coupling to electromagnetism, which is described by the Coleman-Weinberg potential. The Higgs potential is then seen as radiation correction. In QED the radiation correction is the coupling of the electron to the vacuum via photons. They are nothing else than the loop corrections in the Feynman diagrams. Only loops of first order are used by Kaku. This interaction leads to a real permanent phenomenon and has an impact on spacetime, i.e. the energy and momentum content of spacetime is physically permanently different. Spacetime has been subjected to an acceleration.

3. In symmetry breaking a new real particle is created that has a lower ground state. This is caused by the vacuum. I a gauge transformation the symmetry of the Lagrangian is first broken and then, in order to re-establish it, a new field (particle) is introduced represented by connection symbols that is, by a feature of spacetime or in internal space. GR is not sufficient since it only considers external sapcetime.

4. The gravitomagnetic effect in GR has already shown that a coupling between spacetime and matter exists that is, a large rotating mass is twisting spacetime. This means that the the energy and momentum content of

[a] The concept of Hermetry form (hermeneutics, i.e. the physical meaning of geometry) or metric tensor of physical significance, e.g. describing a photon, is discussed in detail in[4–14] , see at www.hpcc-space.de. Internal coordinates of subspaces R^3 , T^1 ,S^2 , and I^2 are numbered consecutively from 1 to 8. Therefore, for instance, the coordinate term (4,4) denotes a short form of the partial term in the metric tensor g_{44} that is, this element is containing the internal T^1 coordinate (responsible for charge) only. It should be noted that all subspace coordinates are internal coordinates and only a four-dimensional spacetime exists in *EHT*.

spacetime is actually changed and the physical system to be considered is spacetime and rotating mass. If now, instead of coupling to gravity a coupling of spacetime and electromagnetism with a subsequent conversion of an electromagnetic vector potential into a gravitational potential is considered, gravity-like fields can originate from electrodynamics.

5. Scattering of an electron by a magnetic potential. In our case there is an imaginary positively charged quark that is scattered by an imaginary vector potential.

6. The gravitomagnetic experiments comprise two stages. First, through the phase transition at low temperature, it seems that by the shift of the Higgs potential, both imaginary electrons e_I and imaginary quarks q_I are generated. If the cryogenic rotating disk above the coil is not present, no gravitomagnetic or gravity-like field can be generated, there is the possibility only. When the rotating disk or ring is present, the imaginary quarks q_I interact with the imaginary vector potential produced by the imaginary electrons e_I in the coil and through the conversion of imaginary photons into gravitophotons $\gamma_I \rightarrow \gamma_{gp}^{01}$ (Heim experiment) or $\gamma_I \rightarrow \gamma_{gp}^{02}$ (Tajmar experiment) the extreme gravitomagnetic fields are generated. The situation is similar o the Aharonov-Bohm effect. The magnetic vector potential cannot be measured. In this regard no actual physical process has taken place. However, its presence provides the possibility for an electron phase shift that is, for a real physical phenomenon.

The reason for the lack in progress in space propulsion is that *physical laws pose strict limits on the practicality and the performance of even the most advanced propulsion systems* and in practice have *prevented the construction of efficient and effective propulsion systems*. First, all systems considered so far operate on the basis of expulsion of mass and energy, i.e., have to obey classical momentum conservation. Hence, some kind of propellant needs to be provided. Second, the speed of light in vacuum is limited by special relativity, so interstellar travel in general does not seem to be feasible in our spacetime. This, however, is not at all a concern at present, since our current chemical propulsion systems are delivering velocities of about 10 km/s.

The state of the art of different types of advanced space propulsion concepts, based on more sophisticated physics, like space drives, warp drives, or gravity control are described in Davis and Millis (eds.)[23] . Nevertheless, these concepts are all utilizing one of the known four fundamental physical interactions. For instance, they are making use of special properties of the spacetime metric of general relativity (*GR*), or try to exploit quantum entanglement for faster than light travel. Although these concepts have been known, too, in *physics since the late 1930s*, their engineering realization seems to be as unlikely today as it was at the time of their discovery. In particular, faster than light approaches in general relativity, *GR*, as investigated by Davis, Chapter 15, in[23] *probably are ruled out by novel causal dynamical triangulation computer simulations*[24–26] , since realistic spacetime topologies do not seem to allow this kind of traversable wormholes, and this type of interstellar travel thus appears unfeasible.

II. Physical Conservation Principles and the Spacetime Field

The **concept of physical system** is fundamental in the analysis of conserved physical quantities. For any type of *reaction engine* the *physical system* to be considered comprises the *total vehicle mass and the ejected fuel mass*. Thus, such a physical system is riddled with all kind of limitations. For *gravity-like field propulsion*, the *physical system* comprises the *vehicle mass including the gravity-like field generator* and the *surrounding spacetime field*. In the following two sections the features and the physical implications of these two different propulsion principles are discussed.

A. Conservation Principles for Conventional Propulsion

The rocket principle requires that momentum is taken from the fuel and transferred to the space vehicle. This means the physical system to be considered for momentum conservation comprises the rocket and the ejected fuel mass. The limits of this principle are *too* well known and cannot be overcome by technical refinement or by selecting more energetic fuel. For instance, if we consider the kinetic energy to be provided by the fuel for a space vehicle flying at only one per cent the speed of light and assuming a vehicle mass of 3×10^6 kg, this corresponds to an energy content of 1.5×10^{19} J. This amount of energy cannot be provided by any chemical propellant, since chemical combustion involves processes in the atomic shell, which release the amount of about 20 eV per atom or molecule. Nuclear fission is much more efficient, releasing about 2 MeV per reaction, as the nuclei of the atoms or molecules are involved. A nuclear reactor of sustained 100 MW power would need 1.35×10^{11} s or more than $4,280$ years to provide this energy, which is technically unfeasible, not even accounting for the substantial mass of such a reactor and the respective shielding material. For a modest velocity of 30 km/s, the energy budget is 1.5×10^{15} J which amounts to a reactor operating time of some 5 months. However, no nuclear reactor has been flown in space (upper stage only, since the thrust to mass ratio of a nuclear reactor is not sufficient for a launch from the surface of the *Earth*), despite massive efforts dating back from the early 1960s (Kiwi project etc.).

Therefore the only alternative lies in propellantless propulsion that is, the space vehicle does not generate any momentum by itself. Since **conservation principles for energy and momentum must hold in all physical processes**, because they represent the fundamental symmetries of our spacetime, the question arises how propulsion without fuel might be physically conceivable. There seems to be only a single alternative.

Fundamental to all conservation principles is the concept of CV (control surface), not only in fluid dynamics, but for all physical systems. Any physical system can be analyzed using a CV, which is not a real closed surface but a fictitious one. The CV encloses the volume of interest that is, the physical system under consideration. The CV can be fixed or moving, and it can be rigid or deformable. Regardless which physical processes are happening inside the physical system, only the amount of momentum that crosses the CV can change the momentum budget of the physical system (e.g. rocket) which resides inside the CV. In other words, in order to see whether a novel propulsion principle will work or not, it is by no means necessary to understand the mechanism of this principle, it suffices to account for the momentum that can leave or enter the CV using this principle.

Thus, by formulating the laws of physics with regard to all processes involving momentum flux concerning the CV, the total momentum budget is established. The same holds true for the conservation of energy. Since non-relativistic flight is considered, conservation of momentum and energy are different that is, generation of energy inside the CV has no impact on the momentum balance. This issue has been overlooked by numerous inventors for novel space propulsion [b]. The *rocket principle* requires that *momentum is taken from the fuel and transferred to the space vehicle*. This means the **physical system** to be considered for momentum conservation comprises **the rocket and the ejected fuel mass**.

B. Conservation Principles for Gravity-Like Propulsion

The limits of the rocket principle are *too* well known and cannot be overcome by technical refinement or by selecting more energetic fuel. In contrast, according to (propellantless) field propulsion, the space vehicle is *acquiring velocity by imparting an equal and opposite momentum to the spacetime field*. A simple analogy is used to differentiate between the *classical rocket principle* (including all other means of propulsion) and the *field propulsion concept* incorporating spacetime as a physical quantity, replacing the part of the fuel.

From the physics of gravity-like fields, as discussed above, the principle of propellantless propulsion can be straightforwardly envisaged. For this principle to work, sufficiently strong gravity-like fields need to be generated by the gravity-like propulsion system leading to an interaction with the surrounding spacetime field. Graviy-like propulsion **is entirely different** from the above concepts of chemical or nuclear propulsion etc. in that it **involves the spacetime field** itself as part of the **physical system**. This means that there is an exchange of momentum and energy between the space vehicle and the local spacetime. The amount of this exchange is determined by the magnitude of the generated $\mathbf{B}_{gp}$ field. The physical basis of gravity-like propulsion lies in the intercation with the spacetime field, which leads to an expansion of spacetime, lowering the ground state of the spacetime field. In other words, **any gravity-like propulsion system attributes to the (accelerated) expansion of the *Universe***. In Sec. III a mathematical description of this process is presented that assumes the validity of the so called holographic principle as formulated by Bekenstein, Susskind, and Hawking et al., see the discussion in Motion Mountain Vol. V[27] .

According to the interaction of the gravity-like propulsion system with the surrounding spacetime field (for the construction principle see Sec. IV A), the space vehicle is *acquiring velocity by imparting an equal and opposite momentum to the spacetime field*. There is also the possibility that one of the six Higgs fields pervading the *Universe* might be involved. Since the Higgs fields seem to confer special physical quantities (mass to hitherto massless particles, inertia, or electrical charge etc.) it could be assumed that interaction takes place with spacetime. Spacetime as a physical field is subject to changes in momentum and energy. In case the space vehicle (or any other physical entity) is interacting with the spacetime field, the physical system to be considered for energy and momentum conservation needs to incorporate spacetime as an active partner. The momentum scale of the space vehicle is minuscule compared to that of the spacetime of the *Universe*, and thus the recoil kinetic energy and momentum that spacetime is receiving

[b] The second author, while working at ESA, had to to review several proposed novel principles of space propulsion suggesting highly complex mechanical mechanisms taking place inside the space vehicle, or, they were based on the generation of energy inside the space system. There is no need to analyze the proposed mechanism whatsoever. Regardless what the mechanism is, it cannot change the momentum budget if no momentum goes through the CV.

from the vehicle are almost negligible. Since momentum must be conserved, however, the *exact momentum balance* must include the momentum transferred to the spacetime field. Hence, the expansion of the *Universe*, at least in principle, must accelerate, although this contribution is exceedingly small and clearly cannot be measured. There may be other processes on the cosmic scale that may, however, have an observable effect. In any case, the **accelerated expansion of the *Universe* seems to be caused by the principle of momentum conservation**.

The mediators of this effect could be the novel gravitational particles, namely the gravitophotons and the quintessence particle, which are produced through the formation of imaginary matter. It is obvious that this principle is applicable to any other type of transportation as long as an interaction with spacetime can be established. The interpretation of the experiments by Tajmar et al. (in short *Tajmar effect*) leads exactly to this conclusion. Furthermore, the proposed *Heim experiment* for the axial gravity-like field proposed in Sec. IV A requires the existence of two neutral gravitophotons. The independent confirmation of the*Tajmar effect* (both, extreme gravitomagnetic field as well as circumferential gravity-like field), would rise the confidence that the technologically highly significant *Heim effect* (axial gravity-like field) also might be realizable.

A simple analogy is used to differentiate between the *classical rocket principle* (including all other means of propulsion) and the novel *field propulsion concept* incorporating spacetime as an active physical entity. The classical momentum principle requires that a person in the boat is throwing, for instance, bricks in the opposite direction to push the boat forward. However, everybody is well aware of the fact that there is a much better propulsion mechanism available. Instead of loading the boat with bricks, it is supplied with sculls, and by rowing strongly the boat can be kept moving as long as rowing continues. The important point is that the **medium itself is being utilized**, i.e., the water of the lake or ocean, which amounts to a completely **different physical mechanism**. The rower transfers a tiny amount of momentum to the medium, but the boat experiences a substantial amount of momentum to make it move. For space propulsion **the medium is spacetime** itself. Thus, if momentum can be transferred to spacetime by field propulsion, a repulsive or recoil force would be acting on the space vehicle moving it through the medium, like a rowing boat. The medium, spacetime, is a physical quantity, namely a field, and if properly quantized, the respective particles mediating forces should also be present. Thus, in principle, spacetime should have the capability to interact with a space vehicle. If this effect somehow can be experimentally established, the principles of momentum and energy conservation require that the combined system, i.e., both spacetime and space vehicle, are considered. This is also the physical mechanism to explaining the experiments by Tajmar et al. and Graham et al. Important to note, this mechanism does not simply extract momentum from the spacetime field and transfers it to the space vehicle. Instead, an active process has to be triggered for the creation of gravitophotons, i.e., generating a strong gravitomagnetic field, which is based on gravitophotons, $\mathbf{B}_{gp}$. Its process of formation is entirely different from the gravitomagnetic field of *GR*, resulting from Newtonian gravitation (gravitons) and denoted as $\mathbf{B}_g$. Second, in order to produce the gravity-like field seen in the experiments at AIT, experimental conditions have to be such that the $\mathbf{B}_{gp}$ field can decay, producing gravitons and quintessence particles.

The important point is that in the scheme of the three gravitational fields not only gravitons exist, but also gravitophotons as well as quintessence particles. In the generation of the gravitomagnetic force via the decay of the gravitophoton, *as is assumed to be the case in the gravity-like experiments by Tajmar et al.*, both the *OM* (**graviton**, negative gravitational energy density) and *NOM* (**quintessence particle**, positive gravitational energy density) are generated. The total energy in the generation of these two particles is therefore zero. *Gravitons interact with the space vehicle*, i.e. they are absorbed by the space vehicle, while the *quintessence particles are reabsorbed by spacetime itself*. This effect causes an acceleration of the space vehicle, while the momentum of the quintessence particle is not felt by the space vehicle, but by the surrounding **spacetime and leads to its expansion**, because of the repulsive force, and thus total momentum is being conserved. This effect is most likely too small to be observed, but this kind of space propulsion should contribute to the expansion of the *Universe*. In the same way the momentum change of the ocean would not be discernible from the presence of a rowing boat. Perhaps a local disturbance of spacetime might be measurable in the experiments by Tajmar et al.?

In the Heim experiment (vertical gravity-like field), see Figure 2, the neutral gravitophoton, ν_{gp}, decays into the positive, ν_{gp^-}, and negative, ν_{gp}^+, gravitophotons, which follows from the construction of the set of Hermetry forms that, in turn, are a direct consequence of internal Heim space and its four subspaces. It is assumed that the positive and negative gravitophotons are decaying into gravitons and quintessence particles that finally act on the spacecraft and on spacetime, respectively, such that the total momentum is conserved. As long as the experimental conditions for the production of gravitophotons are maintained, the proper acceleration field will be maintained. For the same period of time the interaction between space vehicle and surrounding spacetime remains. As soon as the gravitophoton production and its subsequent decay stop, the acceleration field ceases to exist.

Field propulsion needs to interact with spacetime in order to work without propellant. The rocket principle is only concerned with the energy and momentum balance of the physical system comprising the space vehicle and its fuel. Therefore, regardless of the technology employed, this system is bound by the momentum that can be extracted from the stored fuel. Therefore this principle, by definition, cannot produce a viable propulsion system delivering high speed, long range, or high payload ratio.

III. Physics of Tangential and Axial Gravity-Like Fields

The question now arises how to **actually perform the numerical calculations** of the strength and direction of the extreme gravitomagnetic $\mathbf{B}_{gp}$ and gravity-like fields. At present we do *not* have a working quantum mechanical theory of the experiments of Tajmar[49–51,53–55] , Graham[52] , GP-B[39] or the Heim experiments[13] . To this end, the history of superconductivity can providing practical guidelines. In 1911 Kammerling Onnes detected the phenomenon of superconductivity in his laboratory in Leiden. Only in 1953 Bardeen, Cooper, and Schriefer published their BCS theory that provided the quantum mechanical picture of how the crystal lattice of the ions produced a novel type of boson particle, the Cooper pair, via phonon coupling. However, already in 1935 F. London came forward with an heuristic model, which is now known of the London equations of the first and second kind, of superconductivity that is, treating superconductivity as electron conductivity without resistance. Clearly, this model was not able to account for the internal physical mechanism, but was sufficient in combination with the Maxwell equations to describe the macroscopic effect of superconductivity. In other words, instead of calculation the electric current density $\mathbf{j}$ by the BCS theory, the heuristic London equations can be used to determine $\mathbf{j}$, and subsequently solving the Maxwell equations employing this value for $\mathbf{j}$. One further step ahead is the Ginzburg-Landau model of 1941 that provides a semi-classical theory employing the quantum mechanical momentum operator and introducing an order parameter ϕ that is a scalar field. In the Ginzburg-Landau theory it is assumed that a physical system in equilibrium has its free energy F minimized and $F = F(\phi)$ which is a fourth order polynomial in ϕ where $n_s = \phi^2$ and n_s denotes the spatial density of the Cooper pairs.

A. Symmetry Breaking and Interaction Electromagnetism-Gravitation

Hence, a similar approach is used in simulating the experiments by Tajmar and the proposed Heim experiment. There are several caveats to be observed in this procedure, because two entirely novel physical processes are supposed to take place, derived from the concept of OM and NOM as described in[12,13] , which is an extension of the current system of fermions and bosons of the Standard model. This extension follows from the concept of Hermetry form that is of geometrical origin (metric tensor), e.g. see.[11]

- Most important, the observed *gravitational fields are supposed to result from a conversion of the imaginary electromagnetic vector potential* $\mathbf{A}_I$ into a gravitomagnetic vecor potential $\mathbf{A}_{gp}$.
- The cause of $\mathbf{A}_I$ is the current density of imaginary electronse_I that are assumed to be produced (see M. Kaku,[41] Chapter 10) by a phase transition (Higgs mechanism) at cryogenic temperature.
- This means that the formation of a novel type of particle from symmetry breaking is only the first stage in the generation of extreme gravitomagnetic fields. The second stage, which goes beyond symmetry breaking (e.g. superconductivity) is the interaction between electromagnetism and gravitation. Here gravitation means the extreme gravitomagnetic field resulting from this conversion, which is represented by its boson, namely the gravitophoton ν_{gp} (it should be remembered that there are three different types of gravitational fileds according to EHT, namely Newtonian, gravitomagnetic, and quintessence).
- The process for the generation of the imaginary electrons e_I follows the conversion sequence $\gamma \rightarrow \gamma_{IR} \rightarrow \gamma_I$. This means t
- The gravitophoton decays according to the relation
- A modified set of the linearized Einstein-Maxwell field equations (termed Einstein-Heim equations) is utilized, replacing the current density of moving masses by its appropriate electromagnetic counterpart.

This approach is now outlined in detail below.

In the experiments by Tajmar et al. a **circumferential** (tangential) a gravity-like field is measured, when the Nb disk is accelerated or decelerated. In the **technologically important Heim experiment** (see Sec.A) an **axial gravity-like field** should be generated. As reported in Tajmar et al. , the observed acceleration field, whose measurement is

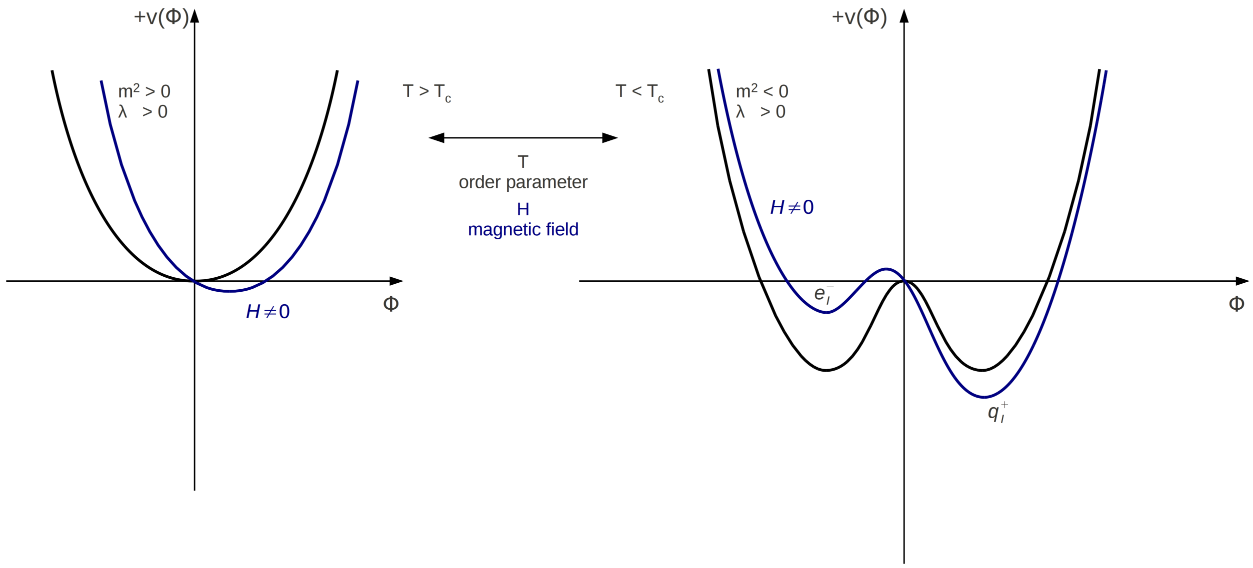

Figure 1. The Ginzburg-Landau potential $V(\phi) = m^2\phi^2 + \lambda\phi^4$

where ϕ

made by four accelerometers, which are offset by 90 degrees to each other, is acting opposite to the direction of the mechanical acceleration of the Nb disk, exhibiting the *Lenz* effect behavior of electrodynamics. The question is, can a simple explanation for this phenomenon be given, based on analogy to quantum field theory? To this end, we first consider quantum electrodynamics (QED).

In *QED* there is the four potential A^μ, the *gauge field*, from which the electric **E** and magnetic induction **B** fields can be calculated. However, the reverse process is not possible, because there exists an infinitude of gauge fields that all give rise to the same electric and magnetic fields. The set of gauge fields A^μ is connected by a so called symmetry transformation [c] that maps one gauge field A^μ into another one $\tilde{A}^\mu$, but leaves the **E** and **B** fields invariant. In this regard the gauge field is a hidden field[34] , since there are no measurements to detect it. The continuous symmetry transformation is a called a hidden symmetry, i.e. it is not directly visible in spacetime, but *does effect* physical events in spacetime, and, according to *EHT*, resides in the internal Heim space H^8 . A consequence of this hidden symmetry is that, according to Noether's theorem, *electric charge* remains invariant.

It is a *general principle* that all physical interactions are equivalent to (gauge) symmetries. This means that not only the *Maxwell* equations, but also the *Schrödinger and Dirac* equations as well as the *Einstein field* equations together with the *Einstein-Maxwell* equations should *exhibit invariance with respect to local phase transformations*. It should be remembered that the Einstein-Maxwell equations are a linearized version of the Einstein field equations and thus, despite of their name, are *purely gravitational equations* existing within the framework of *GR*.

This principle should also hold true for the **Einstein-Heim** equations (*EH*) that, according to *EHT*, are the set of equations that govern the generation of extreme gravitomagnetic and gravity-like fields. The *EH* equations comprise a linearized version of the Einstein field equations, but different from the *EM* equations, together with the London equations of electrodynamics that are used to producing the set of governing heuristic equations for extreme gravitomagnetic and gravity-like fields, presented in[13] . These equations are termed *Einstein-Heim* equations since the original Einstein-Maxwell equations **only** describe gravitomagnetic fields within the framework of *GR*, which indeed exist, as was shown by Ciufolini and the Stanford NASA Gravity Probe B experiment. These gravitomagnetic fields are extremely weak, and thus clearly **cannot be the source** of the fields measured by Tajmar et al. On the other hand, the *EH* equations foresee a **coupling between electromagnetism and gravitation through the current density** $\mathbf{j}_{gp}$ that is of electromagnetic origin, resulting from the London equations, and is **not** due to the movement of large masses (planets, as in GP-B, or stars).

It is important to note that the name *Einstein-Heim* stands for a set of equations comprising a coupling between electromagnetic and gravitational phenomena, which is in contrast to the original Einstein-Maxwell equations. Despite the similarity of their names, the two sets of equations describe completely different physical phenomena. The type of

[c] The mathematical form of this transformation is not of importance at the moment.

gravitation of the *EH* equations is a new phenomenon, and is **not** related to Newtonian gravitation. The gravity-like fields of *EH* have their origin in *electrodynamics in combination with a novel type of matter*, termed *imaginary matter* that is supposed to be generated in the rotating disk at cryogenic temperature forming a special type of imaginary boson e_I^B. The existence of this type of matter follows from the set of *Hermetry* forms of *EHT*, for details see the review article[14] .

Bosonic fields are the mediator of the forces, which, by quantization, carry their boson mediator particles with them. *QED* is an example of a gauge theory and the photon γ is the gauge boson that mediates the electromagnetic force. The invariance of physical equations with respect to local phase transformations require the existence of an additional external field with which the charged particles must interact. The quanta of such a field must have a rest mass of zero. Gauge invariance only holds for this type of field. Since it is known that for instance the quanta of the weak interaction have masses in the GeV range, and thus are of short range, require the existence of one or several background field(s), termed *Higgs* field. The Higgs field has screening effect, and thus the infinite range of the interaction becomes finite. This phenomenon is known as *spontaneous symmetry breaking*.

B. The Einstein-Heim Equations

In order to determine the set of equations that are describing extreme gravitomagnetic as well as gravity-like fields an analogy from superconductivity is used. The heuristic equations that account for the physical phenomenon of superconductivity comprise the Maxwell equations in combination with the London equations. The London equations simply state the fact that once the phase transition has occurred, Cooper pairs are formed that are moving without any resistance through the lattice of the solid (i.e. no damping, friction free). In other words, Newton's second law for a moving coordinate system, $\frac{d}{dt}(m\mathbf{v})$, is applicable. However, the Maxwell equations are also still valid.

The Einstein field equations are nonlinear, but the fields observed in the experiments by Tajmar et al., Graham et al., and GP-B are small compared to gravitational fields generated by massive black holes, and thus their curvature only slightly deviates from Minkowski space. Hence it is justified to use the mathematical structure of the linearized Einstein field equations. However, as was pointed out by Thorne[35] , the expansion of the full nonlinear Einstein field equations up to first order, termed the Einstein-Maxwell equations, **does not result in the analog to the Maxwell equations**. Linearizing up to first order, the metric tensor $g_{\mu\nu}$ is replaced by $g_{\mu\nu} = \eta_{\mu\nu} + h_{\mu\nu}$ where $\eta_{\mu\nu}$ is the well known Minkowski tensor and $h_{\mu\nu}$ denotes the small deviation from Minkowski space. Rewriting $h_{\mu\nu} = \varepsilon H_{\mu\nu}$, inserting the expression for $h_{\mu\nu}$ into the Einstein field equations, and expanding up to $O(\varepsilon^2)$ results in the linear Einstein-Maxwell equations. However, this expansion **does not give the term $\partial\mathbf{B}/\partial t$**, which is of second order in ε. Therefore, the Einstein-Maxwell equations, as will be shown shortly, cannot be employed in the case of the extreme gravitomagnetic and gravity-like fields.

If the expansion includes second order terms, the similarity of the original Einstein-Maxwell with the Maxwell equations is destroyed, because of the additional terms that enter in the second order equations. However, such an expansion is not employed either in the present approach.

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

$$\nabla \cdot \mathbf{E}_{gp} = 0 \tag{1}$$

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

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

$$\nabla \times \mathbf{B}_{gp} = 2\alpha_g^3 \frac{1}{c^2}\frac{\partial\mathbf{E}_{gp}}{\partial t} \tag{4}$$

$$\nabla \cdot \mathbf{B}_{gp} = 0 \tag{5}$$

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

$$0.328\, ie\alpha_{gp}\mathbf{v}\cdot\mathbf{A}_{e_I} + m_p\mathbf{v}\cdot\mathbf{A}_{gp} = 0 \tag{6}$$

where the factor 0.328 comes from the radiation correction (Coleman-Weinberg potential), e is the positive charge of the quark of imaginary mass and $\mathbf{v}$ is the velocity of the rotating disk above the coil. It should be noted that the gravitomagnetic field $\mathbf{B}_{gp}$ is not imaginary but real, since the product of *const* and the supercurrent $\mathbf{j}_{gp}$ (obtained from the bosons of imaginary mass) is real. In all subsequent calculations the value $const = 0$ was used, since there are no sources in the form of real current densities that are responsible for the acceleration field $\mathbf{E}_{gp}$. Instead, the place of the current density is taken by the conversion equation Eq. 6. This means that the system of equations comprising Eqs. (1, 2, 4, 5, 6), termed *Einstein-Heim* equations, describes the generation of extreme gravitomagnetic and gravity-like fields. The subscript gp is used to distinguish the gravitomagnetic field generated by gravitophotons from the two other gravitational fields.

The value for α_g is given in Eq. (24) below. These equations need to be complemented by the analogy of the London equations, see below, and, most important, by the conversion equation, Eq.(6), from the imaginary electromagnetic vector potential $\mathbf{A}_{e_I}$ into the gravitomagnetic vector potential $\mathbf{A}_{gp}$. This set of equations then governs the production of extreme gravitomagnetic and gravity-like fields.

The decay of the imaginary photon into the neutral gravitophoton of the first type, i.e., $\gamma_I \to \nu_{gp}^{01}$ with coupling strength α_{gp} leads to the real gravitophoton potential $\mathbf{A}_{gp}$. From the above equation a constraint on the direction of the resulting is obtained, which is of the form

$$\mathbf{B}_{gp} = \gamma\mathbf{B}_{e_I} + \beta\mathbf{v}\times\mathbf{B}_{e_I}. \tag{7}$$

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

$$\mathbf{B}_{gp} \sim \mathbf{v}\times\mathbf{B}_{e_I}, \tag{8}$$

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

For the extreme gravitomagnetic field to be generated, two types of decay occur, first the photon is converted into an imaginary photon $\gamma \to \gamma_I : \alpha$. Then the neutral gravitophoton is produced according to $\gamma_I \to \nu_{gp}^{01} : \alpha_{gp} = \sqrt{\lambda}$. The coupling constants of these decays are the **fine structure constant** α and the gravitophon coupling constant α_{gp}, determined from the **Coleman-Weinberg potential**, respectively. This is an extraordinary fact, since it seems that the **process of gravitomagnetic field generation is governed by quantum electrodynamics**, *in contradiction to our earlier assumption* where coupling constants were calculated from number theory, see[46] . In other words, once the *existence of fermions with imaginary mass* is accepted, i.e., the concept of matter has been extended, the basic machinery of current physics seems to apply.

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

$$\mathbf{j} = -\frac{n^2}{m_e}\mathbf{A} \tag{9}$$

which means that the current density $\mathbf{j}$ is obtained from a vector potential $\mathbf{A}$. The question is, which type of potential does generate such a current density? The phase transition that occurs at cryogenic temperature leads to a current of imaginary bosons with charge e_I^B that results in an imaginary vector potential $\mathbf{A}_{e_I}$. Utilizing the structure of the London equation, Eq.9, the gravitophoton current density that would be obtained from the imaginary vector field $\mathbf{A}_{e_I}$ is

$$\mathbf{j} = -\frac{n_{e_I}^B (e_I^B)^2}{m_{e_I}^B}\mathbf{A}_{e_I} \tag{10}$$

The combination of London equation and Maxwell equation leads to

$$(-\nabla^2 + \frac{1}{\lambda^2})\mathbf{B}_{e_I} = 0 \tag{11}$$

where the wavelength $\lambda = \left(\frac{m^B_{e_I}}{(e^B_{e_I})^2 n_{e_I}}\right)^{1/2}$. It should be noted that λ is an imaginary wavelength since the mass $m^B_{e_I}$ is imaginary.

However, since eventually a gravitomagnetic field $\mathbf{B}_{gp}$ is observed, it is the respective gravitomagnetic vector potential $\mathbf{A}_{gp}$ that needs to be used in the calculation of the gravitomagnetic current density $\mathbf{j}_{gp}$. In the experiments of Tajmar et al., however, a *real gravity-like field is observed* that is, the potential in Eq.(10) should be the *gravitational potential*. On the other hand, this gravitational potential cannot be generated by moving masses. The rotating disk has a mass of about 400 g, while, according to *GR*, the *mass of a white dwarf* would be necessary. It is the coupling between electromagnetism and gravitation triggered by the phase transition that eventually leads to a gravitational field by converting the imaginary vector potential $\mathbf{A}_{e_I}$ into the real gravitophoton potential $\mathbf{A}_{gp}$. In this process, the Lagrange densities before and after the conversion going from the imaginary electromagnetic into the real gravitomagnetic potential are assumed to be related according to Eq. (6), since energy needs to be conserved. The corresponding gravitomagnetic field $\mathbf{B}_{gp}$ is given by Eq.(7). It should be noted that *these two vector fields may have different directions*. In general, In the Heim experiment, which should produce a axial gravity-like field, the relation between the gravitomagnetic and the imaginary vector field is given by Eq.(8). We therefore formally write

$$\mathbf{j}_{gp} = -M^2 \mathbf{A}_{gp} \tag{12}$$

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

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

In the particle picture, the conversion of the fields is realized by the conversion of the imaginary photon γ_I into the neutral gravitophoton of the first type ν^{01}_{gp} (Heim experiment) or the second type ν^{02}_{gp} (Tajmar experiments) that leads to the real gravitophoton potential $\mathbf{A}_{gp}$. The details for calculating the corresponding extreme gravitomagnetic field $\mathbf{B}_{gp}$ are presented in Sec. A. In Tajmar et al. experiments we need to distinguish two different sets of experiments. In one set, Tajmar et al. generated extreme gravitomagnetic fields. Any material body that is moving in such a field is subject to the Lense-Thirring effect, except that the Tajmar effect (i.e. the force acting on the moving body) is outside *GR*, but the force law itself remains unchanged. In the second set of experiments, Tajmar et al. accelerated or decelerated the rotating disk by changing its angular velocity (the rpm), which led to the circumferential gravity-like field, described above. According to *QED*, the gauge theory with its hidden symmetry leads to a profound consequence, namely, if the electron is accelerated, then, the gauge field itself is actually emitted as a quantum particle. In other words, if an electron initially has a momentum $\mathbf{p}$ and an acceleration is applied changing the electron into a state with momentum $\tilde{\mathbf{p}}$, a photon of momentum $\mathbf{p} - \tilde{\mathbf{p}}$ is produced. The gauge field, formerly unobservable, has become a physical entity in form of the photon (in the field picture: a combination of electric and magnetic fields) that is observable in spacetime. It seems that an accelerated electron has generated a real photon (gauge particle of *QED*) with its proper momentum and energy. Light is therefore emitted from accelerated charges.

C. Energy and Momentum Extraction from the Spacetime Field

The fact that *material bodies can physically interact with the surrounding spacetime* is known since 1918, when Lense and Thirring predicted their frame dragging effect, which is a direct consequence of *GR*. Hence, the Lense-Thirring effect should lead to an exchange of angular momentum between the surrounding spacetime and, for instance, the rotating *Earth*. This effect has been confirmed recently by Ciufolini as well as the GP-B experiment. However, it is far too small for any type of technical application. Therefore, Newtonian gravitation, despite the fact that a physical interaction between matter and spacetime exists in principle, cannot be considered as a means for gravity-like field propulsion. Technically, these acceleration fields are totally irrelevant and cannot even be measured in the laboratory.

However, as the experiments by Tajmar et al. indicate, there seems to be a way to generate extreme gravitomagnetic fields in the laboratory. From the foregoing discussion it should be obvious that these fields must be outside *GR*. The physical mechanism behind these fields was presented in Secs. A, and B above. In this section, the question is addressed how the extreme gravitomagnetic fields might extract momentum and energy from the surrounding spacetime field. It needs to be shown that not only the *physical conservation law*s are satisfied but also the *second law of thermodynamics* has to hold.

To this end, we consider the physical system of *spacetime field - space vehicle*. It is known since Hubble that the *Universe* is expanding. About 15 years ago, the accelerated expansion of the *Universe* was measured. It is further assumed that the initial *Universe* started with the total energy of zero [d]. As was discussed in[9,12,13] there seem to exist five basic principles that are employed in the construction of the *Universe*. The principle of *duality* and the *quantization principle* are among these fundamental principles. It is assumed that the *Universe* started from a quantum fluctuation with total energy zero. The *Universe* acting as a (quantum mechanical) thermodynamic engine should possess internal energy $U = U(V,T)$ and free Helmholtz energy $F = U - ST$. Therefore, the sum of the three known energies in the *Universe* that is, of *Newtonian* and *dark matter* as well as *dark energy* on the one side, and the *internal energy U* of the *Universe* should always add up to zero. Initially, all these energies should have been zero. The initial quantum fluctuation changed the internal energy and thus lead to a redistribution of energy, rendering at least dark energy different from zero, since the size of the Universe became different from zero. Instead of zero the minimal values compatible with quantum mechanical laws could be used, but this will not change the character of the discussion. the principle of duality ensures that the zero energy of the initial *Universe* could be separated into two different energies, termed negative (U) and positive energies (Newtonian and dark matter, dark energy) that is, the energies are of opposite sign. As will be shown below, the second law with $dS > 0$, dynamic Universe exists, leads to an expanding *Universe*. Thus energy is being transferred between the negative and positive energies in this process [e]. Hence, dark energy is increasing with the size of the *Universe*. The current redistribution of the three energies is about 4% Newtonian (visible) matter, 23% dark matter and 73 % dark energy. In particular, at the end of the inflationary phase these energies should have become large. Momentum conservation would follow directly from the spherical topology of the *Universe*. Regarding the *Universe* as a thermodynamic engine that possesses internal energy (characterized by the temperature of the CMB radiation and its radius) it should have the ability to perform work. Here, we only want to show that an *interaction between space vehicle and spacetime field necessarily imparts energy and momentum to the space vehicle*, while the internal energy of the *Universe* is changing accordingly. The following scenario is considered.

According to Bekenstein the maximum entropy S that an object of size R and energy E can have is given by

$$S = \frac{\pi k_B}{\hbar c} R_U E_U \tag{13}$$

where R_U and E_U denote the Hubble radius and the three different types of energy in the *Universe*. It should be noted that this equation contains Planck's constant and therefore is derived from quantum mechanics.

Furthermore, the *Universe* is assumed to act like a black hole so that the holographic principle is applicable. The holographic principle states that the entropy of a black hole is proportional its surface area and the information is stored on its surface. The surface is quantized in form of minimal areas of the Planck length $\ell = \frac{G_N \hbar}{c^3}$ squared.

$$S = A_U \frac{k_B c^3}{4 G_N \hbar} = \frac{k_B}{4} A_U \ell_P^{-2} = \frac{4\pi k_B G_N}{\hbar c} \tag{14}$$

where$S$ is the entropy, A_U denotes the surface of the *Universe*, k_B is the Boltzmann constant, and M_U denotes the sum of ordinary and dark matter in the *Universe*. Since the dark energy belongs to the spacetime field, it is not included. For a spehrical geometry,

$$A_U = 4\pi R_U^2 = 4\pi \frac{2 G_N M_U}{c^2} \tag{15}$$

whereR_U is the Hubble radius of the *Universe*. Assuming that the interaction of the physical system spacetime field-space vehicle leads to an extremely small expansion of the *Universe*, the new radius $R_U(t+\Delta t) > R_U(t)$ where t and $t + \Delta t$ are the instants of time before and after the interaction takes place. If the interaction is continuous, a discrete time sequence $t, t+\Delta t, t+2\Delta t, \ldots, t+n\Delta t$ can be used as an approximation. From Eq.15 we obtain

$$dS = S(R_n) - S(R_{n-1}) = R_n^2 - R_{n-1}^2 > 0 \tag{16}$$

[d]The total energy of the *Universe* is constant and does not change with time. This constant can be set to zero.

[e]Since we do not believe that infinities exist in physics, the expansion process eventualy should come to a halt, and, by the principle of duality, contraction should set in. A cyclic *Universe* therefore seems to be the logical consequence.

and setting $E \approx R^3$ [f], it follows from Eq. 14

$$dS = S(R_n) - S(R_{n-1}) = E_n^{4/3} - E_{n-1}^{4/3} > 0 \tag{17}$$

which means that energy (momentum) was transferred from the spacetime field from to the space vehicle, while the internal energy U of the *Universe* changed accordingly. Therefore, any *propellantless propulsion system has an effect on the size and/or temperature of the Universe*, although too small to be measured.

This short discussion should have shown that **propellantless propulsion has a physical basis**, but the physics involved is based on the existence of three gravitational fields:

- Newtonian matter: attractive interaction via graviton ν_g,
- Dark matter: attractive interaction with Newtonian matter via gravitophoton ν_{gp}^0,
- Dark matter-dark matter, dark-matter-dar-energy, and dark-energy-dark energy: repulsive interaction via quintessence ν_q.

This means that, through the classification scheme of Hermetry forms, the number of fundamental interactions in physics has increased to six, three of them being of gravitational nature. Moreover, the set of fundamental particles had to be increased (there might be should be two symmetry groups $O(8,q)$, where q denotes the field of quaternions), including (virtual) particles of imaginary mass, as described by the matter hypercube in.[9,12,13] In conclusion, the experiments by Tajmar et al. might have a physical basis, indicating that novel physical interactions of long range exist that could lead to a technology of gravitational engineering.

IV. Experiments for Extreme Gravitomagnetic and Axial Gravity-Like Fields

A. Heim Experiment for Axial Gravity-Like Fields

Tajmar et al. were the first reporting the generation of extreme gravitomagnetic fields in the laboratory, which are denoted as $\mathbf{B}_{gp}$, since they are assumed to result from gravitophotons and not from gravitons. It should be noted that the existence of these fields was postulated by the authors before these experiments became known, see for instance[3] that is, theory and experiments were developed independently of each other. Even if these experiments could not be confirmed, extreme gravitomagnetic and gravity-like fields should be producible based on theoretical reasons.

It is important to distinguish between the gravitomagnetic field in the experiments by Tajmar et al. and the proposed Heim experiment. These two fields are different and subsequently lead to different types of forces. Modanese et al.[44] have tried to explain the Tajmar effect by employing the linear Einstein-Maxwell equations, but have come to the same conclusions as the authors, namely that these equations do not even reproduce the correct sign of the gravity-like field (acceleration field) that was observed by Tajmar et al. when the angular frequency of the cryogenic ring was subject to change, i.e. the ring was accelerated. The other problem of course is that the $\mathbf{B}_{gp}$ field measured is up to 18 or 19 orders of magnitude larger than predicted by *GR*.

Without further discussion, it should be mentioned that the often cited ratio of the gravitational and the electromagnetic force, which for proton and anti-proton is in the range of 10^{-38}, can no longer be used to justify the negligibility of gravitational effects. This value only holds for Newtonian gravitation. Furthermore, there is a most interesting hypothesis found in the recent book by A. Zee[42] pp. 516, which states that gravity could be the square of Yang-Mills theory that is, gravity $\sim$ Yang-Mills $\times$ Yang-Mills or in more mathematical terms $\mathscr{M}_{gravity} \sim \mathscr{M}_{gauge} \times \mathscr{M}_{gauge}$. In other words the spin 2 field of gravitation might be comprised of two spin 1 fields of the Yang-Mills type. The coupling constant of Newtonian gravitation is 10^{-38}, therefore the coupling constant of the two Yang-Mills fields is 10^{-19}, which comes close to the Tajmar effect and could be a hint that additional gravitational fields are indeed existing. However, this idea so gar has not been investigated in how it could be used to provide an explanation for the extreme gravitomagnetic fields.

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

The *Tajmar effect* cannot be explained from *GR*, which becomes clear in comparing the GP-B experiment with Tajmar's experiments. In GP-B, which was orbiting the *Earth* for more than 10 months at an altitude of about 640

[f] Even if the exponent were not equal to 3, but larger than 1, the subsequent conclusions will not change.

km, the predicted Lense-Thirring precession of the gyro spin axis (inertial frame dragging by the rotation of the mass of the *Earth*), initially pointing at a guide star (locked by a telescope), is some *42* milli-arc seconds/year. This value is small compared to the already tiny geodetic effect (spacetime curvature caused by the mass of the *Earth*) of *6.6* arc seconds/year. The geodetic precession occurs in the orbital plane of the satellite, while the Lense-Thirring effect causes a precession of the gyro spin axis in the same direction the *Earth* is rotating (the gyro is assumed to be initially in free fall along the axis of rotation of the *Earth*). For the GP-B experiment an inertial frame was required with non-gravitational acceleration less than 10^{-13} m/s^2. Compared to Tajmar's equipment, his gyroscopes definitely are not capable to detect accelerations that small. One of the major challenges of the GP-B experiment was to provide such a drag-free (weightless) satellite. **It is therefore impossible that Tajmar has observed any effect related to *GR***. His effect must therefore be outside *GR*, pointing to a **new class of gravitational phenomena**, provided, of course, *that his measurements are correct*. This were an **indication that the standard picture of gravity as manifested in Einstein's 1915 *GR* does need an extension** that goes beyond the picture of gravity of simply being the result of the curvature of four-dimensional spacetime. Therefore, the two additional gravitational fields as postulated in *EHT*, represented by gravitophotons and the quintessence particle, are at least qualitatively supported. In other words, the nature of gravity is more complex than represented by *GR*. All predictions of *GR* are correct, but **it seems that it is *GR* which is not complete instead of *QM* (quantum mechanics)**. Moreover, the geodetic and Lense-Thirring effects show that an interaction between spacetime and massive bodies exist. This could mean that the *Tajmar effect, being many orders of magnitude larger, should have a much stronger interaction with its surrounding spacetime*. This is **exactly what is needed for propellantless propulsion**, which can only work if there is an intense *exchange of energy and momentum among space vehicle and spacetime*, see the discussion in Sec. II .

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

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

- The magnitude of the extreme gravitomagnetic field points to an electromagnetic origin, being the only other long range field with sufficient coupling strength.
- Therefore, the London equations will be employed to complement the Einstein-Maxwell equations.
- Moreover, there should be a physical mechanism that converts an electromagnetic into a gravitomagnetic (or gravity-like) field modeled by a phase transition of **Ginzburg-Landau** type.
- Such a mechanism is not conceivable within the framework of the four fundamental interactions which cannot incorporate additional gravitational fields along with their additional interaction bosons. The standard model cannot accommodate these additional particles and thus needs to be extended.
- For energy and momentum to be conserved, the interaction of the matter of the rotating disk (ring) with the surrounding spacetime field must be accounted for.
- In the Tajmar experiments the gravity-like field of the accelerated ring is acting in the plane of the rotating ring, opposing its origin. In the proposed Heim experiment, the gravity-like field of the disk, rotating at constant angular velocity, is calculated to be directed along the axis of rotation. Therefore, these two experiments seem to be based on two different physical mechanisms.
- The first neutral gravitophoton, indicated by ν_{gp}^{01}, which is deemed to be responsible for the Heim effect, should decay into the positive (attractive) ν_{gp}^{+} and negative (repulsive) ν_{gp}^{-}gravitophotons. The resulting gravity-like field is supposed to be pointing in axial direction.
- The second neutral gravitophoton, indicated by ν_{gp}^{02} decays only if the ring is being accelerated, and the resulting gravity-like field is in circumferential direction, and thus this decay route is believed to occur in the experiments by Tajmar et al., denoted as Tajmar effect.
- From a technological point of view the axial gravity-like field is the one that could provide the enabling technologies for propellantless propulsion and novel air and land transportation systems as well as green energy generation etc. At present, it does not seem possible to fully assess the technological consequences of the existence of such a field.

- The two experiments for circumferential and axial gravity-like fields are fundamentally different, but in both cases a conversion from electromagnetic to gravitational fields seems to take place, triggered by the generation of imaginary electrons, see NOM cube in the 4D hypercube of.[9]

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

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

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

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

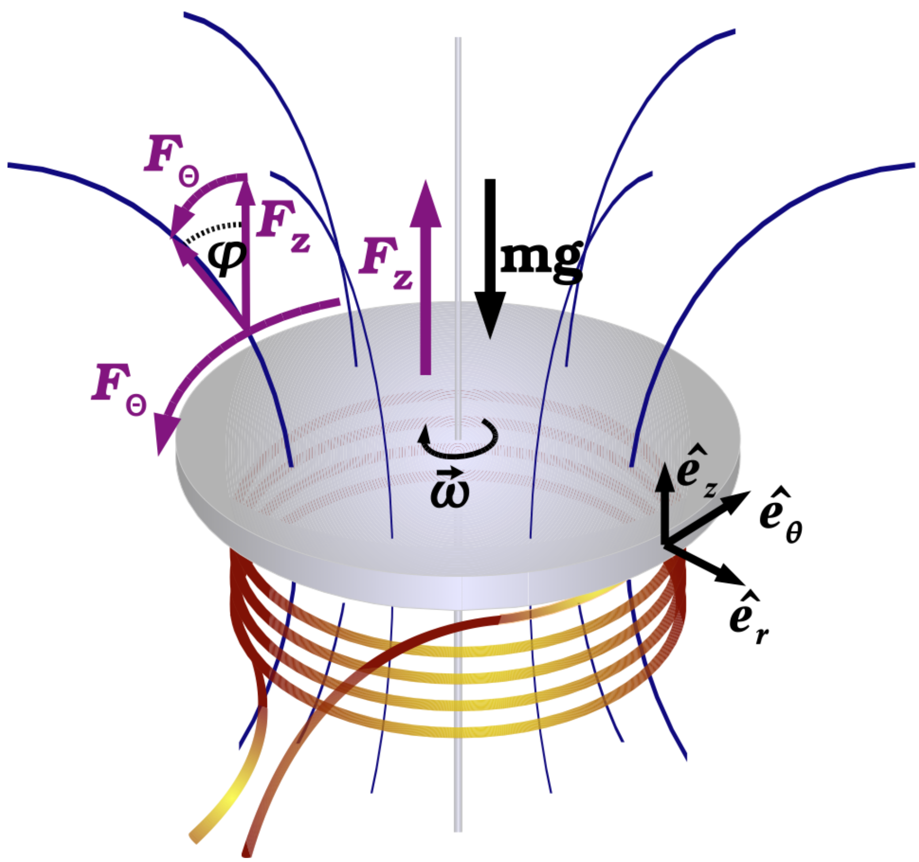

Figure 2. Heim experiment: in this gravity-like field experiment generated should be directed along the axis of rotation. The second component is in the azimuthal direction and should accelerate the ring or disk. Therefore, energy does not need to be supplied to keep the angular velocity of the ring or disk constant. The experimental setup could serve as field propulsion device, if a non-divergence free field were generated (the physical nature of the gravity-like field is not with certainty known at present). It should be noted that in order to produce the gravity-like field the current of the bosons of imaginary mass needs to be induced in the coil, which is supposed to be achieved via the Josephson effect.

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

B. Analysis of the AxialGravity-Like Field

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

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

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

$$\mathbf{B} = -\frac{2m_e}{e}\omega \tag{18}$$

where $\mathbf{B}$ is the magnetic induction field caused by the Cooper pairs. In the experiments by Tajmar et al., as discussed in Sec. I , an extreme gravitomagnetic field is generated. For the explanation of these experimental results as well as for the Heim experiment, it is assumed that the current of the superconducting electrons (Cooper pairs) causes a current of imaginary electrons. Imaginary particles are formed via the Higgs mechanism, for instance, as described by M. Kaku, Chap. 10[41] , further details are also given in[8] . Due to the interaction of the imaginary particles with OM in the crystal lattice, they should not behave like tachyons. For the Heim experiment, the imaginary current *needs to be coupled into the superconducting coil by some kind of tunnel effect* as stated above. The Cooper pair current is not important by itself, it only acts as the source for the accompanying imaginary current that is

$$\mathbf{B}_{e_I} = -i\,\alpha\frac{4\pi^2 m_e}{e}\omega_I \tag{19}$$

where ω_I denotes the angular frequency of the imaginary bosons formed by the coupling of the e_I [h]. Therefore, this value is used in the above equation. It is important to ensure experimentally that an imaginary current is flowing in the coil, i.e. an *experimental mechanism must be provided to couple this current into the coil*, once the real super-current sets in. It should be mentioned that the chain of formation of the three types of photons $\gamma \to \gamma_{IR} \to \gamma_I \to \nu_{gp}^{01}$ takes only place below a certain critical temperature. The question arises how to couple the electromagnetic energy to the gravitational energy. The value of the coupling constant $\alpha_{gp} = \sqrt{\lambda} \approx \frac{1}{221}$ is related to the radiative correction of the Higgs field, described by the parameter λ in Kaku[41] p.353, via $\sqrt{\lambda} \approx \alpha_{gp}$ Here, Kaku is discussing the use of the

[g] It is not known if the direct imaginary current is superimposed by a high frequency alternating imaginary current as observed for Cooper pairs in the Josephson effect.

[h] The charge of the imaginary electron e_I and electron $-e$ are the same.

Coleman-Weinberg potential to calculate λ and is treating the Higgs field as radiative correction of the electromagnetic field. This has the following meaning. The interaction potential Φ contains a fourth order term with coefficient λ, which was inserted by hand to account for the symmetry breaking, i.e. to model the phase transition process that generates charged particles of imaginary mass. Therefore, no relation between the two parameters m and λ could be specified. For instance, if λ changes sign, according to the theory Landau, a symmetry breaking will take place. This kind of phase transition that is governed by the quasi symmetry breaking, is supposed to take place in the form of generation of particles of imaginary matter. Kaku then shows (see Figs. 10.4 and 10.5 in[41]) that if the so called radiative correction is used that is, in order to calculate the effective potential by summing up over all one loops in the Feynman diagram, a relationship between the fine structure constant $\alpha = w_{ph}^2 = e^2/4\pi\varepsilon_0\hbar c$ and the value λ can be established. The following relation was calculated

$$\lambda = \frac{33}{8\pi^2}\alpha^2 = \frac{33}{8\pi^2}\frac{1}{16\pi^2\varepsilon_0^2}\frac{e^4}{\hbar^2 c^2}. \tag{20}$$

The coupling constant in quantum electrodynamics is the well known fine structure constant, which has the value $\alpha = 1/137 \approx 7.3 \times 10^{-3}$, which is small. The factor $6m_{eI}$ is obtained when an imaginary instead of a real mass is considered.

It should be noted that $\mathbf{A}_{e_I}$ is the imaginary vector potential that belongs to Eq. 19. Thus the resulting gravitomagnetic field is

$$\mathbf{B}_{gp} = 0.328\,\alpha\alpha_{gp}\frac{4\pi^2 m_e}{m_p}\frac{\mathbf{v}}{c} \times \omega_I. \tag{21}$$

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

$$\mathscr{L} = \frac{1}{2}mv^2 + e\Phi + \mathbf{v}\ \cdot \mathbf{A}_{e_I} \tag{22}$$

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

$$\mathbf{F} = m\,\mathbf{v} \times \mathbf{B}_{gp} \sim m\,\mathbf{v} \times (\mathbf{v} \times \mathbf{B}_{e_I}), \tag{23}$$

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

$$\mathbf{B}_{gp}^{+} = \alpha\alpha_{gp}\alpha_g\frac{4\pi^2 m_e}{m_p}\frac{\mathbf{v}}{c} \times \omega_I \tag{24}$$

with $\alpha_g = \left(\frac{G_N}{G_{gp}}\right)^{1/2} = 67$. Since $\mathbf{v}$ is the circumferential speed of the rotating disk, the average velocity of the particles in the disk is given by

$$v_A^2 = \frac{1}{3}v^2 \tag{25}$$

and therefore the $\mathbf{B}_{gp}^{+}$ field is

$$\mathbf{B}_{gp}^{+} = \alpha\alpha_{gp}\alpha_g\frac{4\pi^2 m_e}{3m_p}\frac{\mathbf{v}}{c} \times \omega_I. \tag{26}$$

Since the acceleration is eventually caused by gravitons, which requires one more gravitational conversion process, the additional factor α_g is introduced in the equation below. Furthermore Eq. (24) does not contain the dependence on the material that is, it is valid only for Nb. The factor in the middle of Eq. (27) accounts for the material in relation to the reference material. The new variables appearing in the following equation are specified in the numerical example below. The final form for the magnitude of the gravitomagnetic acceleration in z-direction (vertical) is

$$\mathbf{g}_g = \frac{0.328}{1.18}\alpha_g^2 \mathbf{v}\times\mathbf{B}_g = \frac{0.328}{1.18}\alpha\alpha_{gp}\alpha_g^3 \frac{4\pi^2 m_e}{3m_p}\frac{\rho_D}{\rho_{0D}}\frac{h_D}{h_{0D}} N \frac{A_C}{A_{0C}}\frac{v^2}{c}\omega_I \tag{27}$$

Since $\alpha\alpha_{gp}\alpha_g^3 \sim \dfrac{\alpha^2}{\alpha^3}$ a multiplication with the form factors 0.328 and 1.18 of the α terms of the radiation correction takes place. Quantities h_D and h_{0D} denote the respective penetration depths of the $\mathbf{B}_{gp}$ field with respect to the disk or ring. The ratio $\dfrac{h_D}{h_{0D}} \sim 1$ and $h_{0D} = \dfrac{\hbar}{m_e c_I} \approx 9\times 10^{-3}$ m and c_I is the propagation speed of the electrons of imaginary mass in the disk. This would mean that gravitophotons in analogy to photons of a superconductor would gain mass.

As an example for a laboratory experiment to producing a sizable axial field a disk of $d = 0.2m$ diameter together with the following parameters is used: $\dfrac{m_e}{m_p} = \dfrac{1}{1836}$, $\dfrac{\rho_D}{\rho_{0D}} = 0.19$, $\dfrac{h_D}{h_{0D}} = 1$, where ρ_{0D} and h_{0D} are reference density and reference penetration depth for the disk or ring, and $N = 50$ is the number of turns of the coil. A value of $A_C/A_{0C} = 5$ is chosen, where A_C and A_{0C} are the cross section and the so called reference cross section of the coil, respectively. The circumferential speed of the disk is $v = 50$ m s^{-1} and $\omega_I = 7.5\times 10^5$s^{-1}. Inserting these values results in

$$g_g = \frac{0.328}{1.18}\frac{1}{137}\times\frac{1}{212}\times 67^3 \times \frac{13.16}{1836}\times 0.19\times 50\times 5\times \frac{2.5\times 10^3}{3\times 10^8}\times 7.5\times 10^5\times\frac{1}{9.81}g = \mathbf{0.62}g \tag{28}$$

where g denotes the acceleration of the *Earth*. This value denotes a fairly strong acceleration given the modest technical requirements for the experiment. For the limit of the real current I_L one finds

$$I < I_L = \frac{2\pi R}{\mu_0}\left(\frac{A_C}{A_{0C}}\right)\frac{4\pi^2 m_e}{e}\omega_I \approx 416\,A. \tag{29}$$

In summary, in the Heim experiment the following conversion takes place : Electromagnetism → gravitation + spacetime. Gravitation and spacetime form some kind of unity that is, there is not only the gravitational acceleration from Eq.(24) but also spacetime should be locally subject to acceleration mediated by the quintessence particle. With g_g fields matter is accelerated, with g_q field there will be an interaction with spacetime and momentum conservation, in order to be satisfied, need to be applied to both.

V. Conclusions and Future Activities

A paradigm shift in space propulsion is necessary, if space flight is to take place as envisaged by von Braun in the 1950s. Already, from the 1930s on numerous magazines and books, see Kakalios[57] , predicted that the rule of gravity would be overcome within the next fifty years, and von Braun's vision of spaceflight and spacestations would become reality. Furthermore, a revolution in energy generation could be expected and *Earth* bound transportation would be completely different. Comparing these predictions with the reality of today, it is obvious that nothing comes close. Earlier in 2010 NASA was even forced to cancel the program for having astronauts back to the moon within the next decade. This program was replaced by the grander mission of sending astronauts to Mars. However, without a moon base and under the present propulsion limits, the United States likely will not have a manned flight to Mars anytime soon. China and India have announced programs to land astronauts on the moon before 2030. The technological and scientific value of these programs is questionable, since landing astronauts on the moon with the brute force technology of the 1960s will not result in a viable long-term space program. In particular, the U.S. does no longer have a vigorous space program, having discontinued their manned space flight program in 2011.

The situation in energy generation is equally dire. Fossil energy is disliked, and fission energy is no longer pursued in the western world, and countries like Germany have opted out completely of nuclear energy. Whether renewable energies can efficiently and effectively can replace atomic energy is more than questionable. Fusion seems to be out of reach[58] , and it is a very long way to an all electric car. The energy density of batteries is very limited, depending on the basic physical properties of atoms and molecules that cannot be changed.

To overcome these limits, **advanced technology derived from novel physical laws** is needed. However, any laws built on the **reduction of gravity**, as were announced in several, but (*never confirmed*) experiments, despite substantial international efforts, will not change this bleak picture. This kind of gravity modification is not helpful, since the corresponding propulsion principle still is governed by classical momentum conservation. Thus no paradigm shift can be achieved. Any currently available propulsion system is similar to a flying fuel tank, whose stored energy will be a major risk for the astronauts. This problem cannot be overcome by engineering efforts, since it is imposed by the physics inherent to this propulsion principle.

Since 2002 ideas of a geometric approach for describing physical interactions, termed Extended Heim Theory (*EHT*), have been published. This approach predicts **six fundamental physical interactions**, namely *three gravitational fields*, electromagnetism as well as the weak and strong interactions[5–7] . Gravitational fields can be both *attractive and repulsive*. In addition to the existence of ordinary matter (fermions and bosons), non-ordinary matter in the form of **stable neutral leptons** should exist as well as particles of imaginary mass, which might be accountable for dark matter. Together with the three gravitational fields and the particles of **imaginary mass** the *conversion of an electromagnetic into a gravitational field*, under experimental conditions at low temperature that give rise to a phase transition, should be possible.

In 2006 the generation of extreme gravitomagnetic and gravity-like fields in the laboratory by rotating cryogenic rings or disks of small mass have been reported. These fields, if confirmed, would be definitely outside *GR*, requiring novel physics beyond the four known physical interactions. recently novel experiments were published by McGaugh, clearly contradicting Newtonian (Einsteinain) gravitation. While the experiments by Tajmar et al. were performed in the laboratory and because of the smallness of the extreme gravitomagnetic fields observed, might be more prone to experimental error, the experiments by McGaugh on the rotational speeds of galaxies seem to be completely reliable. Therefore, there is reasonable doubt that Newtonian gravitation alone does give a complete physical description of the nature of gravity. In other words, there is experimental evidence for the assertion of of the existence of more than one gravitational field. In particular *Tajmar et al.* have carried out numerous experiments on the generation of gravitomagnetic as well as gravity-like fields. The *gravitomagnetic effects measured were about 18 orders of magnitude larger than predicted by the so called Lense-Thirring effect of GR*. In other words, the rotating niobium ring, having a mass of some 400 grams utilized by Tajmar, produces a frame dragging effect similar to the mass of a white dwarf[7] .

In summary, the present situation is characterized by the fact that credible experimental data exist, employing different measurement techniques, showing similar, but highly unexpected results, which are not in accordance with *GR*. This means that *GR* cannot be used to explain these phenomena, even if the full nonlinear Einstein field equations were used. The Lageos and GP-B experiments have clearly demonstrated that the inertial frame dragging effect, even from celestial bodies, is extremely small and within *GR*. The experimental findings of McGaugh and Tajmar et al. provide evidence for *novel physics in the form of additional long range fundamental forces* and support the predictions of EHT, namely the existence of six fundamntal forces, of which three are gravitational like, but gravity is now both attractive ad repulsive.

Moreover, it is obvious that if the speed of light cannot be transcended, interstellar travel is impossible. We conclude with a phrase from the recent book on future propulsion by Czysz and Bruno[59] : *If that remains the case, we are trapped within the environs of our Solar System*.

A flight to the nearest star at a velocity of some 16 km/s would take about 80,000 years. On the other hand, a space vehicle with a mass of 10^5 kg at the high velocity of 10^5 km/s would take approximately 12.8 years to reach this star. Its kinetic energy would amount to about 5×10^{20} J. Supplied with a 100 MW nuclear reactor, it would take some 150,000 years to generate this amount of energy. However, there is novel substantial and credible experimental evidence from different sources that indicates that *GR* might need to be extended.

In this paper it was shown how experiments (Tajmar et al. Graham et al.) performed at cryogenic temperatures might lead to symmetry breaking that produces novel particles lead to a macroscopic quantum mechanics effect and to an interaction between electromagnetism and gravitation. Moreover, this interaction is supposed to involve the spacetime field, causing a momentum transfer to spacetime. i.e. enlarging the radius of the *Universe*. The same amount of momentum of opposite sign would be imparted on the space vehicle. The physical system for gravity-like field propulsion (axial field) therefore comprises the space vehicle and the spacetime field. Furthermore, it was shown that if the Universe is expanding through this interaction between spacetime and space vehicle, the energy content of the Universe (spacetime field) must decrease, which follows from the application of Bekenstein's formula. Regarding the physical system under consideration as a thermodynamic system, the energy of the space vehicle should increase in form of kinetic energy, since energy needs to be conserved. This process clearly is not a perpetuum mobile, but seems to be the mechanism matter is being generated in the *Universe*. In particular at the end of the inflationary phase, matter in large quantities should have been generated. In other words, the (accelerated) expansion of the Universe seems to be a consequence of the conservation of momentum, energy and angular momentum.

Gravity-like fields most likely should lead to novel technologies in the field of energy generation in that a direct conversion of the energy from the spacetime field in electric energy should be possible, which is highly relevant to solving the upcoming energy crisis. In the general field of transportation, gravitational engineering should be of major interest to the public and, in particular, to industry.

Of even more practical importance would be the aspect of **energy conversion from direct interaction between electromagnetism and gravitation**, or from **employing gravity-like fields as plasma stabilizers in nuclear fusion**. Given the *severe problems with plasma stability* in the ITER tokamak geometry and with the construction of a genuine fusion reactor itself[58] , a combination of magnetic and gravity-like fields might be capable of overcoming plasma instabilities. Given the huge investment at stake, computer simulations could be performed to investigate the efficiency of gravity-like fields as well as determining their magnitude to be effective as an auxiliary field in confining the plasma. In addition, with the aid of gravity-like fields topologically simpler configurations like magnetic mirrors might be conceivable, leading to **fusion devices that are much more manageable**. A second, highly important, topic is to **maintain a fusing plasma practically indefinitely**, in order to attain an *economically viable fusion reactor*. So far less than a second has been reached, and the plasma has proved to be extremely unruly. Perhaps, a combination of gravity-like field and magnetic induction field might lead to a simpler, *linear fusion device* that is less susceptible to this kind of problems.

In view of the relatively small theoretical and experimental efforts, along with the short time scale of three to five years [i] needed to determine whether these ideas might lead to real engineering concepts, major research should *now* be initiated to get a more fundamental understanding of gravitomagnetic phenomena, both theoretically and experimentally. Given the **present evidence, and considering the enormous implications of these ideas** in many areas of advanced technology as well as the monumental potential benefit, such a research investment seems to be entirely justified.

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