American Institute of
Aeronautics and Astronautics

AIAA 2006-4608

SPACETIME PHYSICS AND ADVANCED PROPULSION CONCEPTS

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

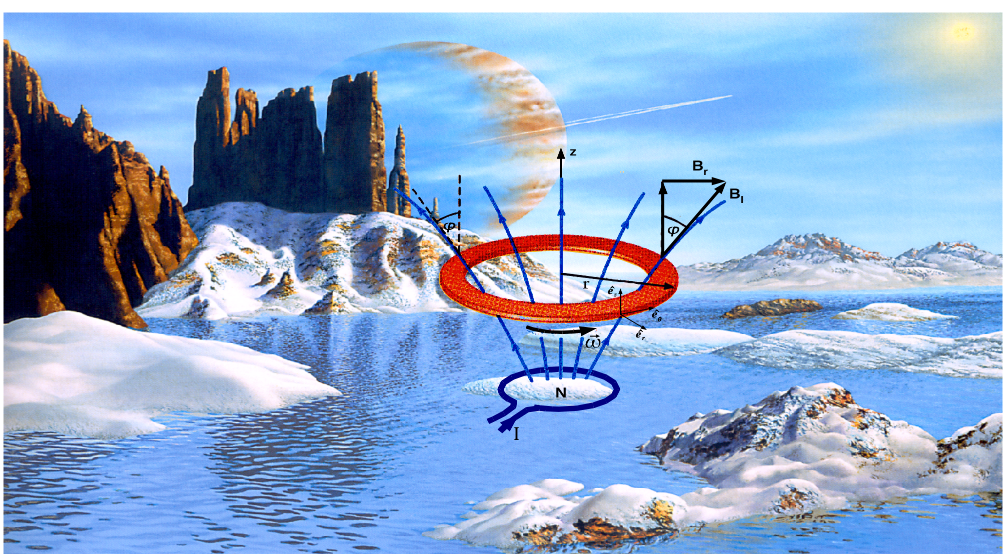
[1]Institut für Grenzgebiete der Wissenschaft, Innsbruck, Austria

and

[2]Faculty Karl-Scharfenberg, University of Applied Sciences, Salzgitter, Germany

Revised Extended Version (20 Agust 2006)

Abstract: Spacetime physics includes general relativity (*GR*), quantum theory, quantum gravity, string theory (additional external dimensions), and gauge theory (additional internal dimensions) as well as some modern variations. The paper will discuss the requirements on future propulsion systems stemming from the demands for routine missions to *LEO*, the moon, or planetary missions within the solar system, as well as interstellar flight. These requirements are compared with the limits imposed by the physical laws of *GR* in conjunction with the physical theories listed above. The physical consequences of these field theories in curved-spacetime as well as string and gauge theory, are discussed. Moreover, recent developments in the structure of spacetime are presented, and their consequences for advanced propulsion systems are outlined. In particular, a novel experiment (*ESA*, March 2006) reporting about the generation of an artificial gravitational field in the laboratory is discussed. This experiment, if confirmed, could serve as the basis for a field propulsion device. Since a thorough understanding of the underlying physical principle as provided by *Extended Heim Theory* (*EHT*) is of prevailing importance, both the theoretical and quantitative analysis of this experiment are presented. Utilizing the experimental data along with the insight gained from theoretical considerations of *EHT*, the concept for a field propulsion device is briefly outlined. Preliminary results of the propulsion capability of this device are also given. Finally, an outlook on the necessary experimental and theoretical prerequisites is presented, to comprehend the novel physics regarding the two different coupling mechanisms for *fermions* and *bosons*. Finally, the technical requirements for such a *propellantless propulsion device* are briefly described.



1 Senior scientist, 2 Senior member *AIAA*, member *SSE*,

1 Spacetime and Space Propulsion[2]

Space flight within the solar system requires the covering of large distances. The distance to our moon is approximately 3.8×10^5 km, while Mars, our favorite destination is about 0.5 A.U. away (astronomical units, 1 A.U. = 1.5×10^8 km). The next planet, Jupiter, is already 4 A.U. away from Earth. The closest star is Proxima Centauri, which is 1.30 pc away from earth (parsec, 1pc = 3.3 ly) or, using a light-year, the distance light travels in the time of 1 year, (1 ly = 9.46×10^{12} km), it would take the light some 4.3 years to reach this star. Expressed in miles, the distance is some 25 trillion miles from earth. The star closest to us which is similar to our sun with respect to size and surface temperature is Centauri, 1.33 pc away. But these distances are small compared to the dimension of the Milky Way Galaxy which comprises a galactic disk of about 100,000 ly in diameter and 4,000 ly for the galactic bulge. Our solar system is located some 8 kpc (kilo parsec) from the galactic center. Our galaxy contains about 100 billion stars, and the universe contains some 100 billion galaxies. The farthest of these galaxies is approximately 13 billion ly away, which is roughly the size of the observable universe. The age of the Earth is estimated to be some 4.5 billion years, while there are stars that are 7 to 10 billion years old. Having mentioned both distance and time, the concept of **spacetime** has been utilized and also, implicitly, the concept of **metric** has been employed to measure distances in this four-dimensional spacetime. This is the environment in which spaceflight has to take place.

Next, we will briefly discuss our current capabilities[3] to travel through space and time. **C**urrent space transportation systems are based on the principle of momentum generation, regardless whether they are chemical, electric, plasmadynamic, nuclear (fission) or fusion, antimatter, photonic propulsion (relativistic) and photon driven (solar) sails, or exotic Bussard fusion ramjets. Solar sails, nuclear explosions (pusher, Orion), antimatter propulsion are most likely in the realm of unfeasible technologies because of the large engineering and/or safety problems as well as their prohibitively high cost. The specific impulse achievable from thermal systems ranges from some 500 s for advanced chemical propellants (excluding free radicals or metastable atoms), approximately 1,000 s for a fission solid-core rocket (NERVA program [2]) using hydrogen as propellant (for a gas-core nuclear rocket specific impulse could be 3,000 s or higher but requiring very high pressures) up to 200,000 s for a fusion rocket [3]. Although recently progress was reported in the design of nuclear reactors for plasma propulsion systems [4] such a multimegawatt reactor has a mass of some 3×10^6 kg and, despite high specific impulse, has a low thrust to mass ratio, and thus is most likely not capable of lifting a vehicle from the surface of the earth. For fusion propulsion, the gasdynamic mirror has been proposed as highly efficient fusion rocket engine. However, recent experiments revealed magnetohydrodynamic instabilities [5] that make such a system questionable even from a physics standpoint, since magnetohydrodynamic stability has been the key issue in fusion for decades. The momentum principle combined with the usage of fuel, because of its inherent physical limitations, does not permit spaceflight to be carried out as a matter of routine without substantial technical expenditure. The above discussion does not even consider the difficulties encountered when the simplicity of the physical concept meets the complexities of the workable propulsion system.

At relativistic speeds, Lorentz transformation replaces Galilei transformation where the rest mass of the propellant is multiplied by the factor $(1 - v^2/c^2)^{-1}$ that goes to infinity if the exhaust velocity v equals c, the speed of light in vacuum.

For instance, a flight to the nearest star at a velocity of some 16 km/s would take about 80,000 years. 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 [6] : *If that remains the case, we are trapped within the environs of our Solar System.* In other words, the technology of spaceflight needs to be based on novel physics that provides a novel propulsion principle.

In addition, this discussion leads us to conclude that the current state of propulsion neither permits comfortable flights to other planetary systems nor to our moon. Even the achievement of a Low Earth Orbit will remain a laborious, dangerous and extremely costly procedure with this technology. In the long run this technology will inflict prohibitively high cost and risk for all kind of space missions. This is not because the technology is insufficiently advanced, but the underlying physical principles *do not allow efficient and effective as well as safe space travel*. Although advanced propulsion concepts as described above *must* be pursued further, a research program to look for **fundamentally different propulsion principles** is both needed and justified, especially in the light of the *recent experiment* by Tajmar et al. [7], and also because ideas for a fundamental physical theory predicting *additional physical*

2 Invited paper in the session 50-NFF-3 *Faster Than Light,* AIAA 42nd Joint Propulsion Conference, Sacramento, CA, 9-12 July 2006. Revision date 24 July and 20 August 2006. This paper supersedes the original AIAA 2006-4608 *Short Version* as well as the AIAA 2006-4608 *Extended Version* paper.

3 The cover picture shows a combination of two pictures. The first one, taken from ref. [1], shows a view (artist's impression) from an existing planet orbiting the solar-type star HD 222582 some 137 ly away. The second one depicts the principle of the propulsion system used to reach this planet, see Fig. 10.

interactions recently became more concrete and realistic, for instance, [8], [9]. In Sec. 4 this theory will be used to calculate Tajmar's experiment and to provide guidelines for a modified experiment that would serve as demonstrator for a *propellantless propulsion* device.

As mentioned by Krauss [10], general relativity (*GR*) allows metric engineering, including the so-called warp drive, see Sec. 2.2, but superluminal travel would require negative energy densities. Furthermore, in order to tell space to contract (warp), a signal is necessary that, in turn, can travel only with the speed of light. *GR* therefore does not allow this kind of travel.

On the other hand, current physics is far from providing final answers. First, there is no unified theory that combines *GR* and *QM* (quantum mechanics). Second, not even the question about the **total number of fundamental physical interactions** can be answered. Hence, the goal to find a *unified field theory* is a viable undertaking, because it might lead to novel physics, which, in turn, might allow for a **totally different principle** in space transportation[4]. The *only solution* for an advanced propulsion system lies in the detection of those hitherto unknown physical laws. As has been discussed above and will be outlined further in Sec. 7, **there exists credible experimental evidence in conjunction with a theoretical framework** for these laws to exist which may lead to the construction of a technically feasible propulsion device. This propulsion principle would be **far superior** compared to any device based on momentum generation from fuel, and would also result in a *much simpler, far cheaper, and much more reliable* technology. Such a technology would revolutionize the whole area of transportation.

2 Classical Spacetime

Since any space vehicle is flying through spacetime, the nature and properties of spacetime should be thoroughly understood, because they may eventually be the key for an advanced space propulsion mechanism. As we will see, the nature of spacetime is not obvious and the classical point of view, see below, does not represent the physical facts. The physical consequences, however, have not yet been fully worked out.

In *GR* the model of space and time supports continuous and differentiable functions and provides a structure that has the same local topology as $\mathbb{R}^4$. Therefore, spacetime is a topological space and thus comprises a collection of open sets. For small regions it is assumed that the open sets possess the topology of $\mathbb{R}^4$. Therefore, a one-to-one mapping exists between the open set of spacetime and $\mathbb{R}^4$. Each point in spacetime has a unique image in $\mathbb{R}^4$ and vice versa.

2.1 Spacetime as a Manifold

Equipped with the features described above, spacetime is called a *manifold*. In general, physical fields defined on an open set of this manifold are assumed to be differentiable. Spacetime thus is considered to be a *multiply differentiable manifold*. However, as will be shown in Sec. 4, space- time must be quantized. Therefore, it is not generally possible to have a third point between any two points in spacetime. Spacetime is not dense and hence the concept of manifold is incorrect, at least on the Planck length scale. In *SRT* (special theory of relativity) Lorentz contraction is continuous, but this contradicts the concept of minimum length.

At Planck scales *SRT* cannot be correct. *GR* uses the concept of curvature, but at Planck scales it cannot be measured exactly. This is equivalent to fluctuations of curvature and thus of gravitation itself. A unified field theory describing all physical interactions by a set of individual metric tensors would be subject to fluctuations as well that is, all physical forces would be subject to these fluctuations.

Physics in the way we know it is not possible below the Planck scale, since concepts of metric, dimensionality, or points are not defined. Spacetime itself is a field and thus needs to be quantized, leading to quantum gravity (*QG*), see, for instance [11]. So far, *QG* has not lead to a unified field theory, and *does not predict any phenomena* that could lead to a novel propulsion concept. The *same holds true for String* theory, for instance [2] that does not make any testable predictions at all. Conventional wisdom claims that quantized spacetime acts on the Planck scale only. On macroscopic scales the concepts of *GR* are sufficient to describe spacetime. However, this **argument** may turn out to be **invalid**, since despite the smallness of the quantized action, denoted by the Planck constant h, physical phenomena on the macroscopic scale do occur, for instance superconducting and condensed matter phenomena [12]. Therefore, it is conceivable that a quantized spacetime may lead to novel observable physical phenomena. For instance, quantized spacetime together with the prediction of a *repulsive gravitational force*, predicted by *EHT*, see *quintessence* particle in Table 1, leads to the concept of a covariant (physical equations remain form invariant) **hyperspace** (or *parallelspace*), in which the limiting speed of light is nc, with $n > 1$ integer, and c the vacuum speed of light [13], [14]. As was shown in these papers, conditions can be derived under which, at least theoretically, material objects might **enter and leave hyperspace**. These conditions were obtained from a coupling mechanism based on *vacuum polarization involving virtual electrons* (*fermions*, particles with half-integer spin). So far, no investigations were made to determine whether these **conditions would change in the light of Tajmar's experiment** that takes place in a condensed matter environment and involves the coupling to *bosons* (particles with integer spin, Cooper pairs in superconducting).

2.2 The Physics of Continuous Spacetime

Einsteinian spacetime [15], [16] is indefinitely divisible and can be described by a differentiable manifold. In reality, however, spacetime is a quantized field. Gravitation is the dominant force in systems on astronomical scales. *GR* can be summarized in the single sentence: *matter curves spacetime.* For a flat geometry, the angles of a triangle add up to 180 degrees. For a generally curved spacetime the

4 A more detailed discussion will be given in our paper entitled *Field Propulsion I: Novel Concepts for Space Propulsion.*

metric is written in the form (double indices are summed over)

$$ds^2 = g_{\mu\nu} dx^\mu dx^\nu \tag{1}$$

where $g_{\mu\nu}$ is the metric, x^1, x^2, x^3 are the spatial coordinates, and x^4 is the time coordinate[5]. Einstein summation convention is used, i.e., indices occurring twice are summed over. The following metric examples are considered in increasing complexity.

The spacetime metric of a flat universe is given by

$$ds^2 = dx^2 + dy^2 + dz^2 - c^2 dt^2 .$$

Presently it is assumed that the observable *Universe* is flat, see Fig 1. It still can be closed, see for instance [17]. Since we reject the idea of infinities in physics, because they contradict the quantization principle, the *Universe* should not be open [18].

On the surface of a sphere spherical coordinates are used

$$ds^2 = dr^2 + r^2 d\theta^2 + r^2 \sin^2\theta \, d\phi^2 - c^2 dt^2 .$$

The cosmological principle states that the *Universe* does not have preferred locations (homogeneous) or directions (isotropic). Therefore the spatial part of the metric has constant curvature. Extending the spherical metric, the most general metric is given by the *Robertson-Walker* metric

$$ds^2 = a^2(t) [\frac{dr^2}{1 - k r^2} + r^2 (d\theta^2 + \sin^2\theta \, d\phi^2)] - c^2 dt^2 ,$$

where $a(t)$ is the scale factor for an expanding *Universe*. Here it is assumed that the *Universe* started from a fixed size x_0 and expanded according to $a(t)$. Two points that were at distance x_0 at time t_0, now are at distance $x(t) = a(t)\, x_0$. This is a cosmological model with a radially symmetric metric tensor, and a function $a(t)$ that acts as the radius of the universe.

In 1994 *Alcubierre* [19], [20] specified the following metric, termed the **warp-drive** spacetime

$$ds^2 = [dx - V_s(t) f(r_s) dt]^2 + dy^2 + dz^2 - c^2 dt^2 ,$$

where $V_s(t)$ is the velocity along a given curve $x_s(t)$ [6] and $r_s(t) = (x - x_s(t))^2 + y^2 + z^2$. A choice for $f_s(t)$ is $f_s = (1 - r_s/R)^4$ and R is a distance. Without proof it is stated that, if this warp-drive metric could be generated - the term *metric engineering* was coined - around a spaceship, the vehicle would be traveling faster than the speed of light, seen from a spacetime diagram of flat space. Locally the ship is moving *less* than the speed of light. A bubble of spacetime curvature must surround the spaceship. Since the Alcubierre metric requires a negative local energy density, it cannot work in *GR*. Quantum mechanics allows negative energy density, and perhaps a combination with the quintessence particle, see Fig. 3, the **sixth fundamental force** predicted by *EHT* provides a theoretical framework. It is interesting to note that the experiment by Tajmar et al. [21] could be interpreted as **metric engineering**, since an artificial gravitational field was generated and, as a result, the local metric has been changed.

There are also spacetime concepts of *higher dimensionality*. Kaluza (1921) introduced an additional fourth spatial dimension into Einstein's field equations, and in a letter to Einstein pointed out that Maxwell's theory of electromagnetism was comprised in the now 5-dimensional Einstein equations. However, his theory produced divergencies and could not answer the question about the visibility of this 5th dimension. In 1926 Klein, a Swedish physicist, introduced the concept of a curled up dimension that exists on the Planck length scale only, and thus cannot be observed by experiment. *String* theory, for instance [22], see Sec. 5, has extended this concept by introducing 7 additional spatial dimensions, resulting in a total of 10 spatial an 1 time dimensions.

3 Symmetries in Classical Spacetime

Symmetries (beauty) have a fundamental role in classical and modern physics. They completely determine the physics. Eventually **all symmetries are a feature of the underlying physical space** which is the combination of spacetime and an additional *internal* or *external* space. Any physical law is based on a corresponding symmetry. Therefore physical space should be the generator of all physical interactions and this should be reflected by any physical theory. Symmetry means that one can transform the object in some way, so that it appears *unchanged* after the transformation. In other words if there is an *invariance* under transformation or *symmetry* the respective feature is unobservable.

If in a mirror image a systems looks the same, the system possesses *reflection symmetry*. There is also invariance under *rotation*, for example if the system is a soccer ball. The difference between these two symmetries is that the first one is discrete and the second one is continuous, i.e., the rotation angle varies continuously between 0 and 2π. In classical physics the *Lagrange* function of a system, $L(\boldsymbol{x}, \dot{\boldsymbol{x}}, t)$, is the object whose symmetry properties are investigated with respect to the homogeneity and isotropy of space as well as the homogeneity of time. Invariance under translation, leads to *momentum conservation*. Invariance in time translation results in *energy conservation* and invariance under rotation is responsible for conservation of classical *angular momentum* [23].

5 Often the time coordinate is denoted as x^0.

6 For simplicity $y = 0$ and $z = 0$ are assumed.

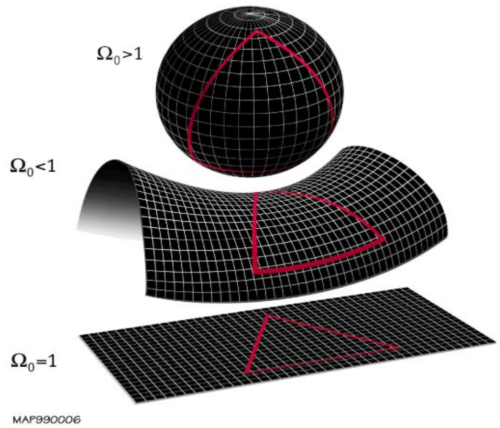


Figure 1: This picture, taken from Wikipedia, shows three types of possible geometries for the *Universe*, namely closed, open, or flat. At present, a flat *Universe* is assumed (that means the part that can be observed appears flat, i.e., whose redshift is smaller than the speed of light *c* in vacuum). This only means that the *Universe* is very large [17].

In general, Noether's theorem says that if the equations of motion (Euler-Lagrange, which follow from the variation of the Lagrange function) are invariant under a transformation, then there exists an integral of motion, i.e., a conserved quantity. The symmetry concept also holds for the Lagrange function describing electromagnetism. These simple considerations show the fundamental role of spacetime. All classical physics follows from the *geometry and topology of spacetime as a manifold*. However, as will be shown in the next chapter, spacetime is not a manifold nor a set of points, but a fluctuating field. Moreover, in the fifties of the last century it was shown by experiment that there are additional discrete symmetries that are not conserved. For instance, reversing the spatial coordinates that is, doing a *space parity* transformation, should not change the physics. Empty space does, however, distinguish between left and right. Some elementary particles are left-handed in their interaction. This is a clear sign that particles may have more degrees of freedom, and thus looking at an elementary particle in spacetime only does not reveal all its physical information. Therefore, *physical space* needs to be considered that contains the complete set of information for a particle containing spacetime as a subset. Spacetime could either be part of a higher dimensional space with additional spatial coordinates, or at each point in spacetime, an additional *internal space* must exist that accounts for the additional degrees of freedom.

4 Quantized Spacetime

In the following it is shown that the **combination** of **quantum theory** (Heisenberg's uncertainty relation) with **special relativity** (constancy of the speed of light and $E = mc^2$) and **general relativity** (Schwarzschild radius) directly leads to a **quantized spacetime**, resulting in the well known Planck scales. The proof is straightforward and is given below. The quantization of spacetime in conjunction with the sixth interaction of *EHT*, repulsive gravitation, see Sec. 6, leads to the proposition of a *hyperspace* (*parallel space*) in which superluminal speeds should be possible, as was shown in [24].

Heisenberg´s indeterminacy (uncertainty) relation, for instance relating time and energy indeterminacies, $\Delta t \Delta E > \hbar$, allows for arbitrarily small Δt by making the energy uncertainty arbitrarily large. However, this is not the case in the real physical world. It is straightforward to prove the discreteness of spacetime. To prove the discrete nature of spacetime, the time measurement process using clocks is analyzed [25] Einstein's *GR* itself is used to disprove the existence of continuous spacetime. According to Einstein, the energy of any material object is $E = mc^2$. The smallest time interval, δt, that can be measured must of course be larger than the time uncertainty required to satisfy Heisenberg's uncertainty relation that is $\delta t > \Delta t = \hbar / \Delta E$. A clock of mass m cannot have an energy uncertainty $\Delta E > mc^2$, because this would lead to the creation of additional clocks, hence $\delta t > \Delta t = \hbar / m c^2$. A clock of length l needs a measuring time $c\,\delta t > l$ in order to receive the measuring signal. A characteristic length of a material body is its Schwarzschild radius, namely when its gravitational energy equals its total energy mc^2, i.e., $r_S = Gm/c^2$. This means for the mass of the clock $m < r_S\, c^2/G$, because the body must not be a black hole from which signals cannot escape. Inserting the value l for r_S , $m < \delta t\, c^3/G$. Inserting the value of m in the above relation for δt, one obtains the final relation $\delta t^2 > \hbar G / c^5$. Thus the quantization aspect of the *GODQ* principle, see the following section, directly delivers a fundamental lowest limit for a time interval, termed the *Planck time*. In a similar way the smallest units for length and mass can be found. As shown above, Planck units are constructed from the three fundamental constants in *Nature*, namely $\hbar$, c, and G. The values for the Planck units are:

- *Planck mass* $m_p = (\hbar c/G)^{1/2} = 2.176 \times 10^{-8}$ *kg*,
- *Planck length* $l_p = (G\hbar/c^3)^{1/2} = 1.615 \times 10^{-35}$ m ,
- *Planck time* $t_p = (G\hbar/c^5)^{1/2} = 5.389 \times 10^{-44}$ *s*.

This means that the *classical picture of points in a continuous spacetime does not make physical sense* (this also applies to Feynman diagrams). Physics below the Planck units must be totally different, since one cannot distinguish between vacuum and matter. No measurements are possible. The nature of spacetime is discrete in the same way as energy is discrete, expressed by $E = h\nu$. Therefore spacetime is a **quantum field**, and it should have corresponding quantum states, described by a quantum field theory. Since spacetime is equivalent to gravity, gravity itself needs to be described by a quantum field theory. In both classical physics and quantum mechanics point particles are used, and the inverse force law leads to infinities of type 1/0 at the location of the particle. As was shown above, any particle must have a discrete geometric structure, since it is finite in size. The minimal surface must be proportional to the Planck length squared. From scattering experiments, however, it is known that many particles have a much larger radius, for instance, the proton radius is some 10^{-15} m, and thus its surface would be covered by about 10^{40} elemental *Planck surfaces*. Hence, an **elementary particle would be a highly complex geometrical structure**. Heim [26], [27] has analyzed in detail the structure of elementary particles and introduced the concept of a smallest surface termed *Metron*. According to Heim, the current area of a *Metron*, τ, is $3Gh/8c^3$.

The *Metron* size is a phenomenologically derived quantity and is not postulated. It is therefore mandatory that point particles are banished conceptually.

5 Spacetime of Higher Spatial Dimensions: String Theory

Novel physics most likely comes from a unified theory. Over the last five decades many attempts have been made. No successful theory has emerged so far. One of the most prominent recent theories is *String* theory which uses ideas from Kaluza and Klein. The theory by Kaluza and Klein (1921, 1926) already introduced a fourth spatial dimension to account for electromagnetism. There is nothing in Einstein's theory to forbid the introduction of additional coordinates. According to string theory, electrons are not point particles, but are *vibrations of a string*, whose length is at the Planck scale, some 10^{-35} m. Strings are one-dimensional entities. Sounding these strings they can turn into other particles, for instance, the electron can turn into a neutrino, or into any of the known subatomic particles. *String* theory leads to a unification of the four fundamental interactions, but requires more spatial dimensions. However, because of the discrete nature of spacetime there seems to be no need for string theory, which replaces point particles by strings, but requires hitherto unobserved additional spatial dimensions.

6 Gauge Theory as Spacetime with Internal Dimensions

However, there is a fundamental difference compared to the concept of spacetime with internal dimensions, in that strings are objects in spacetime, while in this section a geometrization concept is employed that explains all particles as geometric objects constructed from spacetime itself.

There exists another concept, coming from the idea that elementary particles have *additional degrees of freedom* in some kind of internal space. Therefore, the concept of physical space as the combination of spacetime and internal space is introduced. This marriage of 4-dimensional spacetime with internal space is called *fiber bundle space* mathematically. In the following the term **physical space** will be used for this combination, since *all* the fundamental forces of physics will be described in this space. These internal degrees of freedom can then be connected with the dynamical motion in spacetime. This is the geometrical structure utilized in gauge theory. The dimension of the internal space and its symmetries determine the physics that is possible. In order to have a unified field theory the proper internal space has to be constructed that encompasses all interactions of physics. In the next section, *GR* is equipped with an 8-dimensional internal space, termed Heim space. Once this internal space is set up, all physical interactions are fixed. There is only one single selection rule for building internal subspaces that have physical meaning, see below. It turns out that *six fundamental physical interactions* should exist.

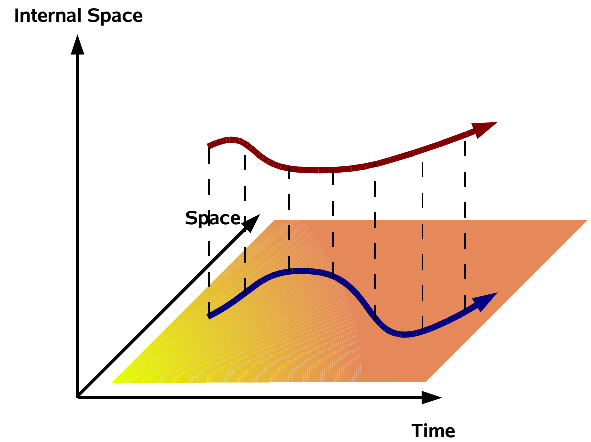


Figure 2: In gauge theory particles have additional degrees of freedom, expressed by an internal space. The horizontal plane depicts spacetime, the vertical axis denotes internal space. In this sense *EHT* can be considered as a gauge theory where an 8-dimensional internal space is constructed at each point in spacetime, forming a fiber bundle space. All internal coordinates, except the spatial energy coordinates (mass), have negative signature. In *EHT* no additional *external spatial* coordinates exist. It remains to specify the proper gauge potentials and the corresponding Lagrange densities for describing the fundamental interactions in *EHT*.

6.1 Special Gauge Theory: Extended Heim Theory

In *EHT* a set of 8 additional coordinates is introduced, but contrary to *String* theory, the theory postulates an internal space with 8 dimensions that governs physical events in our spacetime (actually a curved 4D manifold M).The crucial point lies in the construction of the internal space that should come from basic physical assumptions, which must be generally acceptable. In *EHT*, an 8-dimensional space is constructed, termed Heim space, H^8 that is missing in *GR*. In other words, *GR* does not possess any internal space, and thus has a very limited geometrical structure, namely that of pure spacetime. Because of this limitation, *GR* cannot describe the fundamental forces in physics and consequently has to be extended. The extension as done in *EHT*, lies in the introduction of the internal space H^8. *EHT* reduces to *GR* when this internal space is omitted. The metric tensor, as used in *GR*, has *purely geometrical means* that is of immaterial character only, and does not represent any physics. Consequently, the *Einsteinian Geometrization Principle* (*EGP*) is equating the Einstein curvature tensor, constructed from the metric tensor, with the stress tensor, representing energy distribution. Stated in simple terms: *matter curves spacetime*. In this way, the metric tensor field has become a physical object whose behavior is governed by an *action principle*, like that of other physical entities.

According to the quantization principle, the minimal length in the space part of H^8 is the Planck length. Applying the geometrization rule of the *GODQ* principle, see next paragraph, Planck mass and Planck time are converted into length units leading to two additional lengths constants $l_{pm} = \hbar / m_p c$ and $l_{pt} = ct_p$ that have the same numerical value as l_p but define two additional different length scales, relating lengths with time units as well as length with mass units. The introduction of basic physical units is in contradiction to classical physics that allows infinite divisibility. As a consequence, measurements in classical physics are impossible, since units cannot be defined. Consequently, *Nature* could not provide any elemental building blocks to construct higher organized structures, which is inconsistent with observation. Thus the quantization principle is fundamental for the existence of physical objects. Therefore the three Planck length units as defined above must occur in the structure of both spacetime and internal space H^8. In spacetime length unit l_p is the basic unit for the spatial coordinates and l_{pt} measures the time coordinate. In order to connect geometry with physical entities, in the internal symmetry space coordinates ξ^i are measured in units of l_{pm}. Hence all lengths in H^8 are represented by multiples of $1/m_p$, and therefore internal coordinates ξ^i with i = 1,...,8 are denoted as *energy coordinates*. In other words, the concept of energy coordinate ensures that an inverse length is representing a physical mass. Since length values are quantized, the *same holds for physical mass*. In this regard the connection of geometry with physical objects has been established, but, in order to achieve this goal, the quantization principle had to be introduced *ab initio*.

In contrast to Einstein, *EHT* is based on the following four simple and general principles, termed the ***GODQ*** principle of *Nature*[7].

i. ***Geometrization principle for all physical interactions,***

ii. ***Optimization (Nature employs an extremum principle),***

iii. ***Dualization (duality, symmetry) principle (Nature dualizes or is asymmetric, bits),***

iv. ***Quantization principle (Nature uses integers only, discrete quantities).***

From the duality principle, the existence of additional internal symmetries in Nature is deduced, and thus a higher dimensional internal symmetry space should exist, termed **Heim space** H^8, which will now be determined.

In *GR* there exists a four dimensional spacetime, comprising three spatial coordinates, x^1, x^2, x^3 with positive signature (+) and the time coordinate x^4 with negative signature (-). It should be remembered that the *Lorentzian* metric of $\mathbb{R}^4$ (actually spacetime is a manifold M) has three spatial (+ signature) and one time-like coordinate (- signature)[8]. The plus and minus signs refer to the local *Minkowski* metric (diagonal metric tensor, see Eq. (1)). Therefore, the squared proper time interval is taken to be positive if the separation of two events is less than their spatial distance divided by c. Hence a *general coordinate system* in a spacetime manifold M (locally $\mathbb{R}^4$) comprises the curvilinear coordinates η^μ with μ = 1,..,4 and $\eta = \eta^\mu \in M$ where η denotes an element (point) of M.

The set of 8 internal coordinates is determined by utilizing the *GODQ* principle introduced above. The three internal spatial coordinates ξ^1, ξ^2, ξ^3 are associated with Planck length l_{pm}, the internal time coordinate ξ^4 with l_{pt}. The other four coordinates are introduced to describing the degree of organization and information exchange as observed in *Nature*. To this end, the second law of thermodynamics is considered, which predicts the increase of entropy. Although negative entropies are possible, they cannot account for the high degree of organization prevailing in *Nature*. The second law of thermodynamics says something about the direction of a process, but will not lead to highly organized structures by itself. Everywhere in *Nature,* however*,* highly organized structures can be found like galaxies, solar systems, planets, plants etc., which, according to the duality principle, have to be introduced into a unified theory. We are referring to the article of P.W. Anderson *More is Different* [28]. It simply says that the ability to reduce everything to its basic constituents and fundamental laws does not imply the ability to start from these laws and reconstruct the phenomena, i.e., the *Universe*. In that sense, these coordinates express some kind of a **collective behavior,** which is reflected by the *entelechial* and *aeonic* coordinates, see below. A description of *Nature* that *only* provides a route to decay or to lower organizational structures is in contradiction to observation.

Therefore, an additional, internal (negative signature -) coordinate, termed **entelechial** coordinate, ξ^5, is introduced. The entelechial dimension can be interpreted as a **measure of the quality of time varying organizational structure** (inverse or dual to entropy). It should be mentioned that all other additional internal coordinates have *negative* signature, too. When the *Universe* was set into motion, it followed a path marked by a state of great order. Therefore, to reflect this generic behavior in *Nature*, the **aeonic** dimension, ξ^6, is introduced that is interpreted as a **steering coordinate toward a dynamically stable state**. On the other hand, the entropy principle is firmly established in physics, for instance in β- decay.

7 This will be discussed in detail in our forthcoming paper: *Field propulsion I: Novel Physical Concepts for Space Propulsion.*

8 Normally the time coordinate is denoted as x^0. Because of the additional coordinates with negative signature this convention is not useful. The signature signs are convention only and can be reversed.

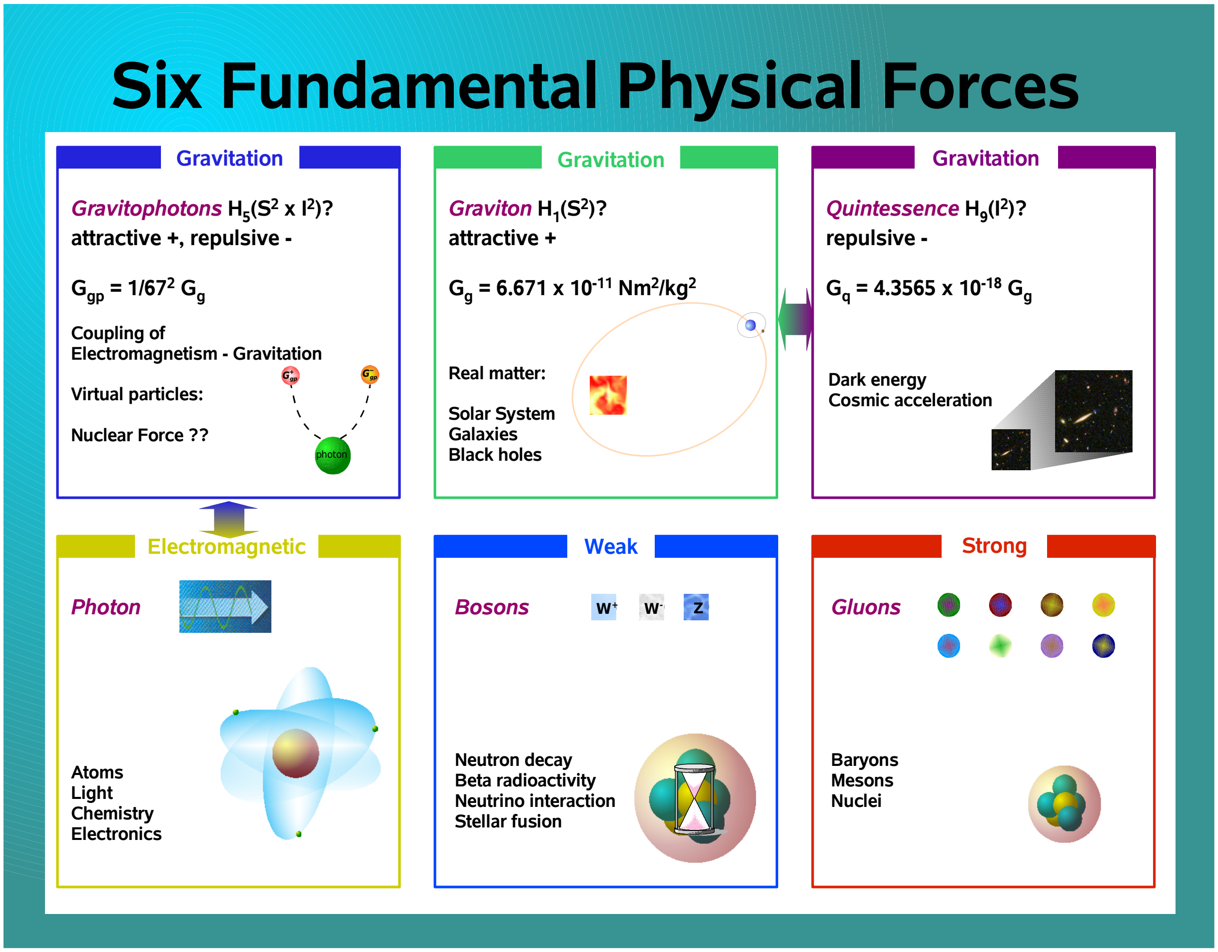


Figure 3: *EHT* predicts, as one of its most important consequences, two additional, gravitational like interactions and the existence of two messenger particles, termed *gravitophoton* and *quintessence*. That is, there is a total of *six fundamental physical interactions*. The name gravitophoton has been chosen because of the type of interaction, namely a transformation of the electromagnetic field (photon) into the gravitational field (gravitophoton). The arrow between the gravitophoton and electromagnetic boxes indicates the interaction between these messenger particles that is, photons can be transformed into gravitophotons. In the same way the quintessence interaction can be generated from gravitons and positive gravitophotons (repulsive force) where it is assumed that first a neutral gravitophoton is generated that decays into a pair of negative (same sign as gravitational potential) and positive gravitophotons.

Entropy is directly connected to probability, which in turn is related to information. Therefore, two additional coordinates ξ^7, ξ^8 are needed, which are complementary to the organizational coordinates, to reflect this behavior of *Nature*, termed **information coordinates** that are describing information waves. Finally, a *connection from geometry* (*space and time*) *to physics* (mass) has to be established [9]. Since space and time coordinates are associated with Planck length scales, see above, they provide the connection between geometry and mass via the *Compton wave length* and thus are present in H^8.

In summary, internal coordinates ξ^i with $i = 1, \ldots, 4$ denote *spatial and temporal* coordinates, ξ^i with $i = 5, 6$ denote *entelechial and aeonic* coordinates, and ξ^i with $i = 7, 8$ denote *two information* coordinates in H^8, mandating four sets of types of coordinates.

With the introduction of a set of four different types of coordinates, the **space of fundamental symmetries** of internal space H^8 has been fixed. The theoretical framework is provided in Sec. 5 where a set of metric subtensors is constructed, each of them describing a physical interaction or particle. Thus the connection between physical space and physics (symmetries) is established in exactly the way as

9 Tables of hermetry forms and their physical meaning are also described in the brief introduction to *EHT*, which can be downloaded from *www.hpcc-space.com*.

foreseen by Einstein. Physical space is responsible for all physical interactions. However, in order to reach this objective, spacetime had to be complemented by internal space H^8. This is the novel aspect in *EHT,* which otherwise is based on the well known concept of gauge theory. Once the internal space with its sets of coordinates has been determined, everything else is fixed because Eq. 2 is nothing but the direct extension of *GR* provided with an internal space. The relationship between the mappings of *GR* and *EHT* follows from the comparison of Figs. 4 and 7.

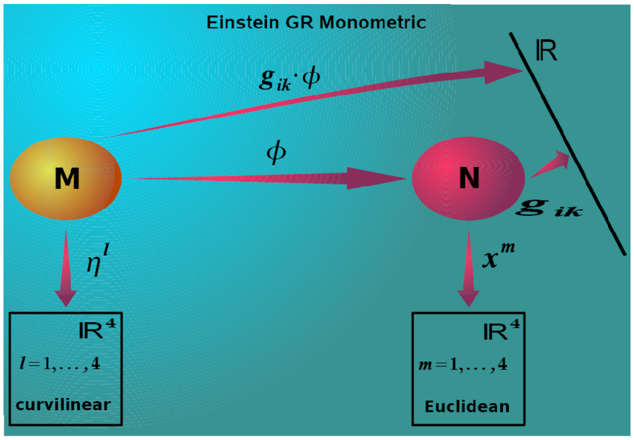


Figure 4*:* In *GR* the metric tensor is computed using a mapping from manifold M (curvilinear coordinates η^l) to manifold N in flat spacetime (locally) $\mathbb{R}^4$ (Euclidean coordinates are denoted by x^m). Calculating the components of the metric tensor as well as lengths, areas, and volumes from the metric tensor, a mapping to the set of real numbers is needed. This kind of mapping delivers *one single* type of **monometric tensor** that is responsible for *gravity* only, appearing on the LHS of the Einstein field equations.

In order to construct a hermetry form, either internal space S^2 or I^2 *must* be present. In addition, there are three degenerated hermetry forms that describe partial forms of the photon and the quintessence potential, for details see Table 4. They allow the conversion of a photon into a **gravitophoton** (gravitation can be both attractive and repulsive) as well as of gravitophotons and gravitons into **quintessence** (gravitation is repulsive) particles. It should be noted that a dimensional law can be derived that does not permit the construction of, for instance, a space H^7. Heim space, H^8 , comprises four subspaces, denoted as R^3, T^1, S^2, and I^2. Fig. (7) shows the set of metric-subspaces that can be constructed, where each admissible metric subtensor is denoted as **hermetry** form**.** The word hermetry is a combination of *hermeneutics* and *geometry* that is, a hermetry form stands for the physical meaning of geometry. Each hermetry form has a direct physical meaning, for details see refs. [13], [29].

6.1.1 The Physics of Hermetry Forms

The four tables, Tables 1-4, contain the complete set of hermetry forms (individual metric tensors) and their associated physical meaning. It is most important to note that gravitation comprises three interactions that are mediated by three messenger particles, termed *graviton* (*attractive*), *gravitophoton* (*attractive and repulsive*), and *quintessence* (*repulsive*) *particle*. The gravitophoton interacts with virtual matter, while the quintessence particle interacts with the vacuum.

6.1.2 Hermetry Forms and Physical Interactions

The concept of an internal 8D space comprising four subsets, leads to a modification of the general transformation being used in *GR*. The existence of the internal space requires a double transformation as shown in Fig. 5. Each of the 15 admissible combinations of metric subtensors (hermetry forms) is ascribed a physical meaning, see Fig.7 and Tables 1-4.

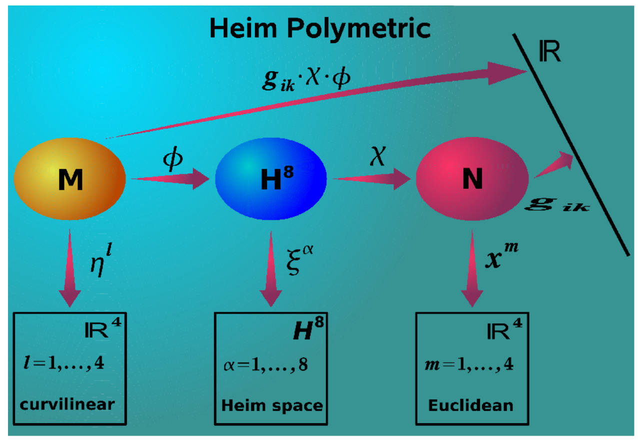


Figure 5: Einstein's goal was the unification of all physical interactions based on his principle of geometrization, i.e., having a metric that is responsible for the interaction. This principle is termed Einstein's geometrization principle of physics (*EGP*). In order to obtain all physical interactions, the concept of an **internal space**, denoted by the authors as Heim space H^8, having 8 internal dimensions, is introduced. These invisible internal coordinates govern events in spacetime. Therefore, a mapping from manifold M (curvilinear coordinates η^l)in spacetime to internal space H^8 and back to manifold N in spacetime must be used to properly describe the physics. This is a major deviation from *GR* and leads to a **polymetric tensor.** *EHT* contains *GR* as a special case.

In *EHT* therefore a double transformation involving Heim space H^8 occurs, see Eq. (2). This global metric tensor does not have any physical meaning by itself, instead by deleting corresponding terms in Eq. () eventually leads to the metric of the proper hermetry form[10].

$$g_{ik}=\frac{\partial x^m}{\partial \xi^\alpha}\frac{\partial \xi^\alpha}{\partial \eta^i}\frac{\partial x^m}{\partial \xi^\beta}\frac{\partial \xi^\beta}{\partial \eta^k} \qquad (2)$$

As described in [9], [24] there is a general coordinate transformation $x^m(\xi^\alpha(\eta^i))$ from M (locally $\mathbb{R}^4$)→ H^8→ N (locally $\mathbb{R}^4$) resulting in the polymetric metric tensor, see Figs. 5 and 7.

10 A more complete discussion can be found in refs. [9], [24].

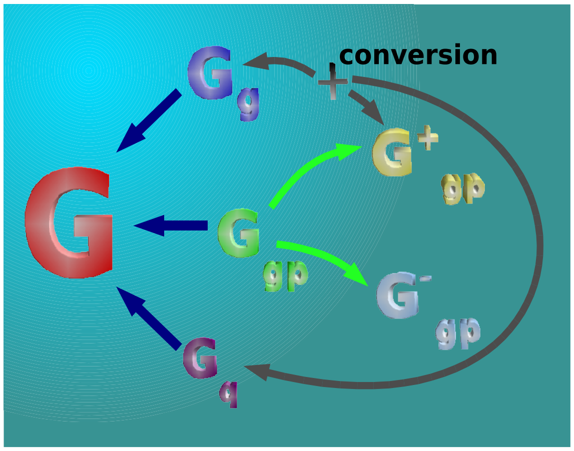


Figure 6: There should be three gravitational particles, namely the **graviton** (attractive), the **gravitophoton** (two types, attractive and repulsive), and the **quintessence** or vacuum particle (repulsive), represented by hermetry forms H_5, H_{11}, and H_{12}, see Table 1. For additional features of hermetry forms see Tables 2-4.

where indices α, β = 1,...,8 and *i, m, k* = 1,...,4. The Einstein summation convention is used that is, indices occurring twice are summed over. It is clear from Eq. 2 that *GR* is a special case of *EHT*. If Heim space were not existing, the *polymetric* of *EHT* collapsed to the *monometric* of *GR*.

A particular component of the metric tensor belonging to one of the four subspaces is given by Eq. (3).

Because of the double transformation each component of the metric tensor in spacetime can be written as the sum of 64 subcomponents, Eq. (4). Each hermetry form is marked by the fact that only a subset of the 64 components is present. This means that certain components are 0 for a given hermetry form. Therefore each hermetry form leads to a different metric in the spacetime manifold and thus describes different physics. This is why Eqs. (5) represent a polymetric.

$$g_{ik}^{(\mu\nu)} = \frac{\partial x^m}{\partial \xi^{(\mu)}} \frac{\partial \xi^{(\mu)}}{\partial \eta^i} \frac{\partial x^m}{\partial \xi^{(\nu)}} \frac{\partial \xi^{(\nu)}}{\partial \eta^k}. \tag{3}$$

$$g_{ik} = \sum_{\mu,\nu=1}^{8} g_{ik}^{(\mu\nu)} \tag{4}$$

$$g_{ik}(H_\ell) =: \sum_{\mu,\nu \in H_\ell} g_{ik}^{(\mu\nu)} \tag{5}$$

Twelve hermetry forms can be generated having direct physical meaning, by constructing specific combinations from the four subspaces. The following denotation for the metric describing hermetry form H_ℓ with ℓ=1,...,12 is used. Summation indices are obtained from the definition of the hermetry forms, see Fig. 7 and Table 2.

The expressions $g_{ik}(H_\ell)$ are interpreted as different physical interaction potentials caused by hermetry form H_ℓ, extending the interpretation of metric employed in *GR* to the **polymetric** obtained from the complete physical space that is, the combination of internal space of H^8 with four-dimensional spacetime M.

Internal space H^8 is a *factored space* that is $H^8 = R^3 \times T^1 \times S^2 \times I^2$. The factorization into one space-like manifold R^3 and three time-like manifolds T^1, S^2 and I^2 is inherent to the structure of H^8. For the construction of the individual hermetry forms, a **selection rule** is used, namely any physically meaningful *hermetry form* **must contain space** S^2 or I^2.

Each individual hermetry form is equivalent to a physical potential or a messenger particle. It should be noted that hermetry forms in *spaces* $S^2 \times I^2$ *describe gravitophotons,* and spaces $S^2 \times I^2 \times T^1$ *are representing photons,* see Table 2. This is an indication that, at least on theoretical arguments, *photons* can be *converted* into *gravitophotons*, if the time dependent part T^1 of the photon metric can be canceled. How this can be achieved experimentally will be outlined in Sec. 7.

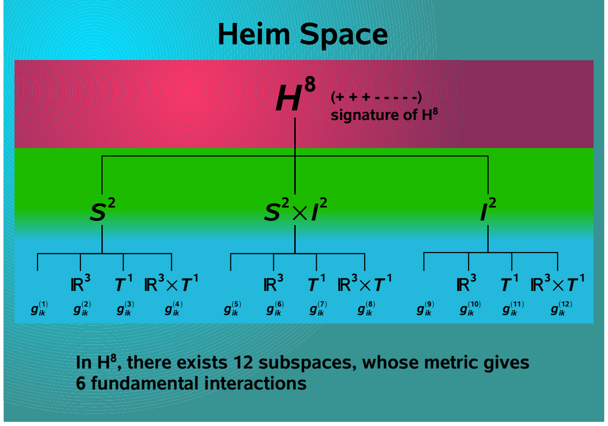


Figure 7: In Heim space there are eight internal coordinates, the four spacetime coordinates that are interpreted as energy coordinates, since a length is associated with the R^3 and T^1 coordinates, and four additional *timelike* coordinates (negative) signature, giving rise to two additional subspaces S^2 and I^2. Hence, Heim space H^8 comprises four subspaces, namely R^3, T^1, S^2, and I^2. The picture shows the complete set of metric-subspaces that can be constructed from the polymetric tensor, Eq. 2. Each subspace is denoted as hermetry form, which has a direct physical meaning, see Table 2. In order to construct a hermetry form, either internal space S^2 or I^2 coordinates **must** be present. In addition, there are three degenerated hermetry forms, see Table 4 that are only partial forms of the photon and the quintessence potential. They allow the conversion of photons into gravitophotons as well as of gravitophotons and gravitons into quintessence particles.

7 Propulsion Concepts from Spacetime Physics

In recent publications [9], [24] a gedankenexperiment was developed to achieve the cancellation of the time T^1 part in the photon hermetry form in order to produce a gravitophoton. Furthermore, in a very recent announcement by the European Space Agency, 23 March 2006, the measurement of an *artificial gravitational field* was reported, generated by a rotating superconducting ring. In the following this experiment will be analyzed in detail using the *photon-gravitophoton* interaction, which is based on the possibility of metric transformation. Second, a modified experiment is suggested that should produce a force in the vertical direction and thus might serve as the physical principle for a field propulsion device.

7.1 Metric Transformation (*Transmutation*)

All physical interactions are mediated by so called *messenger particles* (mediator particles) that are *bosons*. If each physical interaction can be described by its individual metric tensor, then the question arises: is it possible to cancel metric terms in one hermetry form to obtain a different one. This hermetry form then might represent a different physical interaction. Looking at the hermetry forms for the photon and the gravitophoton it seems, at least theoretically, possible that the hermetry form of the photon is transformed in the one of the gravitophoton. This means that an interaction between electromagnetism and gravitation should exist. Beside the details of the theoretical derivation, the question of how to achieve such a conversion experimentally is of prime importance. For this effect in order to lead to a field propulsion principle, it must be understood how the strength and the direction of the gravitational field can be experimentally manipulated. Therefore, guidelines need too be provided by theory that allow to design the technical details needed for such a field propulsion device. Although this effect, namely the coupling between electromagnetism and gravitation, was predicted already in [24], the recent experiment by *Tajmar* et al., see below, if proved to be correct, would be a breakthrough, since an artificial gravitational field would have been generated. Moreover, the novel information obtained from this experiment with regard to *EHT* is that there is a need to distinguish between the coupling of *fermions* and *bosons* when gravitophotons are to be generated. In previous publications the authors only dealt with fermion coupling. As soon as the **boson coupling** is taken into account, technical requirements such as magnetic field strength seem to be substantially reduced in comparison to fermion coupling.

7.1.1 Gravitomagnetic Field Experiment

In a recent experiment, funded by the European Space Agency and the Air Force Office of Scientific Research, Tajmar et al. [7] report on the generation of a toroidal (tangential, azimuthal) gravitational field in a rotating accelerated (time dependent angular velocity) superconducting *Niobium* ring. In a recent presentation at Berkeley university Tajmar [30] showed improved experimental results that confirmed previous experimental findings.

This would be the first time that an artificial gravitational field has been generated and, if correct, would have great impact on future technology. Furthermore, the experiment would demonstrate the conversion of electromagnetic interaction into a gravitational field. This is exactly the effect that is predicted by *EHT*, and both a qualitative and quantitative explanation of this effect will be given below. Since the experiment generates a tangential gravitational field, it cannot be used directly as a propulsion system. It is, however, of great importance, since it shows for the first time that a gravitational field can be generated other than by the accumulation of mass. In this section we will also discuss the validity of the physical explanation, namely the Higgs mechanism to be responsible for the graviton to gain mass, given by Tajmar and de Matos [21], which they termed the **gyromagnetic London effect**. According to these authors, this effect is the physical cause for the existence of the measured gravitational field.

The arguments of these authors are ingenious, but there is some doubt whether the linearized Einstein equations, see Eqs. (7, 8), can be used in the explanation of this effect, a more detailed discussion is given in the next section.

In the following a derivation from first principles is presented, using the fifth interaction from *EHT*, namely the Heim-Lorentz force, but now using a **coupling to bosons** (Cooper pairs) to explain this effect. Deriving this effect from gravitophoton interaction, a physical interpretation can be given that explains both qualitatively and quantitatively the experimental results. Moreover, theoretical considerations obtained from *EHT* lead to the conclusion that a modified experiment will generate a **gravitational field acting parallel to the axis of rotation of the ring (torus)**, see Fig.10, and thus can serve as a demonstrator for a **field propulsion principle** [11]. In this experimental configuration the superconducting rotating ring is replaced by an insulating disc and a set of superconducting coils as depicted, in principle, in Fig. 10. The actual experiment configuration would, however, be different. *EHT* allows to calculate the magnitude and direction of the acceleration force and provides guidelines for the construction of a propulsion device. Although the experiment devised from *EHT* is different from the one by Tajmar et al., the *coupling to bosons* is the prevailing mechanism. According to the predictions of *EHT,* experimental requirements, i.e., magnetic field strength, current densities and number of turns of the solenoid, are substantially lower than for **fermion coupling (vacuum polarization to change the coupling strength via virtual pairs of electrons and positrons)** that was so far assumed in all our papers, see refs. [9], [13], [14], [24], [29].

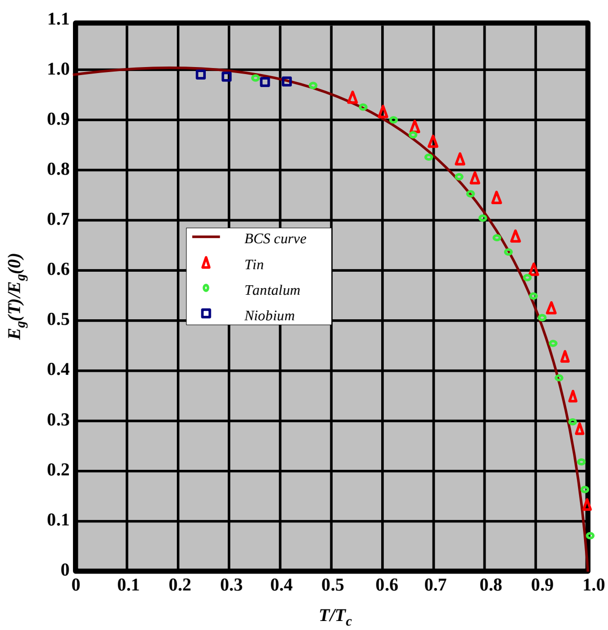


Figure 8: The picture shows the ratio of temperature over critical temperature versus the ratio of energy gap over energy gap at 0 Kelvin. Since the specific heat close to 0 Kelvin is low, small amounts of energy will result in drastic temperature increase, the height of the energy gap is substantially impacted and thus the velocity of the Cooper pairs. The temperature must stay below $T/T_c <$ 0.3 to guarantee the maximal velocity of the Cooper pairs.

Materials for which a strong gravitational acceleration was measured were niobium (Nb, T_C = 9.4 K) and lead (Pb, T_C = 7.2 K). No gravitational field was measured in YBCO (Yttrium barium copper oxide, $YBa_2Cu_3O_{7-x}$, T_C = 94 K) and BSCCO (Bismuth strontium calcium copper oxide, $Bi_2Sr_2Ca_nCu_{n+1}O_{2n+6}$, T_C = 107 K) which are so called high-temperature superconductors whose critical current density is substantially lower than that for Nb or Pb. The effect is strongest in Nb which can sustain a magnetic induction of up to 20 Tesla. In the next section, a theoretical derivation of the gravitomagnetic field strength is given, based on *gravitophoton interaction,* which is the interaction between *electromagnetism and gravitation* predicted by *EHT*.

At critical temperature T_C some materials become superconductors that is, their resistance goes to zero. Superconductors have an energy gap of approximately $E_{gap} \approx 3.5\, kT_C$. This energy gap separates superconducting electrons below from normal electrons above the gap. At temperatures below T_C, electrons are coupled in pairs, called Cooper pairs, which are bosons. The exact formation of Cooper pairs is not known. The coupling of the electron pairs seems to be via *phonons*, generated by electron movement through the lattice of the superconductor. The size of a Cooper pair is some 10^3 *nm.* The crystal lattice contains defects that lead to an energy transfer ΔE from the electron gas to the lattice. ΔE must be smaller than E_{gap}, otherwise the Cooper pairs are destroyed.

The speed of the Cooper pairs can be calculated in a coordinate system where the electron gas is at rest and the lattice is moving, applying classical energy and momentum conservation. Decelerating the grid means that Cooper pairs gain energy. The maximum amount of energy that a Cooper pair can absorb is E_{gap}, otherwise it is lifted in the band above, and superconductivity is lost. Therefore the simple ansatz

$$\frac{1}{2} m v_c^2 = E_{gap} = 3.5\, k\, T_C \qquad (6)$$

can be used, v_c denoting the velocity of a Cooper pair. At temperature T_C = 10 K a speed of about $v_c = 10^4$ m/s is obtained. A smaller band gap therefore cause a decrease in the speed of the Cooper pairs. Quantum mechanics calculations yield a more correct value of some $v_c = 10^5$ m/s.

7.1.2 Artificial Gravity Experiment Explained by Gravitophoton Interaction

Considering the Einstein-Maxwell formulation of linearized gravity, a remarkable similarity to the mathematical form of the electromagnetic Maxwell equations can be found. In analogy to electromagnetism there exist a gravitational scalar and vector potential, denoted by $\boldsymbol{\Phi}_g$ and $\boldsymbol{A}_g$, respectively [7]. Introducing the corresponding gravitoelectric and gravitomagnetic fields

$$\boldsymbol{e} := -\nabla \Phi_g \; and \; \boldsymbol{b} := \nabla \times \boldsymbol{A}_g \qquad (7)$$

the linearized version of Einstein's equations of *GR* can be cast in mathematical form similar to the Maxwell equations of electrodynamics, the so called gravitational Maxwell equations, Eqs. (8)

11 A detailed discussion will be given in our forthcoming paper entitled *Artificial Gravitational Fields.*

$$\nabla \cdot \boldsymbol{e} = -4\pi G \rho, \nabla \cdot \boldsymbol{b} = 0$$
$$\nabla \times \boldsymbol{e} = 0, \nabla \times \boldsymbol{b} = -\frac{16\pi G}{c^2}\boldsymbol{j} \quad (8)$$

where $\boldsymbol{j} = \rho \boldsymbol{v}$ is the mass flux and G is the gravitational constant[12]. The field $\boldsymbol{e}$ describes the gravitational field form a stationary mass distribution, whereas $\boldsymbol{b}$ describes an extra gravitational field produced by moving masses.

Fig. 9 depicts the experiment of Tajmar et al., where a superconducting ring is subject to angular acceleration, which should lead to a gravitophoton force. *EHT* makes the *following predictions for the measured gravitational fields* that are attributed to photon- gravitophoton interaction, the fifth interaction.

- For the actual experiment pictured in Fig. 9, the gravitophoton force is in the **azimuthal direction only** (Tajmar et al.) caused by angular acceleration of the superconducting niobium disk. The acceleration field is opposite to the angular acceleration, obeying some kind of Lenz rule.
- For the gedankenexperiment of Fig. (10), a force component in the **vertical direction** would be generated.

It will be shown in the following that the postulated gravitophoton force completely explains all experimental facts of Tajmar's experiment, both qualitatively and quantitatively.

It is well known experimentally that a rotating superconductor generates a magnetic induction field, the so called *London moment*[13]

$$\boxed{\boldsymbol{B} = -\frac{2m_e}{e}\boldsymbol{\omega}} \quad (9)$$

where $\boldsymbol{\omega}$ is the angular velocity of the rotating ring. It should be noted that the magnetic field in Tajmar' s experiment is produced by the rotation of the ring, and not by a current of Cooper pairs that are moving within the ring.

It should be remarked that there is a major difference between the experiment of Fig. 9 and the proposed experiment depicted in Fig. 10, which is in the generation of the magnetic induction field $\boldsymbol{B}$.

De Matos and Tajmar [31] postulate a *gravitomagnetic London moment* as explanation for the observed acceleration field. This means that in analogy to the London equations and along with the concept of spontaneous symmetry breaking a Klein-Gordon type equation for particles of any type of spin (also called *Proca* equation for spin 1 particles) can be formulated.

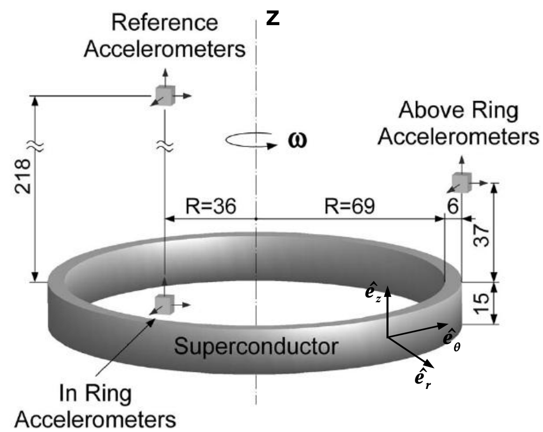


Figure 9: Rotating superconducting torus (Niobium) modified from Tajmar et al., see ref. [7]. All dimensions are in *mm*. A cylindrical coordinate system (r, θ, z) with origin at the center of the ring is used. In Ring accelerometers measure a gravitational acceleration of some 100 μg in the azimuthal (tangential, θ) direction when the ring was subject to angular acceleration, $\dot{\omega}$. The acceleration field **does not** depend on ω. No acceleration was measured in the z-direction (upward). A more recent experiment employed a set of 4 in-ring accelerometers and confirmed the rotational character of this field. If the direction of rotation is reversed, the acceleration field changes sign, too.

In superconductivity spontaneous symmetry breaking (below the critical temperature T_C, two electrons may be coupled by phonons, forming so called Cooper pairs, i.e., breaking the random behavior of the electron gas in the crystal and generating the collective phenomenon of superconductivity) occurs at very low temperatures being responsible for the *Meissner* effect. This means that the magnetic field lines cannot penetrate into the medium and remain in a thin layer on the surface, in which the magnetic field strength falls of exponentially. Hence, there is a finite range electromagnetic field, which corresponds to a massive photon [17]. The penetration depth of the field is associated with the wavelength of the photon and, using its respective Compton wave length, the mass of the photon within the superconductor can be determined. It should be noted, however, that the *Proca* equations for the photon and the graviton *are basically different*, since the photon has spin 1 and therefore the wave function is a four vector (four potential A_μ), while the graviton has spin 2, and the wave function is a tensor of rank 2. If, however, the linearized Einstein equations are used, Eqs. 7, 8, there exists a direct analogy with regard to the electromagnetic Proca equations. The argument is that the gravitational field is weak and therefore this approach should be justified. There remains the fact that the linearized equations are used to calculate an effect which is 31 orders of magnitude higher than originally predicted by these equations. The phenomenological consequences of mass accumulation of the photon due to the Higgs mechanism leads to the Proca equation (or second London equation) for the photon. Assuming a gravitomagnetic analogy requires that the *Higgs* mechanism (massless particles obtain mass through the all pervading scalar *Higgs* field) would also be responsible for the mass accumulation of the graviton. The action of the *Higgs* field was deliberately designed so as to generate spontane-

12 Here no consideration is given to the fact that G comprises three parts according to *EHT*, see Fig. 6.
13 The mass and charge of the Cooper pairs needs to be used.

ous symmetry breaking for **electroweak interactions**. However, the current *Standard Model* of high-energy physics is **definitely not applicable to gravitation**. There also exists a difference between the massive photon and the massive graviton. The massless photon and graviton both only possess two states of polarization. The difference occurs, however, when they become a massive photon (three polarization states) and a massive graviton (five polarization states). De Matos and Tajmar now postulate that the observed acceleration field $\boldsymbol{b}_g$, produced by the rotating superconductor, is equivalent to an additional magnetic field $\boldsymbol{B}$ that has to be added to the *magnetic field of the London moment, see* Eq. (9). This alludes to postulating that a non-relativistic particle of velocity $\boldsymbol{v}$ with charge q and mass m has the Lagrangian $L=\frac{1}{2}mv^2-q\,\boldsymbol{v}\cdot\boldsymbol{A}-m\,\boldsymbol{v}\cdot\boldsymbol{A}_g$ where $\boldsymbol{A}$ is the electromagnetic vector potential and $\boldsymbol{A}_g$ denotes the gravitational vector potential of Eq. (7). However, postulating that gravitation is analogous to electrodynamics causes a contradiction, since the photon has spin 1 and thus is described by three independent fields, namely the spinvector in space. Thus the components of A are not independent and must satisfy $\partial_\mu A^\mu=0$. On the other hand, as was said above, a massive graviton has five polarization states and cannot be described by a four vector.

However, this seems to require a fairly strong coupling*, between electromagnetics and gravitation* by a factor m_e/e. *This needs to be postulated also,* since the four known physical forces **do not provide** such a direct coupling. Last but not least, if quantum corrections are added to the Higgs boson mass at the grand unification scale (10^{15}-10^{16} GeV), the Higgs mass becomes huge. Although this is not the energy level at which the experiment operates, it shows that something is not right with the Higgs mechanism itself [32]. De Matos and Tajmar, however, do not use the Higgs field mechanism to calculate the mass gained by the graviton inside the superconductor, but directly use the measured mass values of the Cooper pairs [31].

On the other hand, a coupling between electromagnetism and gravitation is a basic fact of *EHT*, because of the fifth fundamental interaction, which foresees a conversion of hermetry form H_7, describing the photon, into the hermetry form H_5, describing the gravitophoton, compare Table 2. In the following, results from *EHT* are used to explain the source and to calculate the magnitude of the measured acceleration field.

The experiment shows that the acceleration field vanishes if the Cooper pairs are destroyed. This happens when the magnetic induction exceeds the critical value $\boldsymbol{B}_C(T)$, Fig. 8, which is the maximal magnetic induction that can be sustained at temperature T, and therefore dependents on the material. The rotating ring is no longer a superconductor and the acceleration field vanishes. Eq. 10 assumes that the system is in superconducting state and sufficient Cooper pair density exists.

In the official version (termed short version) of this paper a factor B/B_{max} was introduced into Eq. 10. However, in a recent conversation with M. Tajmar (July 2006), we learned that the measuring process of the acceleration does not take place at a specified angular velocity ω, as we had assumed previously. This factor was added by us to model a putative ω dependency of the acceleration field, and could not be obtained from *EHT*. As was pointed out by Tajmar, instead, the superconductor is rotated with constant or variable angular acceleration, from angular frequency 0 up to a maximum value. The measured data show *no dependence on* ω*,* and thus this factor *is not at all needed*. Therefore, the original derivation as obtained by *EHT* is used in the following analysis without insertion of any additional parameters. *EHT* predicts that the magnetic induction field $\boldsymbol{B}$ is equivalent to a gravitophoton (gravitational) field $\boldsymbol{b}_{gp}$. The following relation is utilized, derived from *EHT* but stated here without proof

$$\boxed{\boldsymbol{b}_{gp}\propto\frac{m_e}{m_p}\boldsymbol{B}} \tag{10}$$

where m_e and m_p are the electron and proton mass. The neutral gravitophoton decays in a gravitationally attractive (negative) and a gravitationally repulsive gravitophoton. The negative one interacts with the **electron** and the repulsive one interacts with the **proton**[14]. From *EHT* the following general relationship between a magnetic and the neutral gravitophoton field, $\boldsymbol{b}_{gp}$, can be derived

$$\boldsymbol{b}_{gp}=\left(\frac{1}{(1-k)(1-ka)}-1\right)\frac{e}{m_e}\frac{m_e}{m_p}\boldsymbol{B} \tag{11}$$

where k = 1/24 and a = 1/8. It should be noted that values of coupling constants k and a were derived some ten years ago, and are published in [33], see Eq. (11) p. 64, Eq. (15) p. 74, and Eq. (16)[15] p. 77. No parameter was adjusted in the derivation of Eq. 16. At present the dependency of *coupling constants k* and *a* on the Cooper pair density was not considered. The values used are accurate for niobium but would be different for lead.

Moreover, the theory also correctly predicts direction and sign of the acceleration field. This is seen as a sign that the predicted six fundamental interactions may actually exist in *Nature*.

The dimension of $\boldsymbol{b}_{gp}$ of is s^{-1}. Differentiating Eq. 11 with respect to time, results in

$$\frac{\partial\boldsymbol{b}_{gp}}{\partial t}=\left(\frac{1}{(1-k)(1-ka)}-1\right)\frac{e}{m_p}\frac{\partial\boldsymbol{B}}{\partial t}. \tag{12}$$

Integrating over an arbitrary area $\boldsymbol{A}$ and using the gravitational induction equation yields

14

15 It should be noted that the quantity $w^2_{3\alpha}$ used in this ref. is termed $w^2_{ph\_gp}$ in our terminology, see also *EHT* glossary *at www.hpcc-space.com.*

$$\int \frac{\partial \boldsymbol{b}_{gp}}{\partial t} \cdot d\boldsymbol{A} = \oint \boldsymbol{e}_{gp} \cdot d\boldsymbol{s} = \oint \boldsymbol{g}_{gp} \cdot d\boldsymbol{s} \tag{13}$$

where it was assumed that the gravitophoton field, subscript *gp*, since it is a gravitational field, see Fig. 6, is separated according to Eqs. (7, 8). As the above formulas will be applied to the experimental configurations depicted in Figs. 9 and 10, cylindrical coordinates r, θ, z are employed. $\boldsymbol{g}_{gp}$ is the acceleration field generated by the gravitophoton field. Combining Eqs. 12 and 13 gives the following relationship

$$\oint \boldsymbol{g}_{gp} \cdot d\boldsymbol{s} = \left(\frac{1}{(1-k)(1-ka)} - 1\right) \frac{e}{m_p} \int \frac{\partial \boldsymbol{B}}{\partial t} \cdot d\boldsymbol{A} \tag{14}$$

From Eq. 9 one obtains

$$\frac{\partial B}{\partial t} = -\frac{2 m_e}{e} \dot{\boldsymbol{\omega}}. \tag{15}$$

Next, we apply Eqs. 14 and 15 to the experimental configuration of Fig. 9, calculating the *gravitophoton acceleration for the in-ring accelerometer*. It is assumed that the accelerometer is located at distance r from the origin of the coordinate system. From Eq. 9 it can be directly seen that the magnetic induction has a z-component only. Applying Stokes law to Eq. 14 it is clear that the gravitophoton acceleration is in the r-θ plane. Because of symmetry reasons the gravitophoton acceleration is independent on the azimuthal angle θ, and thus only has a component in the circumferential (tangential) direction, denoted by $\hat{\boldsymbol{e}}_\theta$. Since the gravitophoton acceleration is constant along a circle with radius r, integration is over the area $\boldsymbol{A} = \pi r^2 \hat{\boldsymbol{e}}_z$. Inserting Eq. 15 into Eq. 14, using the standard values for k and a (in a forthcoming paper their dependency on the superconductor material will be shown), and carrying out the integration, the following expression for the gravitophoton acceleration is eventually obtained

$$g_{gp} = -0.04894 \frac{m_e}{m_p} \dot{\omega} r \tag{16}$$

where it was assumed that the $\boldsymbol{B}$ field is homogeneous over the integration area. Now the experimental values taken from the paper by Tajmar et al. [7] will be inserted. The following values were used:

$$\dot{\omega} = 10^3 \, rad/s^2, r = 3.6 \times 10^{-2} \, m, m_e/m_p = 1/1836$$

The angular acceleration was determined from the slope fit of Fig. 6 in ref. [7] and the r value was determined from Fig. 9. Inserting the proper values into Eq. 16 finally delivers the theoretical value of the gravitophoton acceleration for the experiment by Tajmar et al.

$$g_{gp} = -0.04894 \times 5.447 \times 10^{-4} \times 3.6 \times 10^{-2} \times 10^3 \times 9.81^{-1} \, g \tag{17}$$

resulting in the final value for the circumferential acceleration field

$$g_{gp} = -0.978 \times 10^{-4} \, g. \tag{18}$$

From Fig. 6 in ref. [7] an experimental value of about 1.0×10^{-4} g was determined. For a more accurate comparison, the coupling factor k_{gp} for the in-ring accelerometer, as defined by Tajmar, is calculated from the value of Eq. 18, resulting in $k_{gp} = -9.78 \times 10^{-8} s^2$. The measured values is $k_{gp} = -7.64 \pm 0.28 \times 10^{-8} s^2$. This means that the theoretical value is still within measuring tolerance. Thus there is a close agreement between the predicted **gravitophoton force** and the measured acceleration. It should be kept in mind that the present derivation *does not lead* to a dependence on the density of Cooper pairs, but it can be shown that the coupling values k and a depend on this density. Considering both the mathematical and physical complexity of the derivation the closeness of theory and experiment is **remarkable**. In a forthcoming paper the differences for niobium and lead will be explained.

7.1.3 Gravitomagnetic Field Propulsion by Gravitophoton Interaction

The experiment by Tajmar et al. generates an *azimuthal gravitational field*, and thus is not suitable for propulsion. The lesson learned from the experiment by Tajmar et al. is that the coupling to *bosons* (Cooper pairs) is of prime importance. However, the structure of the Heim-Lorentz force equations remains **unchanged** for boson coupling. Employing the Heim-Lorentz force equations to the experimental setup of Fig. 10, Heim-Lorentz force now produces two force components: one in the radial r direction, and the second one in the z- direction. These components are given by

$$F_r \hat{\boldsymbol{e}}_r = m_e v_\theta^T b_z \hat{\boldsymbol{e}}_\theta \times \hat{\boldsymbol{e}}_z \tag{19}$$

$$F_z \hat{\boldsymbol{e}}_z = \frac{v_\theta^T}{c} m_n v_\theta^T b_z (\hat{\boldsymbol{e}}_\theta \times \hat{\boldsymbol{e}}_z) \times \hat{\boldsymbol{e}}_\theta \tag{20}$$

where v_θ^T denotes the velocity of the rotating disk or ring, and b_z is the component of the (gravitational) gravitophoton field $\boldsymbol{b}_{gp}$ in the z-direction. In contrast to the fermion coupling, ref. [24], experimental requirements seem to be modest.

The superconducting current loop (blue), see Fig. 10, provides an inhomogeneous magnetic field at the location of the rotating disk (red). The z-component of the gravitophoton field, b_z is responsible for the gravitational field above the disk. This experimental setup also serves as the field propulsion device, if appropriately dimensioned. Moreover, using *EHT*, a gedankenexperiment can be devised that produces a gravitational force in the **direction of the axis of rotation**. Fig. 10 describes the experimental setup for which an insulating disk rotates above a superconducting solenoid. The material would not be niobium.

In the *gedankenexperiment* of Fig. 10, the gravitophoton force produces a gravitational force above the disk **in the z-direction upward** and also in **the radial direction**. It should be noted that the actual experiment would *be different.* The velocity of the Cooper pairs with regard to the lab system is given by $r\omega$ in the gedankenexperiment of Fig. 10. The actual velocity of the Cooper pairs can be determined from Fig. 10.

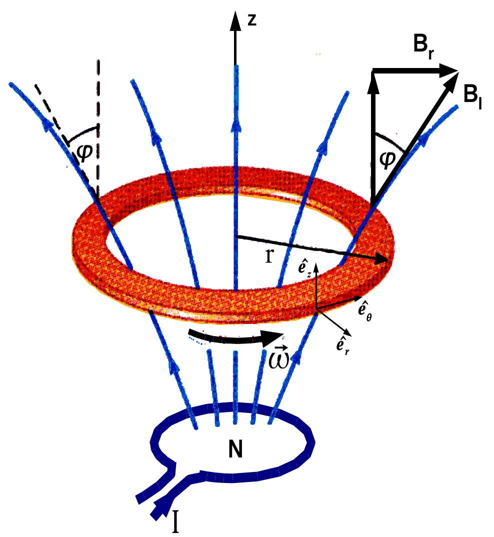


Figure 10: The picture shows the physical principle of the experimental setup to generate a gravitational field in the z-direction (upward, above rotating disk) by the Heim-Lorentz force using a superconducting coil (boson coupling) and a rotating disk or ring. The actual experiment would be different.

The following assumptions were made: $N = 100$, number of turns of the solenoid; current of some 1-2 A (needed to calculate b_z); diameter of solenoid 0.1 m; and $v_\theta^T = 10\, m/s$.

A detailed analysis predicts an acceleration in *z*-direction of some $4.0\times10^{-4}\, g$. From these numbers it seems to be possible that, if our theoretical predictions are correct, the realization of a **workable space propulsion device that can lift itself from the surface of the earth** seems to be feasible with current technology.

Conclusions and Perspectives

In this paper an overview of the current status of space propulsion was given. It has been shown that even with an *advanced fission propulsion system* (the only device that might be feasible among the advanced concepts within the next several decades), space travel will be both *very limited regarding, speed, range, and payload capability as well as extremely costly*. Travel time to other planets will remain prohibitively high. One can safely forget interstellar travel.To fundamentally overcome these limitations, physical laws hitherto not known are needed. If current physics would be the final answer, mankind would clearly be *restricted to the solar system*. Therefore, the **search for novel physics** is justified, because of the potential extreme benefits.

GR is based on the concept of continuous spacetime provided with a metric. Metric engineering of spacetime or using wormholes (singularities) will allow, at least in principle, to overcome some of the limitations, but requires additional concepts such as negative energy density that have not been found in *Nature*. The whole concept does not seem to be technically feasible.

On the other hand, the recent experiment by Tajmar, if confirmed, has shown some evidence that a coupling between electromagnetism and gravitation might exist, which would allow the generation of artificial gravitational fields. *Extended Heim Theory* has predicted this effect, and was used to successfully describe and to quantitatively calculate this experiment. In addition, *EHT* also allows to devise a gedankenexperiment that produces a gravitational field along the axis of rotation of a rotating ring that is self-propelled, and thus can be used to build a **propellantless propulsion device**.

Superconductivity with a high density of Cooper pairs (collective phenomena) is essential for the coupling between electromagnetism and gravitation.

EHT belongs to a well known class of gauge theories. The novel features of the theory are in the introduction of an internal, factored 8-dimensional space to describing the additional fundamental symmetries. A novel feature is the construction of a polymetric tensor which comprises all possible physical interactions. The coupling constants of the interactions were obtained from number theory considerations, and thus are calculated.

The type of coupling that seems to occur in the experiment by Tajmar et al. is included in *EHT*, which knows six fundamental physical interactions. The two additional forces are gravitation like, but gravitation can be both attractive and repulsive. The guidelines provided by the theory can be used for a **demonstration experiment of a field propulsion device,** which would not require substantially higher experimental effort than the original experiment. Research therefore should focus on the modified experiment, because of its substantial applications in the field of transportation as well as on the theoretical foundations of physical interactions. Perhaps the sixth interaction, represented by the quintessence particle, could provide a theoretical explanation for the measured value of the cosmological constant.

In a forthcoming paper, the dependence on the coupling constants on the superconductor material will be reported.

Acknowledgment

The authors are most grateful to Prof. P. Dr. Dr. A. Resch, director of the Institut für Grenzgebiete der Wissenschaft (IGW), Innsbruck, Austria for his continuous support and hospitality in writing this paper.

The authors are particularly grateful to Dr. M. Tajmar, ARC Seibersdorf, Austria for clarification of the measuring process of the acceleration field in his recent experiment that lead to a revision of our calculations.

We are also grateful to Prof. P. Papadopoulos, San Jose State University, CA, Prof. T. Waldeer, TU Claustahl and Univ. of Applied Sciences, Salzgitter as well as Dr. A. Müller for correcting parts of the manuscript.

The second author was partly funded by Arbeitsgruppe Innovative Projekte (AGIP) and by Efre (EU) at the Ministry of Science and Education, Hannover, Germany.

Special thanks go to our friends at the bed and breakfast Adella Villa, Atherton, CA for their hospitality where part of this paper was written by the second author.

References

1. Villard, R., L.R. Cook, *Infinite Worlds*, Univ. of California Press, 2005.
2. Zaehringer, A.: *Rocket Science*, Apogee Books, Chap. 7, 2004.
3. Mallove, E. and G. Matloff, *The Starflight Handbook*, Wiley, Chap. 3, 1989.
4. Jahnshan, S.N., and T. Kammash: *Multimegawatt Nuclear Reactor Design for Plasma Propulsion Systems*, Vol 21, Number 3, May-June 2005, pp.385-391.
5. Emrich, W.J. And C.W. Hawk: *Magnetohydrodynamic Instabilities in a Simple Gasdynamic Mirror Propulsion System*, Vol 21, Number 3, May-June 2005, pp. 401-407.
6. Czysz, P., Bruno, C: F*uture Spacecraft Propulsion Systems*, Springer, 2006.
7. Tajmar, M. et al.: *Experimental Detection of the Gravitomagnetic London Moment*, arXiv, gr-qc/ 06030332006.
8. Wesson, P. S., *Five-Dimensional Physics,* World Scientific, 2006.
9. Dröscher, W., J. Hauser, *Heim Quantum Theory for Space Propulsion Physics*, AIP, STAIF, 2005.
10. Krauss, L.M., *Propellantless Propulsion*: *The Most Inefficient Way to Fly?*, NASA/CP 208694, January 1999.
11. Rovelli, C.: *Loop Quantum Gravity*, IoP, November 2003.
12. Altland, A., B. Simons: *Condensed Matter Field Theory*, Cambridge Univ. Press, 2006.
13. Dröscher,W., J. Hauser, G*uidelines for a Space Propulsion Device Based on Heim's Quantum Theory,* AIAA 2004-3700, 40th AIAA/ASME/SAE/ASE, Joint Propulsion Conference & Exhibit, Ft. Lauderdale, FL, 7-10 July, 2004, 21pp.
14. Dröscher, W., J. Hauser: *Magnet Experiment to Measuring Space Propulsion Heim-Lorentz Force*, AIAA 2005-4321, 42nd AIAA/ASME/SAE/ASE, Joint Propulsion Conference & Exhibit, Tuscon, Arizona, FL, 10-13 July, 2005.
15. Liddle, A.: *An Introduction to Modern Cosmology,* Wiley, 2003.
16. Witten, E: *Reflection on the Fate of Spacetime*, Physics Today, 1996.
17. Kaku, M.: *Quantum Field Theory*, Chap. 19, Oxford, 1993.
18. Levin, J.: *How the Universe Got its Spots,* Penguin Press, 2003.
19. Hartle, J. B.: *Gravity,* Addison Wesley, 2003.
20. Vass, R..: *Tunnel durch Raum und Zeit*, Kosmos, Stuttgart, 2005.
21. de Matos, C. J., Tajmar, M.: *Gravitomagnetic London Moment*, and the Graviton Mass Inside a Superconductor, PHYSICA C 432, 2005, pp.167-172.
22. Zwiebach, R., *Introduction to String Theory*, Cambridge Univ. Press, 2004.
23. Greiner, W., Müller, B.: *Quantum Mechanics Symmetries*, Springer, 1994.
24. Dröscher, W., J. Häuser: *Physical Principles of Advanced Space Transportation based on Heim's Field Theory*, AIAA/ASME/SAE/ASE, 38th Joint Propulsion Conference & Exhibit, Indianapolis, Indiana, 7-10 July, 2002, AIAA 2002-2094, 21 pp.
25. Schiller, C.: *Motion Mountain, The Adventure of Physics* (Chap. XI), September 2005, *www.motionmountain.net.*
26. Heim, B.: *Vorschlag eines Weges einer einheitlichen Beschreibung der Elementarteilchen*, Zeitschrift für Naturforschung, 32a, 1977, pp. 233-243.
27. Heim, B.: *Elementarstrukturen der Materie*, Band 1, 3. Auflage, Resch Verlag, Innsbruck, 1998.
28. Anderson, P.W., Science 177 (1972), pp. 393-396.
29. Dröscher, W., J. Häuser: *Future Space Propulsion Based on Heim's Field Theory,* AIAA 2003-4990, AIAA/ASME /SAE/ASE, Joint Propulsion Conference & Exhibit, Huntsville, AL, 21-24 July, 2003, 25 pp.
30. Tajmar, M.: private communnication, 13 July 2006.
31. de Matos, C.J., Tajmar, M.: *Gravitomagnetic London Moment and the Graviton Mass Inside a Superconductor*, PHYSICA C 432, 2005, pp. 167-172.
32. Bergström, L, A. Goobar: *Cosmology and Particle Astrophysics*, Springer,2004.
33. Heim, B. and Dröscher, W.: *Strukturen der Physikalischen Welt und ihrer nichtmateriellen Seite*, Resch Verlag, Innsbruck, 1996.

Table 2: **Table of hermetry forms describing the six fundamental interaction particles (interaction fields):** classification scheme for physical interactions and particles (for hermetry forms not shown see Table 3) obtained from polymetry in Heim space H^8. Superscripts for subspaces indicate dimension. Subspaces S^2 and I^2 stand for organization and information, respectively. A hermetry form characterizes either a physical interaction, a particle or a class of particles (see Table 3), and is associated with an admissible subspace (a space that has a real physical meaning) of H^8 , which is a combination from the four elementary subspaces comprising H^8. Any admissable subspace either needs S^2 or I^2 or both types of coordinates to be present in order to realize physical events in our spacetime. Elementary subspaces R^3, T^1, S^2 and I^2 form the basis of Heim space H^8. Employing this selection rule leads to 12 admissible hermetry forms, Fig 7. The additional four dimensions of the original space H^{12} are not needed for describing physical interactions, but seem to steer probability amplitudes and are not of interest here. It should be noted that a white field in a table entry of the messenger particle column implies that the corresponding hermetry form does not describe an interaction particle and is therefore listed separately in Table 3. The six different colors in the messenger particle column indicate the six fundamental interactions.

Subspace	***Hermetry form*** ***Lagrange density***	***Messenger particle***	***Symmetry group***	***Physical interaction***
S^2	$H_1(S^2), L_G$	*graviton*	*U(1)*	**gravitation** +
$S^2 \times R^3$	$H_2(S^2 \times R^3)$			
$S^2 \times T^1$	$H_3(S^2 \times T^1)$			
$\underbrace{S^2 \times R^3 \times T^1}_{\textit{particle aspect}}$	$H_4(S^2 \times R^3 \times T^1)$			
$S^2 \times I^2$	$H_5(S^2 \times I^2), L_{gp}$	$\underbrace{-\ \textit{neutral}\ +}_{}$ *three types of gravitophotons*	*U(1)×U(1)*	**gravitation ±** + *attractive* − *repulsive*
$S^2 \times I^2 \times R^3$	$H_6(S^2 \times I^2 \times R^3), L_{ew}$	Z^0 *boson*	*SU(2)*	**weak**
$S^2 \times I^2 \times T^1$	$H_7(S^2 \times I^2 \times T^1), L_{em}$	*photon*	*U(1)*	**electromagnetic**
$S^2 \times I^2 \times R^3 \times T^1$	$H_8(S^2 \times I^2 \times R^3 \times T^1)$	$W^{\pm}$ *bosons*	*SU(2)*	**weak**
wave aspect I^2	$H_9(I^2), L_q$	*quintessence*	*U(1)*	**gravitation** − *vacuum*
wave aspect $I^2 \times R^3$	$H_{10}(I^2 \times R^3), L_s$	*gluons*	*SU*(3)	**strong**
wave aspect $I^2 \times T^1$	$H_{11}(I^2 \times T^1)$			
wave aspect $I^2 \times R^3 \times T^1$	$H_{12}(I^2 \times R^3 \times T^1)$			

Table 1: The three gravitational interactions are related to different types of matter as indicated in the first column. The gravitational hermetry forms are explained in Tables 2 and 3.

Generated by	Messenger particles	Force	Coupling constant	Hermetry form
real particles	*graviton*	*attractive*	G_g	$H_1(S^2)$
virtual particles	*gravitophoton*	*repulsive and attractive*	$G^+_{gp}, G^-_{gp}=1/67^2 G_g$	$H_5(S^2 \times I^2)$
Planck mass vacuum	*quintessence or vacuum particle*	*repulsive*	$G_q=4.3565\times10^{-18}\,G_g$	$H_9(I^2)$

Table 3: **Table of real particles and their interactions.** The lepton weak charge is responsible for the following interactions: lepton weak charge for interactions of: e and ν_e, μ and ν_μ , τ and ν_τ *as well as* interactions between neutrinos caused by Z^0 and $W^\pm$ bosons.

Subspace	*Hermetry form*	*Particle class*
$S^2 \times T^1$	$H_3(S^2 \times T^1)$	**weak charge for leptons**
$S^2 \times R^3 \times T^1$	$H_4(S^2 \times R^3 \times T^1)$	**electrically charged particles**
$S^2 \times R^3$	$H_2(S^2 \times R^3)$	**neutral particles with rest mass**
$I^2 \times T^1$	$H_{11}(I^2 \times T^1)$	**weak charge for quarks**
$I^2 \times R^3 \times T^1$	$H_{12}(I^2 \times R^3 \times T^1)$	**quarks**

Table 4: **Table of the three degenerated hermetry forms:** A * indicates that the metric tensor is from the associated space, but some of the fundamental metric components of that space are 0, which is denoted as *degeneration*. In the first row the probability amplitude for the conversion of photons into gravitophotons is shown. The third row shows the conversion amplitude from gravitophpotons into the quintessence particle.

Subspace	*Associated space*	*Physical quantity*	*Metric tensor*
R^3	$H_{13}{*}(T^1 \times S^2 \times I^2)$	w_{ph_gp}	G = (44, 55, 56, 57, 58 65, 75, 85, 66, 67, 68, 76, 77, 78, 86, 87, 88)
T^1	$H_{14}{*}(R^3 \times S^2)$	neutrinos	
$R^3 \times T^1$	$H_{15}{*}(I^2)$	w_{gp_q}	G = (77, 88)