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FUTURE SPACE PROPULSION BASED ON HEIM'S FIELD THEORY

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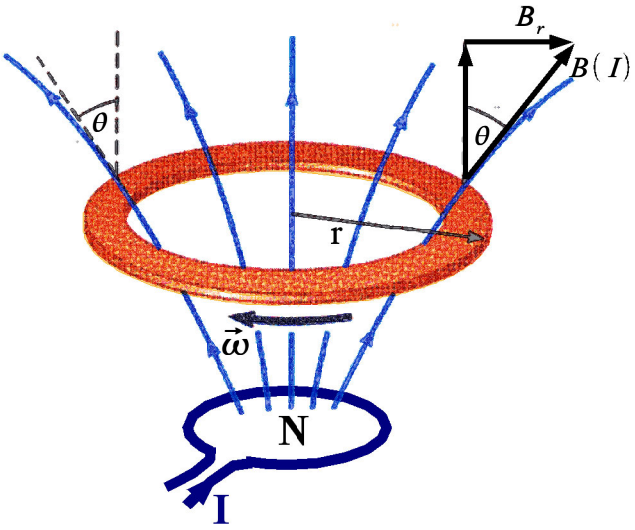
[2]*PROPULSION PRINCIPLE*



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1 Senior scientist, 2 Senior member *AIAA*, member *SSE*, *www.cle.de/HPCC, www.uibk.ac.at/c/cb/cb26/*

2 The upper ring (special material) is rotating in a magnetic field possessing a radial component, giving rise to the *Heim-Lorentz* force as predicted in Heim's Unified Field Theory, generated by so called g*ravitophoton* particles.

Now is the time to take longer strides

-time for a great new American enterprise-

time for this nation to take a clearly leading role in space achievement,

which in many ways may hold the key to our future on earth

President Kennedy's message to the congress on May 25, 1961[3]

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3 It does not seem that the old Europe currently has any vision of space

ABSTRACT

Effective space propulsion for interplanetary or interstellar missions cannot be based on the momentum principle of classical physics. This paper, being a continuation of [1], that discussed the physical principles of Heim's unified field theory, focuses on the properties of the predicted *gravitophoton* particle (similar to the graviton) as a means for a revolutionary propulsion system in the sense of NASA's *Breakthrough Propulsion Physics Program* (BPP) [2]. With regard to ***Mass,*** the propulsion method does not require a propellant, since using the gravitophoton field predicted by an extension of Heim's field theory [1, 5-7], does allow for the conversion of electromagnetic radiation into a gravitational like field (i.e., gravitational interaction takes place through both the graviton and the postulated gravitophoton particles) that reduces the inertia of a material body. Concerning the achievable ***Speed***, the gravitophoton field, as a new interaction (force) that follows from Heim's completely geometrized unified field theory, in principle, admits superluminal travel. The corresponding inertial transformation (conversion of electromagnetic radiation into a gravitophoton field) that does not exist in Einstein's four-dimensional spacetime continuum, however, is Lorentz invariant. Since the laws of energy and momentum conservation [1] are strictly adhered to, the vacuum speed of light is not the limiting velocity for an inertial transformation. With regard to energy, there are two different modes of propulsion. In the first mode, energy will be extracted from the magnetic field (see Figs. 1 and 2), and the spacecraft will be accelerated over a certain period in time, for instance at 1g, up to a certain velocity. For a mission to Mars the velocity would be some 1.5×10^6 m/s. For an interstellar mission, a velocity of some 0.1 c is needed. Now the second propulsion mode is employed, reducing the inertial mass of the space craft by a factor 10^4. The inertial transformation will increase the speed of the spacecraft by a factor of 10^4, *without increasing its kinetic energy*[4]. Energy is needed *only* for the generation of a very strong magnetic field. Otherwise, it would be *impossible to fly at speeds comparable or larger than the vacuum speed of light*. The cost of the necessary energy to fly, for instance, a 100 ton spacecraft close to the speed of light would be *prohibitive* [19, 20].

The paper comprises five sections. The first section gives a qualitative discussion of the role of the gravitophoton field and its double effect on matter, namely acceleration and reduction of inertia of a material body. Section 2 contains material about the role of the two novel particles, the gravitophoton and probability particles. In Section 3 a derivation of the metric tensor for moving electrical charges in 8-dimensional Heim space, $\mathbb{R}^8$, is given. In the next section, an experiment is presented to measuring the double nature of the gravitophoton field, and the strength of the interaction is calculated. The most important result is that an equation was found, termed the *Heim-Lorentz equation*, that has a form similar to the electromagnetic Lorentz force, except, that it is a gravitational like force, while the Lorentz force acts upon moving charged particles only. In other words, there seems to exist a direct coupling between matter and electromagnetism. Section 5 shows the performance of the gravitophoton field as a propulsion device. The performance of a gravitophoton propulsion device is calculated, and a discussion is presented of the interaction of a spacecraft traveling in some type of hyperspace where the speed of light is greater than the vacuum speed of light. In addition, the two-stage nature of a gravitophoton propulsion system is elucidated (two stage device: first acceleration, then inertia reduction). Moreover, the performance of gravitophoton propulsion for an interplanetary (Mars) mission and interstellar (flight to an earthlike planet some 100 light years away) is discussed. In the summary, the paper is concluded with an assessment of the physical credibility of Heim's theory and an outlook on the actual construction of a gravitophoton propulsion device.

It should be emphasized that the introduction of new physics, i.e., the complete geometrization of existing physical forces, will require that some concepts of today's physics need to be changed. It could be that in some circumstances the introduction of the transcoordinates, Section 3.1, may invalidate the second law of thermodynamics. It should be clear, however, if the new physics allows for breakthrough propulsion, substantial changes to currently established physical principles are mandatory.

Nomenclature and physical constants

Compton wave length of the electron

$$\lambda_C = \frac{\hbar}{m_e c} = 2.43\times10^{-12} m \,.$$

c speed of light in vacuum 299,742,458 m/s ,

$(1/c^2 = \varepsilon_0 \mu_0)$.

D diameter of the primeval universe, some 10^{125} m, that contains our optical universe.

D_O diameter of our optical universe, some 10^{26} m.

d diameter of the rotating torus, see caption Table .

d_T vertical distance between magnetic coil and rotating torus (see Fig. 2)**.**

e electron charge $-1.602\times10^{-19}\,C$.

$\hat{e}_z$ ***unit vector*** in z-direction.

4 Kinetic energy is calculated using the speed of light c, c', respectively.

F_e electrostatic force between 2 electrons.

F_g gravitational force between 2 electrons.

F_{gp} gravitophoton force, also termed Heim-Lorentz force, $\boldsymbol{F}_{gp} = \Lambda_p e \mu_0 \boldsymbol{v}^T \times \boldsymbol{H}$, see Eq. (31).

G gravitational constant 6.67259×10^{-11} $m^3 kg^{-1} s^{-2}$.

G_{gp} gravitophoton constant, $G_{gp} \approx (1/67)^2 G$

$g_{ik}^{(gp)}$ ***metric subtensor for the gravitophoton*** in subspace $I_2 \cup S_2$ (see *glossary* for subspace description).

$g_{ik}^{(ph)}$ ***metric subtensor for the photon*** in subspace $I_2 \cup S_2 \cup T_1$ (see *glossary* for subspace description) .

h Planck constant 6.626076×10^{-34} J·s, $\hbar = h/2\pi$

h_{ik} metric components for an almost flat spacetime.

m_e electron mass 9.109390×10^{-31} kg.

m_M Maximon mass, $m_M = \sqrt[4]{2}\sqrt{\frac{ch}{G}} = 6.5 \times 10^{-8} kg$, without the factor $\sqrt[4]{2}$ the Planck mass is obtained.

m_0 mass of proton or neutron 1.672623×10^{-27} kg and 1.674929×10^{-27} kg.

N_n number of protons or neutrons in the universe.

r_e classical electron radius

$$r_e = \frac{1}{4\pi\epsilon_0}\frac{e^2}{m_e c^2} = 3 \times 10^{-15} m$$

r_{ge} ratio of gravitational and electrostatic forces between two electrons.

v velocity vector of charges flowing in the magnetic coil (see Secs. 3 and 4), some 10^3 m/s in circumferential direction.

v^T bulk velocity vector for rigid rotating ring (torus) (see Sections. 3 and 4), some 10^3 m/s in circumferential direction.

w_{gp} probability amplitude *(the square is the coupling coefficient) for the gravitophoton force*

$w_{gp}^2 = G_{gp}\frac{m_e^2}{\hbar c} = 3.87 \times 10^{-49}$ Probability amplitudes (or coupling amplitudes) can be distance dependent (indicated by a prime in [7]).

w_{gq} probability amplitude for the transformation of gravitophotons and gravitons into a particle corresponding to dark energy (rest mass of some 10^{-33} eV).

w_{ph} probability amplitude (*the square is the coupling coefficient for the electromagnetic force, that is the fine structure constant* α)

$$w_{ph}^2 = \frac{1}{4\pi\epsilon_0}\frac{e^2}{\hbar c} = \frac{1}{137}$$

Z atomic number (number of protons in a nucleus and number of electrons in an atom)

Z_0 impedance of free space,

$$Z_0 = \sqrt{\frac{\epsilon_0}{\mu_0}} \approx 376.7\,\Omega$$

α coupling constant for the electromagnetic force or fine structure constant 1/137.

α_{gp} coupling constant for the gravitophoton force .

γ ***ratio of probabilities*** *for the electromagnetic and the gravitophoton force*

$$\gamma = \left(\frac{w_{ph}}{w_{gp}}\right)^2 = 1.87 \times 10^{46}$$

μ_0 permeability of vacuum $4\pi \times 10^{-7}$ N/m^2 .

τ ***Metron area*** (minimal surface $3Gh/8c^3$), current value is 6.15×10^{-70} m^2.

ω ***rotation vector*** (see Figs. 1 and 2).

ω ***propagation speed of gravitational waves***, according to Heim $\omega = 4/3\ c$.

Abbreviations

GRT General Theory of Relativity
rhs right hand side
lhs left hand side
ly light year
ls light second
QED Quantum Electro-Dynamics
SRT Special Theory of Relativity
VSL Varying Speed of Light

Subscripts

e electron
gp gravitophoton
gq from gravitons and gravitophotons into quintessence
ph denoting the photon or electrodynamics
M Maximon
R to indicate the mass of the rotating ring (torus)
sp space

Superscripts
em electromagnetic
gp gravitophoton
ph photon
T indicates the rotating ring (torus) of mass m_R

Note: Since the discussion in this paper is on engineering problems, SI units (Volt, Ampere, Tesla or Weber/m^2) are used. 1 T = 1 Wb/m^2 = 10^4 G = 10^4 Oe, where Gauss (applied to $\boldsymbol{B}$, the magnetic induction vector) and Oersted (applied to $\boldsymbol{H}$, magnetic field strength or magnetic intensity vector) are identical. Gauss and Oersted are used in the *Gaussian* system of units. In the MKS system, $\boldsymbol{B}$ is measured in Tesla, and $\boldsymbol{H}$ is measured in A/m (1A/m = $4\pi \times 10^{-3}$ G). Exact values of the physical constants are given in [25].

Note: For a conversion from CGS to SI units, the electric charge and magnetic field are replaced as follows: $e \rightarrow e/\sqrt{4\pi\epsilon_0}$ and $\boldsymbol{H} \rightarrow \sqrt{4\pi\mu_0}\,\boldsymbol{H}$

1 Introduction to Space Propulsion using the Gravitophoton Field

For effective interplanetary and interstellar travel a *revolution* in space propulsion technology is needed. Such breakthrough propulsion techniques can only emerge from novel physics, i.e., physical theories that deliver a unification of physics that are consistent and founded an basic, generally accepted principles. The theory by the late B. Heim, developed in the fifties and sixties, and partly published in the following three decades of the last century, seems to be compliant with these requirements. It also makes a series of predictions with regard to cosmology and high energy physics that eventually can be checked by experiment. Most important, however, Heim's theory[5] predicts two additional interactions (forces) [1, 5-7]. These new interactions allow the transformation of electromagnetic radiation into a gravitational like field, the so called *gravitophoton* field. This gravitophoton field can be used to both accelerate a material body and to *reduce* its inertial mass. These effects can serve as the basis for advanced space propulsion technology, and are dealt with quantitatively in this paper.

5 To be more precise, Heim's theory was extended to 8-dimensions by the first author, [7], to obtain the unification of the four known interactions (forces). In this process, it was found that two additional interactions occur, termed the gravitophoton field and the probability field [1, 7].

2 Cosmological Consequences from Heim's Theory

2.1 Origin of the Universe

In this section we will address several fundamental questions concerning the origin of the universe and the creation of matter. Since Heim's theory answers these questions in a totally different way as does currently accepted big bang theory, it is of great importance to find out how to experimentally test those predictions. Heim's theory also gives an interpretation of the physical nature of both mass and inertia (crucial to any advanced space propulsion system) that should be experimentally verifiable. His theory provides a model for a general *ab initio* quantized (space-time) *cosmogony* and determines the age of the universe as well as its size and future dynamic evolution.

2.1.1 A Quantized Cosmogony

Today, the hot big bang model of the universe has broad acceptance [9]. According to this theory, the universe originated from an infinitely dense and infinitely small space. In order to describe the very early history of the universe, i.e., its first 10^{-30} seconds, the inflationary model has been developed by Guth (e.g., [8]), causing an expansion of the diameter of the universe by an extraordinary factor of some 10^{50} during this era. This picture, however, is not consistent with the physical laws that govern the expanded universe. Moreover, the assumption of infinities or arbitrarily large numbers seems to lack the proper physical basis and is physically inconsistent with the quantum principle. This principle needs to be employed whenever wave packets cannot be isolated. Moreover, according to [4], the probability that the universe had an initial singularity leading to its current shape is 1 over $10^{10^{123}}$, meaning the universe should not have developed from the big bang singularity. In other words, in order to understand the beginning of the physical universe, nonphysical assumptions have to be made and

physical events have to be conceived that are in stark contradiction of established physical principles.

According to Heim, such a hot big bang did not took place. Instead, a quantized bang did take place. The quantization principle, that is ***Nature counts***, i.e., only *integers* and not floating point numbers are used, was present from the very beginning. Thus any kind of singularity was impossible. In particular, spacetime, as a physical entity, was quantized from the very beginning. The quantization principle, being at the very foundation of physics, is used by Heim in a rigorous way to obtain a unified geometrized field theory. At the foundation of Heim's theory is the *derivation* of an elemental, discrete **surface quantum**, τ **,** denoted as *Metron*. The value of the Metron size is given by $\tau = G\,h/2\omega\,c^2$. It should be noted that in Heim's theory, gravitational waves propagate at a speed of $\omega = 4/3\,c$, where c denotes the vacuum speed of light [18].

Therefore, any surface, $A \in \mathbb{R}^2$, cannot be a point-continuum, but comprises a finite number, $n \in \mathbb{N}$, of these *Metrons*. The current surface area of a *Metron* is 6.15×10^{-70} m^2 . The current granularity of spacetime is extremely fine and therefore has eluded experimental detection.

The most radical concept in Einstein's General Theory of Relativity (GRT) is the removal of the idea of gravity as a force. Instead, it is considered to be a feature of spacetime curvature. Heim extends this idea to **all** physical forces and also employs the equations of GRT, i.e., *their structure,* to the microcosm by quantizing these equations in a higher-dimensional space. This approach leads to a set of eigenvalue equations, whose eigenvalues are the mass spectrum of all existing material particles. As was outlined in[6] [1], the phenomenon of mass thus is a purely geometrical feature. In this context, space and time are not the container for things, but are, due to their dynamic (cyclic) nature, the things themselves. For a quantized unification of gravitation and electromagnetism a 6 dimensional space is needed. If all known interactions are to be incorporated, space becomes 8-dimensional, $\mathbb{R}^8$. It was described in [1] that the metric tensor for the 8-space can be written as a composition of subtensors that are functions of the coordinates from these subspaces. There are, however, selection rules for the combination of subspaces as described in [1]. For instance, constructing a metric tensor from the three real coordinates of physical space only, would not result in a metric tensor associated with a physical interaction. Any metric tensor that can be associated with a physical interaction is termed **Hermetry** form by Heim. Heim extends Einstein's idea, namely that the geometry (metric tensor) of four-dimensional spacetime causes gravity, to the 8-space. Associated with each of these metric subtensors is a specific physical interaction, and thus a correspondence principle between the metric and the actual physical interaction is established. This set of metric subtensors, responsible for all known as well as two new physical interactions, is denoted as **poly-metric** by Heim [1, 3, 5].

However, before matter (i.e., form and inertia) could come into existence (being represented by the proper metric subtensor), the corresponding length scale of the quantized spacetime of the universe had to reach a certain threshold (minimal) length. In other words, the metric scale had to be fine enough to allow for the proper curvature in physical space $\mathbb{R}^3$. Since the universe starts out from a quantized space, when a *single Metron covers the surface of the whole universe*, there are no problems with the initial conditions in this picture. Evidently the *Metron* size is time dependent and has decreased since the **quantized bang**.

For most of the time of its existence this *primeval universe* [7] possessed only structure, until its associated elementary length scale satisfied a certain condition. While the universe was expanding, its associated length scale was decreasing. When this length scale came close to the Planck

6 In order to understand the present paper, reference [1], AIAA-2002-2094, needs to be studied. An updated version can be freely downloaded, see References.

7 From now on the word universe will be reserved to our optical universe, which is embedded in this primeval universe.

length, a phase transition occurred, triggered by fluctuations in the length scale. This phase transition led to the generation of a particle having the mass of the Planck mass. Heim's formula for the mass spectrum for elementary particles (which contains all particles, i.e. including those with zero rest mass as well as ponderable particles) has the form

$$m(n)=\mu\frac{(2n)^{1/4}}{(2n-1)^{1/2}}\eta_q \text{ with } n\in\mathbb{N} \qquad (1)$$

and $\mu=\sqrt{(c\hbar/G)}$. Since we are interested in the upper bound of the possible energy quanta, i.e., in the maximum mass a particle can carry, we choose n=1 and let η_q=1. The exact mass formula is given in [3, 5 see Section 3]. Therefore, we obtain for the mass of the heaviest (neutral) particle, denoted as **Maximon** (it is interesting to note that its Schwarzschild radius is equal to the range of its attractive gravitational field)

$$m_M=\sqrt[4]{2}\,\mu=\sqrt[4]{2}\sqrt{\frac{c\hbar}{G}}=6.5\times10^{-8}kg \qquad (2)$$

It should be noted that in the literature the **Planck mass** is defined using $\hbar$ and without the factor $\sqrt[4]{2}$.

This kind of phase transition occurred at many locations in the primeval universe, in a statistically (random) distributed manner, and led to the creation of many universes, separated from each other, i.e., no optical signal can reach our universe from such a parallel universe. These universes should be similar with regard to their physical laws, since they are all created by the decay of Maximon particles. At a time of about 10^{100} s, when the time dependent Metron size, τ(t), became sufficiently small, a break of a global symmetry group must have occurred. Each of these Maximon particles was the center of a process for the generation of a universe, in which ponderable particles are existing. In other words, our own universe is the result of the decay of one of these Maximons. This is in contrast to the original or *primeval universe* that only holds geometrical structure. The Maximon particle decayed, cascading into mesons and baryons (this process might be interpreted as inflationary universe), with final products as neutrons, protons, and electrons. This avalanche process was accompanied by the emission of gamma quanta that might perhaps explain the existence of the cosmic background radiation. In addition, particles that could be interpreted as vacuum energy might have been created (these particles could be interpreted as dark energy because of their very small rest mass). Their masses corresponds to the greatest possible wavelength possible, namely the diameter of our optical universe, i.e., $D_O\approx4\times10^{26}$ m.

It should be stressed that Heim's cosmogony comprises a *primeval universe* that originated from a quantized bang. Our *optical universe,* that is of much smaller diameter, is embedded in this primeval universe. This optical universe is one of many other universes, created simultaneously throughout the primeval universe, caused by the phase transition mentioned above. This phase transition triggered the production of the heaviest elementary particle, the Maximon, whose subsequent decay eventually lead to our universe. This rapid decay, however, must have taken place by some kind of inflationary process or through a varying speed of light (VSL), which is allowed in Heim's theory, if connected to an inertial transformation.

It is important to note that during this phase transition, mass was not conserved. Heim's universe is a purely geometrical universe, and thus there is a fundamental conservation law based on length scale considerations. All other physical conservation laws are a consequence of this fundamental principle, see [5, Chap. 4]. The contents of this conservation law can be stated as

$$m_M^4=N_n m_0^4 \qquad (3)$$

where m_0 is the mass of the proton or the neutron, i.e., these particles are the final products, and $N_n\in\mathbb{N}$ is the number of protons or neutrons in the universe.

It should be noted that mass is a feature of geometry, i.e., mass is connected with a length scale through the general equation $m = \hbar c / l$, where l is a length and m denotes a mass.

In other words, since mass is inversely proportional to a length (for instance, Compton wave length), a decrease of the length scale leads to an increase in mass. In that sense, the conservation of mass is not satisfied, since it is caused by and also depends on the geometry of the spacetime. The generation of a Maximon particle acts as catalyzer that triggers geometrical change in neighboring spatial cells (denoted as Planck), bounded by *metronic* (Metron) surfaces. Corresponding to these geometrical changes is the appearance of material particles. Knowing the end products of the decay chain, we can compute the number of neutrons, that are finally produced (see Eq. (3)). We thus obtain the total mass of our universe, which is embedded in the primeval universe of much greater diameter of some 10^{125} m. This primeval universe is without mass, but contains a large number of universes that all have their origin in the decay of a Maximon particle. The calculation leads to a mass of 3.71×10^{51} kg of the ponderable (possessing a nonzero rest mass) ordinary, visible matter in our universe. With the generation of the neutron, the corresponding interactions that result from the metric subtensors of space $\mathbb{R}^8$, *give rise to two additional*, heretofore unknown particles, namely gravitophotons, g_{ph}, (rest mass zero) and a very light (unnamed) particle as well as *two new physical interactions* that are the basis for the novel space propulsion.

2.2 Cosmic Numbers

An interesting fact is that there is a relation between the diameter of the primeval universe, D, and the Metron size, τ. In addition, all other physical constants can be expressed by D. In other words, *all cosmic numbers exclusively depend upon the current diameter of the primeval universe*.

The following relations hold:

$$\begin{aligned} \tau &\sim D^{-6/11} \\ \hbar &\sim D^{-8/11} \quad \text{and} \quad G \sim D^{-13/11} \\ \epsilon_0 &\sim D^{13/11} \quad \text{and} \quad \mu_0 \sim D^{-3/11} \end{aligned} \tag{4}$$

Eqs. (4) show that all relevant empirical physical quantities can be derived from the macroscopic structure $\mathbb{R}^3$ of the primeval universe. However, the primeval universe has existed for an extremely long time, so that in our own universe all physical constants are practically invariant, since D, at present (this presence includes the last 15 billion years), is almost constant. Eqs. (4) are a direct consequence of the metrization of the Heim space $\mathbb{R}^8$.

The ratio, r_{ge}, of the gravitational and electrostatic forces between two electrons separated at a distance r is given by

$$r_{ge} = \left| F_g / F_e \right| = 4\pi\epsilon_0 G \left(\frac{m_e}{e} \right)^2 \tag{5}$$

with the mass and charge of the electron given by (see p. 33 [6])

$$m_e = a \sqrt[3]{G\hbar} \sqrt{\frac{h}{cG}} \quad \text{and} \quad e = -b \sqrt{\frac{h}{Z_0}} \tag{6}$$

where a and b are real numbers depending on π, and $Z_0 = \sqrt{\frac{\epsilon_0}{\mu_0}} \approx 376.7\,\Omega$ denotes the impedance of free space. Inserting Eq. (6) into (5) delivers the surprising result that also the ratio of the two forces only depends on the size of the Metron

$$r_{ge} = \frac{16}{3} \pi \sqrt[3]{3} \left(\frac{a}{b} \right)^2 \tau^{2/3} \tag{7}$$

Since, according to Heim, matter was generated quite recently, compared to the cosmic time scale, τ remained practically unchanged during the last 15 billion years. Therefore, the intensity of the intra-stellar thermonuclear processes must have remained unchanged in our universe, and thus the abundances of ^{3}He and ^{4}He cannot be at-

tributed to the change of the ratio of gravitational and electromagnetic forces.

Cold dark matter provides for some 25% of the mass of the universe, but is invisible. According to supersymmetric theories, dark matter particles mass of the galaxy. The standard explanation is that there exists dark matter that compensates for the missing mass. However, so far no sign of the necessary amount of dark matter has ever been observed, neither directly nor indirectly.

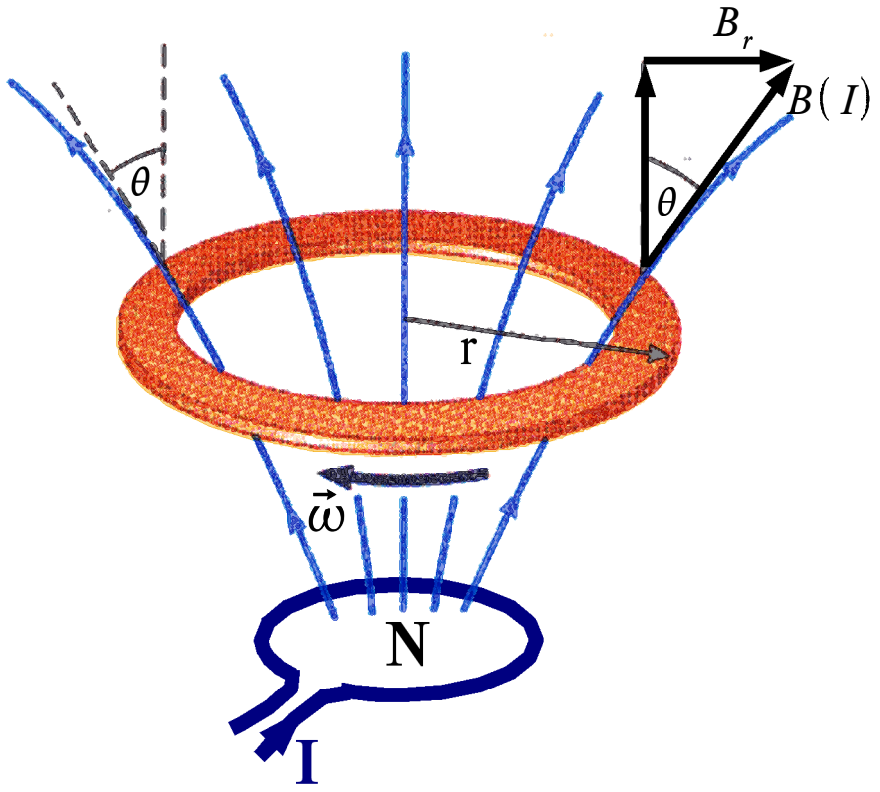

Figure 1: The picture shows the physical principle for generating a gravitophoton field. A ring or a torus (flywheel) of a given mass is rapidly rotating in a magnetic field created by a current loop as depicted. The charges in the current loop (lower part), which is below the rotating mass, are moving in the opposite direction, generating a magnetic field ***H*** (or magnetic induction $\boldsymbol{B}=\mu_0\boldsymbol{H}$, in practice the *velocity of the charges* in the current loop are of importance), as indicated in the upper right. Using cylindrical coordinates r, θ, and z, there should be a gravitophoton force in the negative z-direction (downward), according to Eq. (31). This force component is the result of the circumferential velocity of the rotating ring and the radial component of the ***H*** field. There also exists a gravitophoton force component in radial direction, *r*, that is, however, balanced by the forces within the material of the rotating mass, and therefore is of no interest to propulsion purposes.

have a mass of about 10^{11} eV, heavier than any known particles. The name of this stable particle is neutralino, and it would be a leftover from the hot big bang. The existence of dark matter is inferred from galaxy dynamics [13] that must be present in the vicinity of each galaxy in order to explain the observed fact that the angular frequency of orbiting stars remains constant. Star systems that are circling the center of a galaxy are moving too fast with respect to the visible

As mentioned before, in Heim's theory gravitational waves propagate at a speed of $\omega = 4/3\,c$, which causes a major difference in the explanation of the redshift.

Since the attractive range of gravitation is finite (the ***gravitational limit*** depends on the composi-

8 There is doubt about this relation. ω = c could also be possible.

tion of the atomic mass), a photon outside this gravitational limit, on its way toward a distant galaxy, would be going against a repulsive force, caused by the total mass ahead of it, and thus experiences an increase of its wavelength. Thus most of the observed redshift must be attributed to this phenomenon, and is not caused by the Doppler effect.

3 Force Equations for Gravitophoton Fields from poly-metric Tensor in discrete 8-Dimensional Heim Space

3.1 8D Heim Space and Subspaces

In the following, a brief roadmap for the derivation of the force equations for the gravitophoton field is presented. Before the gravitophoton field can exert any force on a material body, it needs to be generated. This is achieved by creating a strong stationary magnetic field by a current, for instance, in a superconducting coil, above which a material ring (torus, flywheel) is rotated at a high circumferential speed of some 10^3 m/s.

The derivation for the gravitophoton force proceeds in three stages. *First*, the metric tensor for moving electric charges is derived using modified Einsteinian field equations, demonstrating that from this tensor the electromagnetic Lorentz force can be deduced. *Second*, the gravitophoton potential generated in the rotating torus is presented, and *third*, the physical model for the generation gravitophoton field and its interaction are shown. These equations are the physical guidelines for the experimental setup, as depicted in Fig. 1. In Section 4, the experiment to measure the effect of the gravitophoton field on the mass of the rotating torus is outlined in detail.

We showed in [1] that the metric tensor in 8-space comprises several subtensors, such that each subtensor is responsible for a different physical interaction. In the same way the metric tensor of Einstein's GRT acts as a tensor potential for gravitation, the additional subtensors constructed from the *quantized* Heim space, $\mathbb{R}^8$, are responsible for *all* physical interactions in our universe. In other words, the subspaces in $\mathbb{R}^8$, in which the individual metric tensors are specified, are the cause of physical forces. In that respect, we can speak of a completely geometrized theory. In Heim space $\mathbb{R}^8$ four groups of coordinates are discerned:

1. $\mathbb{R}^3$, *spatial coordinates* (real) (ξ_1, ξ_2, ξ_3),
2. T^1, *time coordinate* (imaginary) (ξ_4),
3. S^2, *entelechial and aeonic coordinates* (imaginary) (ξ_5,ξ_6),
4. I^2, *information coordinates* (imaginary) (ξ_7, ξ_8).

In [1] the rules of combining the various coordinates to form the respective metric subtensors were described. Coordinates ξ_5,..,ξ_8 are termed trans-coordinates. There are, however, *no extra* space dimensions. All trans-coordinates are *imaginary*. Any metric subtensor, in order to describe a physical interaction, must contain coordinates from subspaces S^2 or I^2.

Although a space $\mathbb{R}^8$ is considered, all measurable events take place in spacetime $\mathbb{R}^4$. We consider therefore three types of coordinates, namely Euclidean coordinates x, and non-Euclidean (curvilinear) coordinates η in physical spacetime $\mathbb{R}^4$, while ξ denote coordinates in Heim space $\mathbb{R}^8$.

The physical nature of the ξ coordinates is such that their mapping into our spacetime gives rise to all known physical fields in $\mathbb{R}^4$. The non-Euclidean structure of these coordinates is the underlying cause of all observed physical fields.

The following coordinate transformation, Eq. (8), therefore represents the physical fact that Heim space $\mathbb{R}^8$ directly influences the events in four-dimensional spacetime. In Heim's terminology, all known physical fields are represented by their respective hermetry forms (metric tensor in admissible subspaces) (see glossary). Since, according to Heim, the structure of Einstein's equations, supplemented by a quantization condition, is the fundamental set of equations governing physical interactions in $\mathbb{R}^8$, the various metric subtensors can be used to determine these physi-

cal interactions. The gravitophoton field (hermetry form H_{11}, see [1] and glossary), under the action of conversion operator S_1 (glossary), is transformed into the so called probability field, described by hermetry form H_{10} [1]. This can formally be written as $S_1 H_{11} = H_{10}$. The physical interpretation of this conversion could be as follows: one dark energy particle (quintessence) is produced from one gravitophoton and one graviton. This means that gravitophotons and gravitons using the transformation field w_{gq}, are transformed into so called dark energy particles, q, that has a mass of some 10^{-33} eV, which is in good agreement with recent findings from [13].

3.2 The metric Tensor in 8D Heim Space

In GRT a coordinate transformation between Euclidean and curvilinear coordinates in continuous spacetime $\mathbb{R}^4$ is considered. In Heim's theory a similar transformation is used, accounting, however, for the influence of the 8D space on events in our spacetime $\mathbb{R}^4$. Therefore, a third set of coordinates, ξ, is involved in the transformation.

Making use of the general coordinate transformation $x_m(\xi_\alpha(\eta_i))$, one obtains for the metric tensor

$$g_{ik}=\frac{\partial x_m}{\partial \xi_\alpha}\frac{\partial \xi_\alpha}{\partial \eta_i}\frac{\partial x_m}{\partial \xi_\beta}\frac{\partial \xi_\beta}{\partial \eta_k} \qquad (8)$$

where indices $\alpha, \beta = 1,...,8$ and $i, m, k = 1,...,4$. The Einstein summation convention is used, that is, indices occurring twice are summed over. The quantum aspect of the theory is only needed for the derivation of the spectrum of elementary particles. For the purpose of this paper, a continuous transformation can be used.

This metric tensor can be represented, defining so called fundamental kernels, Eq. (9). The various subtensors are characterized by their fundamental kernels, $\kappa_{im}^{(\alpha)}$. It can be shown that the respective Christoffel symbols (termed ***condensors*** by Heim), derived from their metric subtensors, have tensor character, except for gravitation. According to Heim there are so called ***sieve (conversion) operators*** that can be applied to a hermetry form with the effect that one or more of the fundamental kernels become Euclidean, i.e., the resulting metric now describes a different physical field, marked by the new hermetry form. For instance, this is the case for the electromagnetic interaction, Eq. (12), that contains the metric for the gravitophoton interaction. If the part termed $g_{ik}^{(em)}$, could, by some experimental means, be made Euclidean, the gravitophoton force would occur.

In other words, in Heim's theory operators exist that convert one hermetry form into another one. Our main interest in this paper is the interaction between electrodynamics and the gravitational like field, the gravitophoton field that can be used to both accelerate a material body as well as to reduce its inertial mass. Such an acceleration does not exist in GRT, neither is a Lorentz transformation based on a reduced inertial mass conceivable in the framework of GRT. Thus, within GRT, there is no way for a material body flying at superluminal speed.

Contrary to GRT, in Heim's theory the existence of the gravitophoton interaction, reducing the inertia of a material body, *does* allow for superluminal speeds without violating GRT.

3.3 The Metric Tensor Describing Photons

Next, the metric tensor is separated into several subtensors. Using fundamental kernels, the metric tensor can be written in the form

$$g_{ik}=\sum_{\alpha,\beta=1}^{8}\kappa_{im}^{(\alpha)}\kappa_{mk}^{(\beta)}=:\sum_{\alpha,\beta=1}^{8}g_{ik}^{(\alpha\beta)}, \qquad (9)$$

where we defined the $g_{ik}^{(\alpha\beta)}$ different from [1], this being a matter of convenience only. As we showed in [1, Eq. 12], the hermetry form $H_5=H_5(I^2,S^2,T^1)$ [9] is responsible for photons and depends on the subspaces I^2, S^2, and T^1 with

9 Contrary to [1], subspaces are denoted by superscripts instead of subscripts.

coordinates ξ_4, ξ_5,...,ξ_8. The respective metric tensor for photons is

$$g_{ik}^{(ph)} = \sum_{\alpha,\beta=4}^{8} g_{ik}^{(\alpha\beta)} \qquad (10)$$

where the superscript *ph* [10], denotes the metric subtensor for the photon. The new gravitophoton field that originates from the poly-metric of Heim's extended theory [1, 7] is described by hermetry form H_{11}, $H_{11} = H_{11}(I^2, S^2)$ depending on the subspaces I^2 and S^2 with coordinates ξ_5,..., ξ_8. Its metric tensor is given by

$$g_{ik}^{(gp)} = \sum_{\alpha,\beta=5}^{8} g_{ik}^{(\alpha\beta)} \qquad (11)$$

where the superscript *gp* denotes the metric subtensor for the gravitophoton. Comparison of Eqs. (10) and (11) leads to

$$g_{ik}^{(ph)} = g_{ik}^{(gp)} + g_{ik}^{(em)} \qquad (12)$$

where $g_{ik}^{(em)}$ is defined by

$$g_{ik}^{(em)} := \sum_{\alpha,\beta=5}^{8} g_{ik}^{(\alpha 4)} + g_{ik}^{(4\beta)} + g_{ik}^{(44)} \qquad (13)$$

and is part of the electromagnetic interaction and thus the index *em* was used. However, it should be noted that this part of the metric tensor has no physical meaning. It is only the metric tensors of Eqs. (11 and 12) that correspond to physical interactions. This interpretation becomes clear, since Eq. (12) shows that hermetry form H_5, denoted as the photon field, actually contains the metric of the gravitophoton field. We interpret this part of the metric in Eq. (10) as coupling potential between the electromagnetic and the gravitophoton field. It is exactly the metric of the gravitophoton particle. However, there is no gravitophoton interaction coming from Eq. (12). Only by employing the proper sieve (conversion) operator, the metric of Eq. (12) can be converted into the metric of the gravitophoton field. *Only then*, a gravitophoton field would occur. In that respect, separating the metric for the photon, Eq. (12), into two terms is somewhat misleading. It does *not mean* that the electromagnetic field comprises a gravitophoton field and a second part. It does show, however, that conversion between the fields is mathematically possible. According to Heim's extended theory (from 6 to 8 dimensions, see [7]) there exists a transition operator S_2 (not to be confused with subspace S^2) that causes this photon-gravitophoton interaction, that is, a transformation of a photon into a gravitophoton, and is symbolically written as S_2 $H_5 = H_{11}$.

Since only metric tensors (geometry) were considered so far, no guidelines are available how this conversion can be realized by experiment. How this purely mathematical transformation can be brought into concrete physical existence is a most important question, and is addressed in sections 3.4 to 3.7.

3.4 The Metric Tensor for Moving Charged Particles

Making use of the coordinate transformation $x_m(\xi_\alpha(\eta_i))$ one obtains from Eq. (10) the representation for $g_{ik}^{(\alpha\beta)}$ in the following form

$$g_{ik}^{(\alpha\beta)} = \frac{\partial x_m}{\partial \xi_{(\alpha)}} \frac{\partial \xi_{(\alpha)}}{\partial \eta_i} \frac{\partial x_m}{\partial \xi_{(\beta)}} \frac{\partial \xi_{(\beta)}}{\partial \eta_k} \qquad (14)$$

For weak gravitational fields, spacetime is almost flat, so the contribution of $\frac{\partial \xi_4}{\partial \eta_4}$ is large in comparison to $\frac{\partial \xi_4}{\partial \eta_l}$, $l = 1,2,3$. Introducing the abbreviations

10 We adopt the convention of using an *abbreviation* as a superscript to denote the physical meaning of various metric subtensors, instead of using symbols like ' , " or ~ etc., for the sake of clarity.

$$h_{m4} := \sum_{\alpha=5}^{8} g_{m4}^{(\alpha 4)}$$
$$h_{4l} := \sum_{\beta=5}^{8} g_{4l}^{(4\beta)}$$
$$h_{44} := g_{44}^{(44)} \qquad (15)$$
$$h_{ml} := \sum_{\alpha,\beta=5}^{8} g_{ml}^{(\alpha\beta)}$$

where m=1,...,4 and l=1,2,3.

Now the *first stage* of the derivation can be performed. It is investigated *whether there exist modified Einsteinian field equations that provide a metric for describing the motion of electric charges*. The important difference to Einstein's GRT is that a transformation $\mathbb{R}^4 \rightarrow \mathbb{R}^8 \rightarrow \mathbb{R}^4$ takes place, resulting in a metric tensor not available in GRT. Einstein's field equations are therefore used as structural equations only in a discrete 8D Heim space. In this space a metric exists that is rich enough to account for the four fundamental forces and their mediator particles, but, as was stated before, gives rise to two additional interactions.

$$R_{ik} = \kappa\left(T_{ik} - \frac{1}{2} g_{ik} T\right) \qquad (16)$$

And $T = T_k^k$. In the gravitational case, κ is of the form $\kappa = \frac{8\pi G}{c^4}$, while for our considerations κ needs to be adjusted to the electromagnetic hermetry form.

For weak electrodynamic and also for weak gravitational fields, spacetime must be almost flat, so one obtains

$g_{ik} = g_{ik}^{(0)} + h_{ik}$ where $g_{00}^{(0)} = -1$ and $g_{ii}^{(0)} = +1$, and all other components are 0. The h_{ik} are small quantities whose products are negligible. It is well known that the linearized Ricci tensor can be written as (see, for instance, [17], p. 298)

$$R_{ik} = \tfrac{1}{2} \Box^2 h_{ik} \qquad (17)$$

where $\Box^2 = g^{(0)ik} \frac{\partial^2}{\partial x^i \partial x^k} = \nabla^2 - \frac{1}{c^2} \frac{\partial^2}{\partial t^2}$ is the D'Alembertian operator. Einstein's equations can thus be written in the form

$$\Box^2 h_{ik} = \frac{\partial^2 h_{ik}}{\partial x_n^2} = 2\kappa\left(T_{ik} - \frac{1}{2} g_{ik} T\right) \qquad (18)$$

with summation over index n. Eq. (18) is an inhomogeneous wave equation, whose solution is given by the so called retarded potentials.

The components of the stress-energy-momentum tensor are of the following form [17] $T_{ik} = \rho v_i v_k$ and $T = \rho c^2$ since $v_i, v_k \ll c$. For a point-like mass M, the following relation holds

$\int T_{ik} dV = M v_i v_k$. The partial differential equation (18) can be solved by means of Fourier transformation (see, for instance [17], page 217). This eventually leads to the result

$$h_{ik} = \frac{1}{4\pi\epsilon_0} \frac{eQ}{m_e c^2 r} \frac{v_i}{c} \frac{v_k}{c} \qquad (19)$$

where the charge Q is a multiple of the electron charge and i,k =1, 2, 3. It should be noted that h_{ik} are dimensionless quantities.

It is well known from QED that the electric charge is proportional to the coupling amplitude (or probability amplitude), see [26] Chap 13, $e = \sqrt{(4\pi\epsilon_0 \hbar c \alpha)}$ and thus Eq. (19) can be written as

$$h_{ik} = \alpha \frac{Q}{e} \frac{\hbar}{m_e c} \frac{1}{r} \frac{v_i}{c} \frac{v_k}{c} \qquad (20)$$

The meaning of the above equations is that the movement of charges causes a metric h_{ik}, as described in Eq. (19). From Fig. 1 it can be seen that a charge Q (here the simplification is made describing charges in the magnetic coil by a single charge Q) is moving with velocity components v_i in a magnetic coil (current).

3.5 The Metric Tensor for Gravitophotons

In the *second stage*, the gravitophoton metric tensor can be directly found from Eq. (20), observing that the metric for the moving charged particle is proportional to the fine structure constant α. In the same way, it is concluded that the metric for the gravitophoton tensor components is proportional to α_{gp}, the coupling constant for the gravitophoton force. Therefore, the ratio of the metric for a moving charged particle and a gravitophoton particle equals α / α_{gp}.

Thus the metric for the gravitophoton particle is given by

$$h_{ik} = \alpha_{gp} \frac{Q}{e} \frac{\hbar}{m_e c} \frac{1}{r} \frac{v_i}{c} \frac{v_k}{c} \qquad (21)$$

where $\alpha := w_{ph}^2 = \frac{1}{4\pi\epsilon_0} \frac{e^2}{\hbar c}$ and

$\alpha_{gp} := w_{gp}^2 = G_{gp} \frac{m_e^2}{\hbar c}$ Inserting α_{gp}, Eq.(21) takes the form

$$h_{ik} = G_{gp} \frac{Q}{e} \frac{m_e}{c^2} \frac{1}{r} \frac{v_i}{c} \frac{v_k}{c} \qquad (22)$$

The potential derived from the metric of Eq. (22) is denoted as ***gravitophoton potential***. The constant for the gravitophoton field, G_{gp}, is analogous to the gravitational constant *G*.
The following relation holds

$$G_{gp} = \left(\frac{w_{gp}}{w_g} \right)^2 G \approx \frac{1}{67^2} G \ .$$

It is important to note that from the metric tensor components h_{ik},, Eqs. (20, 22), respective potentials for a moving charged particle and a gravitophoton particle can be obtained. However, the ratio between these two potentials is equal to the ratio of their *corresponding probability amplitudes*, and *not* of their coupling constants (probabilities). The reason for this is straightforward to observe. For instance, in Eq. (20), the product of two charges *e* and *Q* occurs. Their product is proportional to α. The respective *electrostatic potential* contains a *single charge* only, and thus the factor is $\sqrt{(\alpha)}$.

It is important to observe that the metric of Eq.(20) corresponds to a Lorentz force, where the first part of the metric, $eQ/r\, v_i/c$, is associated with the magnetic field and the second part, v_k^T/c with the velocity of a material body (in our experiment this is the rotating torus). Since the gravitophoton metric differs from the metric of Eq. (20) only by the factor α_{gp} / α the force that a single gravitophoton exerts is given by

$$\boldsymbol{F}_{gp} = \frac{\alpha_{gp}}{\alpha} e\, \mu_0 \boldsymbol{v}^T \times \boldsymbol{H} \qquad (23)$$

If the force acts on an electron, m_e has to be used, for a proton the mass m_p has to be inserted into α_{gp}. Gravitophotons can either be absorbed by electrons or by protons.

In order to get an appreciable gravitophoton force, a large number of gravitophotons per volume and time unit needs to be generated, see Figs. 1 and 2 for the experimental setup. The interesting fact is that Eq. (23) allows *both to control the magnitude and the sign* of the gravitophoton force. The gravitational action of a gravitophoton is similar to a graviton, except that gravitophotons can be generated through electromagnetic interaction and the force can reverse sign.

The question arises under which conditions gravitophoton fields exist that can propagate into the surrounding space. Following Heim [7], a brief description how to compute the probability amplitudes for the photon conversion into gravitophotons was presented in [1]. Similar to a dielectric, quantum theory and relativity require that for short times so called virtual pairs of electrons and positrons may be present in the vacuum. If there is an electric field present, suppose in form of a point charge, the positive charges of the virtual particles are displaced relative to the

negative ones, known as polarization of the vacuum. For large distances, r, this leads to a shielding of the point charge. In a macroscopic experiment one sees this shielded charge, whereas only for very small r, the bare, unshielded charge becomes visible. The scale of the spatial displacement is set by the length $\hbar/m_e c$, associated with the mass of the electron. The time of existence for a virtual electron-positron pair is about $\hbar/m_e c^2$, which is some 10^{-21} s.

3.6 The Physical Picture: From Photons to Gravitophotons

Before the force equations for the gravitophoton field are derived, i.e., their interaction with a material body, it is appropriate to present a qualitative picture of the transmutation of photons into gravitophotons. The gravitophoton field is a gravitational like field, except that it can be repulsive or attractive. It can both accelerate a material body and reduce its inertia. Any propulsion device therefore would be a two-stage system, first accelerating the body and then reducing the inertial mass of the body.

The *mathematical description* for the conversion process is given by the first equation in Eq. (24). In the following, the *physical mechanism* is presented, responsible for the conversion of photons into gravitophotons.

The physical mechanism for the generation of the postulated gravitophoton particles is based on the concept of vacuum polarization from QED. In QED the vacuum behaves like a dielectric absorbing and producing virtual particles.

The high current in the possibly superconducting coil produces a magnetic field $\boldsymbol{H}$ where v_k is the speed of the charge in the current loop or coil (Figs. 1 or 2, respectively). Together with the velocity v_k^T of the rotating torus, this magnetic field generates the conversion potential according to Eq. (22). This potential interacts with the virtual photons generated in the vicinity of each of the atomic nuclei (field point), comprising the material of the rotating torus.

The nuclei (positive charge) are continually emitting and absorbing virtual photons. Some of the photons create electron-positron pairs that subsequently annihilate. Virtual electrons are attracted, positrons are repelled by the positive charge of a nucleus, resulting in vacuum polarization. Thus the real positive charge is partially shielded and cannot be measured, until one is inside the shielding region. The positive charge is higher closer to the nucleus, since the shielding effect is reduced. The shielding distance is given by the Compton wavelength of the electron, which is $\lambda_C = \frac{\hbar}{m_e c} = 2.43 \times 10^{-12} m$. Therefore the probability amplitude, w_{ph}, which is proportional to the electron charge, will increase at distances smaller than λ_C. Virtual photons are the interaction particles between the electric field of a nucleus and the virtual electron. In addition, at the location of each nucleus, the coupling potential of Eq. (22) is effective. The higher the difference between the unshielded and the shielded probability amplitudes, w_{ph}, the higher the number of virtual photons, as shown in the second equation in Eq. (24). The number of virtual electrons is proportional to the number of virtual photons. Gravitophotons are emitted by the virtual electrons. Thus the number of gravitophotons should be proportional to the difference in the probability amplitudes. Hence, the conversion from photons to gravitophotons must take place close to the nucleus within the the shielding distance λ_C. In order to achieve this goal the conversion potential must be strong enough to generate a distance r, measured from the nucleus to the location of the virtual electron, that is much smaller than λ_C. This condition sets a strict requirement for the parameters determining the magnitude of the conversion potential, namely the velocities v_k^T and v_k.

The gravitophotons are subsequently absorbed by the protons in the torus which have a large absorption cross section compared to the electrons. In the non-relativistic case, the scattering cross section for photon-electron interaction is given by $\sigma = \frac{8\pi}{3} r_e^2$, see [27], where r_e is the clas-

sical electron radius, given by $r_e = \frac{1}{4\pi\epsilon_0}\frac{e^2}{m_e c^2} = w_{ph}^2 \frac{\hbar}{m_e c}$. For gravitophotons w_{ph} has to be replaced by Nw_{gp}, since in the conversion process from photon to gravitophoton, N gravitophotons are generated according to Eq. (24). It should be noted that the factor N does not occur in Eq. (23), since it depends on the conversion process. Thus the absorption cross section for a gravitophoton particle by a material particle (here the electron is used) is given as $\sigma_{gp} = \frac{8\pi}{3}(Nw_{gp})^4 \left(\frac{\hbar}{m_e c}\right)^2$. However, if the absorption is by a proton, the electron mass m_e is to be replaced by the proton mass m_p. Therefore the absorption cross section of a proton is larger by the factor m_p/m_e. Hence, *the absorption of gravitophotons by electrons can be neglected.*

In the next section, this formula will be used to calculate the strength of the gravitophoton field. To increase the strength of the interaction, a material containing hydrogen atoms should be used, because of the small value of r.

3.7 Force Equation on a Material Body exerted by Gravitophotons

In the *third and final stage* of our derivation, the bulk equations of motion for a material body exerted by gravitophoton particles need to be determined. To this end, Eqs. (24) are used

$$\begin{aligned} w_{ph}(r) - w_\kappa &= Nw_{gp} \\ w_{ph}(r) - w_{ph} &= Aw_{ph} \end{aligned} \qquad (24)$$

The first equation in (24) describes the production of N^2 gravitophoton particles[11] from photons with respect to so called conversion potential w_κ. This equation is obtained from Heim's theory in 8D space, in combination with a set algorithm, and predicts the conversion of photons into gravitophoton particles. In particular, it is emphasized that the metric for the photon, Eq. (12), already contains the metric for the gravitophoton particle, Eq. (11)[12].

The second equation in (24), obtained from QED, see [27], describes the screening of the charge of a nucleus by vacuum polarization through virtual electron-positron pair production. It should be noted that probability amplitudes correspond to physical potentials [26]. The coupling amplitude $w_{ph}(r)$ is the probability amplitude depending on the distance from the nucleus, and describes the partially shielded potential of the nucleus [26], Chap. 13. At distances larger than the Compton wavelength, $w_{ph}(r) = \frac{1}{\sqrt{(137)}}$ which is the square root of the fine structure constant α.

Next, the potentials corresponding to the probability amplitudes need to be identified :

1. $w_{ph}(r)$ is interpreted as the potential of the nucleus seen by a virtual electron, $\frac{1}{4\pi\epsilon_0}\frac{Ze}{r}$.
2. Since the potential in 1. is a scalar potential, the potential representing w_κ should also be a scalar potential. From the discussion in Section 3.5 the following potential is assumed:

$$\frac{1}{4\pi\epsilon_0}\frac{1}{m_e c^2}\frac{eQ}{R}\frac{v_i}{c}\frac{v_i^T}{c} \qquad (25)$$

This leads to the following equation between the associated potentials

$$\begin{aligned} &\frac{1}{4\pi\epsilon_0}\frac{1}{m_e c^2}\left(\frac{eZe}{r} - \frac{eQ}{R}\frac{v_i}{c}\frac{v_i^T}{c}\right) = \\ &\frac{Nw_{gp}}{w_{ph}}\frac{\alpha}{\alpha_{gp}} G_{gp}\frac{Q}{e}\frac{m_e}{c^2}\ \frac{1}{R}\ \frac{v_i}{c}\frac{v_i^T}{c} \end{aligned} \qquad (26)$$

11 The factor N^2 results from the fact that in Eq. (24) probability amplitudes are considered, but the generation of particles depends on actual probabilities.

12 This essential equation is stated without proof. The theory of the coupling constants is too comprehensive to be treated in this paper. However, since the metric of the photon contains the metric of the gravitophoton, this could be considered as some kind of evidence for the possibility of such a conversion.

where the factor α/α_{gp} is the ratio of the coupling constants of the electromagnetic and the gravitophoton force. Since the rhs of Eq. (26) is very small, it is treated as 0. This leads to the equation for r

$$r \approx \frac{Z e}{Q} R \frac{c}{v_i} \frac{c}{v_i^T} \tag{27}$$

From Eq. (27) it is obvious that in order to have a small value of r, that is $r < \lambda_C$, the total charge Q, the velocity of the charges v_i, and the rotation speed of v_i^T of the torus should be chosen as large as possible. The torus should also have material that contains hydrogen atoms.

In the next step, the unknown gravitophoton production factor Nw_{gp} has to be calculated. This factor comprises two terms, namely the absorption of the gravitophoton by an electron or by a proton. The absorption of gravitophotons by electrons is not taken into account, because of the much smaller absorption cross section.

From the physical model outlined in Section 3.7, it is concluded that the number of gravitophotons emitted is proportional to the number of virtual electrons, which depend direcly on the difference of the coupling amplitudes, second equation in (24). Therefore, it is assumed that the relation

$$Nw_{gp} = Aw_{ph} \tag{28}$$

holds. Here the proton mass is used. The function A is obtained from radiation correction , $A = \frac{2}{3\pi}\alpha \int_1^\infty e^{-2m_e r\xi}\left(1+\frac{1}{2\xi^2}\right)(\xi^2-1)^{1/2}/\xi^2 d\xi$,

i.e., from the virtual electron-positron pair shielding of the charge of the nucleus, for a derivation see [27].

For the emission of a gravitophoton by a virtual electron, the coupling constant is given by $w_{gpe}^2 = G_{gp}\frac{m_e^2}{\hbar c}$. For the absorption process the coupling constant has the form $w_{gpa}^2 = G_{gp} m_p \frac{m_e}{\hbar c}$.

Using the absorption cross section for protons from Section 3.7, the probability for this process is obtained as

$$w = \frac{32}{3}\left(Nw_{gp}\right)^4 \left(\frac{\hbar}{m_p c}\right)^2 \frac{d}{d_0^3} Z \tag{29}$$

With Eq. (29) the total force on the rotating torus can be determined. The first equation in (24) describes the conversion of photons into N gravitophotons. Therefore, α_{gp} *needs to be replaced by* $N^2\,\alpha_{gp}$.

$$\boldsymbol{F_{gp}} = w N^2 \frac{\alpha_{gp}}{\alpha} e\,\mu_0 \boldsymbol{v}^T \times \boldsymbol{H} \tag{30}$$

Multiplying Eq. (30) by probability w from Eq. (29) results in the total force of the gravitophotons on the rotating body

$$\boldsymbol{F_{gp}} = \Lambda_p e\,\mu_0 \boldsymbol{v}^T \times \boldsymbol{H} \tag{31}$$

where Λ_p indicates that only proton absorption processes were considered. From Eqs. (29) and (30) Λ_p is determined as

$$\Lambda_p = \frac{32}{3}\left(\frac{Nw_{gpe}}{w_{ph}}\right)^2 \left(Nw_{gpa}\right)^4 \left(\frac{\hbar}{m_p c}\right)^2 \frac{d}{d_0^3} Z \tag{32}$$

Λ_p (dimensionless) is a highly nonlinear function of the probability amplitude of the gravitophoton particle. d is the diameter of the torus, d_0 the diameter of the atom in its ground state, and Z denotes the atomic number of the atom.

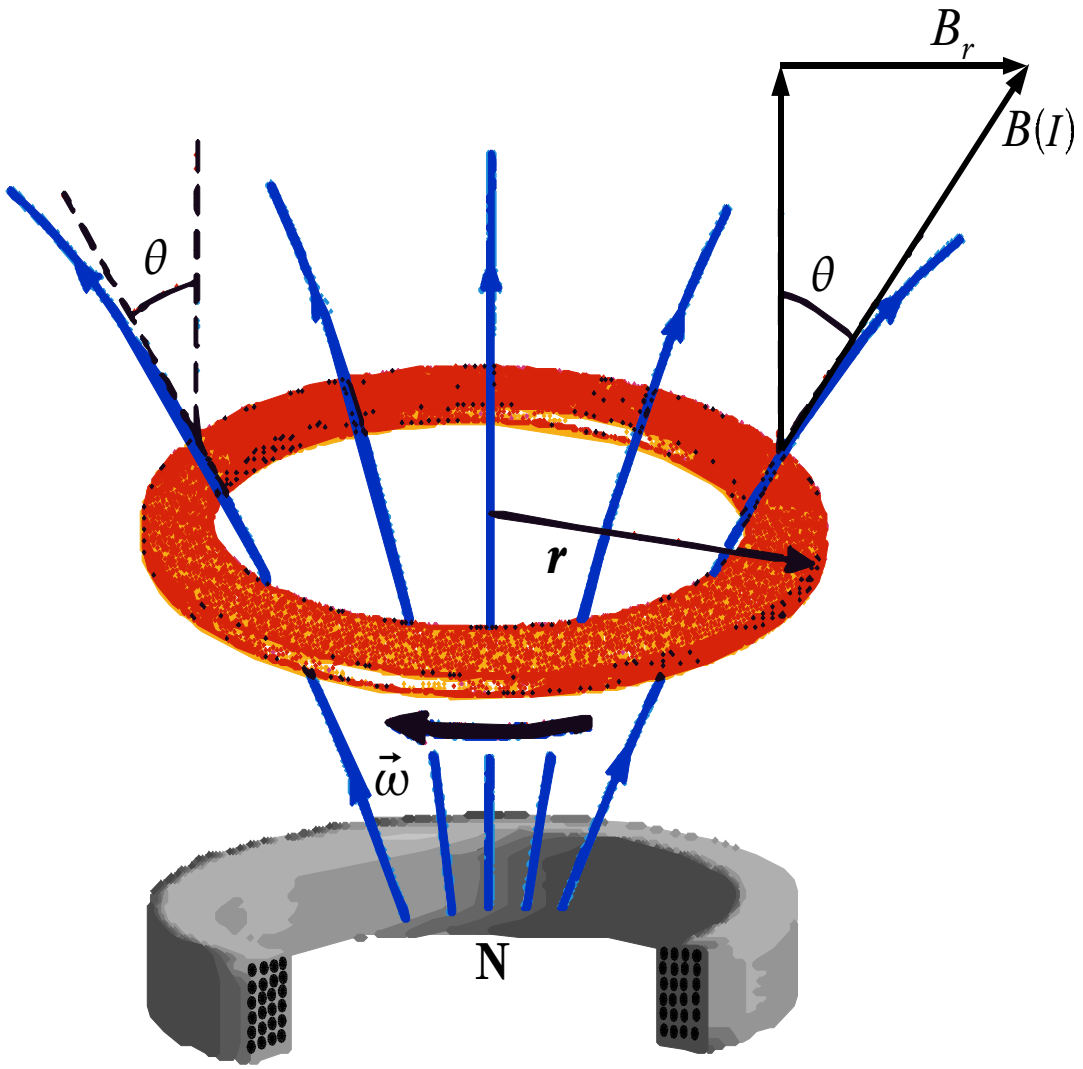

Figure 2: Instead of a simple current loop, a coil with many turns can be used. The field of this coil gives rise to an inhomogeneous magnetic field that has a radial field component. The radial component and the gradient in z-direction are related through $H_r = -\frac{r}{2}\frac{\partial H_z}{\partial z}$. It should be noted, however, that if the ring possesses a magnetic moment, M, there is a magnetic force in the z-direction of magnitude $F = M\frac{\partial H_z}{\partial z}$. This force does not depend on the rotation of the ring. For a diamagnetic material the force acts in the positive z-direction (up), while para- and ferromagnetic materials are drawn toward the region of increasing magnetic field strength (down). The gravitophoton force comes into play as soon as the ring starts rotating, and superimposes these effects. Perhaps equipment used to measuring magnetic moments can be employed to determine the gravitophoton force. For instance, if a diamagnetic substance is used, the gravitophoton force (down) could be used to balance the magnetic force, so that the resulting force is 0. From Refs. [23 and 24] it is found that a quartz sample (SiO_2, diamagnetic) of a mass of 10^{-3} kg experiences a force of 1.6×10^{-4} N in a field of B_z=1.8 T and a gradient of dB_z/dz=17 T/m. A calcium sample (paramagnetic) of the same mass would be subject to a force of -7.2×10^{-4} N. It is important that the material of the rotating ring is an insulator to avoid eddy currents.

For the experiment outlined in Section 4 it is assumed that a material ring of a given mass of some 100 kg (torus) is rotating in the *x-y* (or x_1-x_2) plane. Below that ring, a current *I* carrying a total charge *Q* is flowing through a magnetic coil, located in the *x-y* plane (see Fig. 12). According to Eq. (31) there should be an interaction between the moving charge *Q* (current through the magnetic coil) and the moving charges (electrons) of the rotation ring.

We therefore have shown, starting from Eq. (12), which describes the underlying metric for the electromagnetic interaction, that this metric can actually be used to produce the so called **Heim-Lorentz** force. Hence, the correspondence between metric and physical interaction has been demonstrated.

4 Experiment to determining the double Nature of the Gravitophoton field

The experiment comprises a rotating ring (torus) of a certain mass and a super-conducting magnetic coil, whose inner radius is small in comparison to its outer radius. Let the magnetic coil be located at a distance, d_T, below the torus. The circumferential speed, v^T, of the torus is supposed to be 10^3 m/s. The coordinate system is chosen such that the midpoint of the magnetic coil is at the origin. The torus rotates in the x-y plane, with the z-axis pointing upwards. It is assumed that the volume of the coil is sufficiently small, so that the retardation effect for all points within its volume may be neglected.

The *gravitophoton force on the rotating torus of mass* m_R is given by Eq.(32), which is surprisingly similar to the electromagnetic Lorentz force. It was termed the **Heim-Lorentz** force by these authors. This equation describes the complete conversion of magnetic field energy into kinetic energy. This equation is the basis for the *gedanken-experiment* depicted in Fig. 1. It should be noted that the sign of the force depends on the direction of the velocity of the rotating body. As a rule, the velocity of the charges in the current loop and the circumferential velocity of the rotating ring must be in opposite directions, see Fig. 1.

As numerical examples, four cases are investigated. It turns out that the Heim-Lorentz force is strongly nonlinear, and without proper adjustment of current *I*, rotation speed, and the proper number of turns for the magnetic coil, it cannot normally be observed.

Three different magnetic coils are considered, with 10^4, 10^5, and 10^6 turns. A wire-thickness of 1 mm (10^{-3} m) is chosen. The resulting magnetic induction is 1.2 T, 6.3 T, 20 T, and 50 T. The thickness of the torus (ring) is 0.05 m with a mass of 100 kg.

It is known that the current density decreases exponentially within a conductor. The *skin depth*, δ, measures, for a particular material and frequency, the depth at which the current density in the material has decreased to 1/e, compared to the value at the surface. The value 10^{-7} m was chosen for our example calculation. Together with an electron velocity of 10^3 m/s, this results in a total charge *Q* of 4×10^5 As. With a value of 0.5 m for d_R, Table shows the gravitophoton force acting on the rotating torus. Using a magnetic field strength of some 20 T, a force of some 44 N is obtained for a ring rotating at a speed of 10^3 m/s and a mass of 100 kg. At the very high magnetic field of 50 T the total force should be 2.7×10^3 N.

n	Nw_{gp}	$\mu_0 H$ (T)	F_{gp} (N)
10^4	2.6×10^{-14}	2.0	1.4×10^{-58}
10^5	1.1×10^{-5}	6.3	2.8×10^{-6}
10^6	1.5×10^{-4}	20.0	4.4×10^{1}
10^6	2.5×10^{-4}	50.0	2.7×10^{3}

Table1: The right most column shows the total gravitophoton force in Newton that would act on the rotating ring. The force results from both processes, namely the absorption of the gravitophoton by an electron and a proton. The absorption through a proton results in a much larger force, so that in principle the interaction of a gravitophoton with an electron, regardless whether real or virtual, can be neglected. The number of turns of the magnetic coil is denoted by n, the magnetic field is given in Tesla, and the current through the coil is 100 A, except for the last row where 250 A were used. The mass of the rotating torus is 100 kg, its thickness, *d* (diameter) 0.05m, and its circumferential speed is 10^3 m/s. The wire cross section is 1 mm^2. The meaning of the probability amplitude is given in the text. Because of the highly nonlinear character of Λ_p with respect to Nw_{gp}, the resulting force varies from actually 0 to 2.7g. It should be mentioned that there are type II superconductors that can sustain a magnetic field of up to 34 T[13].

The experiment described is based on two well known ingredients, namely a magnetic coil and a rotating body of mass or flywheel. The interaction is between the charges (electrons) flowing in the magnetic coil and the electrons of the atoms, rotating with the flywheel.

There is perhaps another way to measure the gravitophoton field, namely directly on the atomic scale. Eq. (23) describes the gravitophoton force between a single electron and a charge *Q*. Let us consider a single atom in a so called magnetic micro trap [21]. This trap comprises micro-electromagnets with micro-fabricated Cu-wires of a width of several μm through which a current is flowing. Special potentials can be produced to manipulate the atom that can move in the axial direction. According to Eq. (31) a gravitophoton force between the charges in the Cu-wire and the atom should occur. However, there is also a force acting on the magnetic moment of the atom because of the inhomogeneous magnetic field, which would superimpose the gravitophoton field. This experiment needs to be considered in more detail in order to find out, whether the gravitophoton force could be detected.

Another possible source for the gravitophoton field is on the cosmological scale. It is reported that neutron stars that are pulsars have a magnetic induction of some 10^8 T. Atoms or molecules moving in this very strong field should be subject to a gravitophoton force, resulting from Eq. (31). The question of course is, how to actually observe this effect, separated from all other forces. A neutron star of some 10 km diameter and a mass of about three times the sun's mass, may rotate rapidly at hundreds of revolutions per second [22].

5 Performance of the Gravitophoton Field as a Propulsion Device

In the following, we will do two gedanken-experiments for a gravitophoton propulsion device. First, we consider an interplanetary mission to Mars. Second, an interstellar mission to a planet 100 ly away from earth is discussed.

5.1 Interplanetary Mission

In order to use a gravitophoton device as a propulsion system that can launch a spacecraft from the surface of the earth into outer space, the gravitophoton field that acts normal to the plane of rotation should be able to lift the spacecraft, i.e., the acceleration of the spacecraft must be larger than *1 g* (9.8 m/s^2). Using these values, the magnetic induction of 50 T should be able to launch a spacecraft with a mass of 3×10^4 kg, accounting for losses, see Table 1. For a mission to Mars, whose average distance from earth is some 900 ls (light seconds), which amounts to a distance s of 2.7×10^{11} m. A non relativistic calculation leads to a flight time $t=\sqrt{\frac{2s}{g}}=1.6\times10^5 s$ for half of the distance, and a total flight time of 3.7 days. The peak velocity of the spacecraft would be some 1.5×10^6 m/s, which is, compared to chemical propulsion a

13 The most recent analysis, too late to be included in this paper, shows that substantially larger forces may occur if the recoil virtual electrons are subject to due to emission of gravitophotons is included in the momentum budget.

very high, but still non-relativistic speed. For this interplanetary mission, only the accelerative nature of the gravitophoton field has been used. In order to do an interstellar mission, superluminal speeds are necessary, which can only be achieved by the so called inertial transformation, where the gravitophoton field is used to reduce the inertial mass of the spacecraft by converting electromagnetic radiation into gravitophotons.

5.2 Interstellar Mission

The interstellar mission to a planet some 100 ly away from earth would take place in two stages. In stage one, lasting 30 days, the spacecraft reaches a speed of some *0.1c*, using gravitophoton acceleration. In stage two, the inertial mass of the spacecraft is reduced by a factor of 10^{-4}. To this end a magnetic field is needed that is of the same magnitude as during the acceleration phase. In addition, fine tuning is needed to reduce the gravitational field of the spacecraft. Because the ratio of the initial and the reduced inertial masses is proportional to the ratio of the final and initial velocities of the spacecraft (see [1], which follows directly from the conservation of momentum and energy), the final speed of the spacecraft is 10^3 *c*. The spacecraft would travel in some kind of hyperspace in which the speed of light $c' = 10^4 c$. The total travel time would be $0.1\ y + 2 \times 30\ d$, which is approximately 3 months. A return trip would be feasible in 6 months time. A major advantage would be that during 4 months, the astronauts would be subjected to an acceleration of *1 g*.

The question arises of what will happen to the astronaut flying at a cruising speed close or higher to the vacuum speed of light and eventually flying back to earth. The so called twin paradox should not play a role, since the denominator in the Lorentz transformation does not change, because $v'/c' = v/c$ where primed quantities denoted values in hyperspace. This relation follows directly from momentum conservation. Thus the question which twin aged more is not a relevant one.

SRT introduces the vacuum speed of light, *c*, as the upper speed limit. One might argue that exceeding the vacuum speed of light during an interstellar flight, might cause a change in the uncertainty relation $\Delta x \ \Delta p_x \geq \hbar$. Inserting the value *mc* for the uncertainty of the momentum leads to $\Delta x \geq \hbar / mc$, it is not the value of c, but the total momentum that restricts the uncertainty in the location. However, as was said before, an inertial transformation leaves the momentum of the vehicle unchanged.

Conclusions and Future Work

In the present paper an outline of some of the features of Heim's fully geometrized, unified field theory was given. The most important aspect is his discrete spacetime in 8 dimensions, with a minimal (quantized) surface element, the so called *Metron*. As a physical consequence, the universe started in a quantized bang, with well determined initial conditions. During the expansion of this primeval universe, the associated length scale became smaller. When the length scale reached the value of the so called Planck length, matter could be created, and a phase transition took place. According to Heim's formula for the mass spectrum for all existing particles, the heaviest particle, the *Maximon,* associated with this length scale, was generated. This effect took place at the same time at many locations in the primeval universe. The Maximon rapidly decayed, with the stable particles, namely electrons and protons along with high energy photons as end products. This decay process took place as some kind of inflationary process. Each of these Maximons was the cause of a new universe. Matter was not conserved, instead, the inflationary process was governed by Eq. (3) that allows to calculate the mass of our present universe, which is embedded in the primeval universe.

Heim's theory is an extension of Einstein's theory in that each physical interaction and its associated interaction particle is described in a quantized higher dimensional space. In other words, all forces and all material particles are of geometric origin. Elementary particles possess a complex dynamic structure that also exhibits zones within such a structure. In the 8-dimensional

space, termed Heim space by the authors, several metric subtensors can be formed. Each of these subtensors, called a *Hermetry* form, is responsible of a physical interaction or interaction particle [1]. When these metric subtensors are formed, two new additional interactions along with their interacting particles occur. One of these particles, termed the *gravitophoton*, is responsible for the reduction of the inertial mass of a material body (spacecraft). This physical effect would lead to an inertial transformation in the Lorentz matrix, that, in principle, allows for superluminal travel, because of the conservation of momentum and energy. The kinetic energy of the spacecraft, flying at a velocity greater than the vacuum speed of light, has not increased, since its inertial mass decreased. Otherwise, any spacecraft, flying at velocities close to *c,* would need an amount of kinetic energy that is impossible to supply and to pay for.

In that respect, the goals of NASA's *Breakthrough Physics Propulsion Program*, namely, *no fuel*, *superluminal speed*, and *no excessive amounts of energy* needed for a revolutionary space propulsion system can be met, provided, of course, that Heim's theory represents physical reality.

Again, as was said in [1], the authors are aware of several shortcomings in this paper. Not all of the physical features of Heim's theory were derived properly. Some of the conclusions are based on a somewhat speculative physical model concerning the generation of gravitophoton particles.

It should be mentioned that Heim's legacy is very large, several thousand pages, and his presentation style is not the one of contemporary physics. Heim uses his own terminology that needs to be translated into the language of modern physics. In addition, since his theory is completely geometric, there are many concepts that have no counterpart in modern physics. Whether his theory is actually true, can only be determined by experiment. One of the most important predictions is that of Section 4, exploiting the nature of the gravitophoton field.

In conclusion, it can be said that the gain, if this theory were true, will be close to *infinity,* while the probability of success may be close to *zero*, the product of these two numbers remains undetermined.

The risk, however, to investigate in the suggested experiment seems to be relatively low. If found to be true, a *genuine revolution of space flight* could be the outcome. Such a propulsion system might even be simpler than existing rockets, based on highly complex chemical propulsion.

Needless to say, if the proposed reduction in inertial mass could be confirmed by experiment, not only a revolution in space transportation, but also in ground transportation would take place.

Heim's theory currently is not mainstream physics, but it contains several highly interesting ideas, and its geometric origin of the physical world, is appealing, at least to the authors. As far as the authors understand Heim's theory (many of his calculations remained unchecked so far, simply because of the amount and the difficulty of his work), Heim seems to have achieved a consistent mathematical formulation that describes all physical interactions in geometrical terms. In that respect, he has realized Einstein's original idea, but ascribing space, namely the 8 dimensional Heim space (*3 real* coordinates comprising physical space and *5 imaginary* coordinates) many additional, unusual features.

Future work will focus on a more precise prediction of the gravitophoton field with emphasis on the experiment suggested in order to measure the reduction of inertial mass. Computations will be refined to give a better prediction of the performance of the proposed propulsion device. Furthermore, the physical model underlying this propulsion system will be given a more extensive description.

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Glossary

aeon Denoting an indefinitely long period of time. The aeonic dimension can be interpreted as steering structures governed by the *entelechial* dimension toward a dynamically stable state.

anti-hermetry Coordinates are called anti-hermetric if they do not deviate from Cartesian coordinates, i.e., in a space with anti-hermetric coordinates no physical events can take place.

condensation For matter to exist, as we are used to conceive it, a distortion from Euclidean metric or condensation, a term used by Heim, is a necessary but not a sufficient condition.

condensor The Christoffel symbols $\Gamma^{i}_{k\,m}$ become the so called condensor functions, $\varphi^{i}{}_{km}$, that are normalizable. This denotation is derived from the fact that these functions represent *condensations* of spacetime metric. A condensor corresponds to a physical force.

coupling constant Value for creation and destruction of messenger (virtual) particles, relative to the strong force (whose value is set to 1 in relation to the other coupling constants).

coupling potential (Kopplungspotential) The coupling potential is the first term of the metric in Eq. (12), denoted as $g^{(gp)}_{ik}$. The reason for using the superscript *gp* is that this part of the photon metric equals the metric for the gravitophoton particle and that a sieve (conversion) operator exists, which can transform a photon into a gravitophoton by making the second term in the metric anti-hermetric. In other words, the electromagnetic force can be transformed into a gravitational like force, and thus can be used to reduce the inertial mass of a material body.

cosmogony (Kosmogonie) The creation or origin of the world or universe, a theory of the origin of the universe (derived from the two Greek words kosmos (harmonious universe) and gonos (offspring)).

entelechy (Greek *entelécheia*, objective, completion) used by Aristotle in his work *The Physics.* Aristotle assumed that each phenomenon in nature contained an intrinsic objective, governing the actualization of a form-giving cause. The entelechial dimension can be interpreted as a measure of the quality of time varying organizational structures (inverse to entropy, e.g., plant growth) while the aeonic dimension is steering these structures toward a dynamically stable state. Any coordinates outside spacetime can be considered as steering coordinates.

eschatology Concerned with the final events in the history of the universe.

fundamental kernel (Fundamentalkern) Since the function $\kappa^{(\alpha)}_{i\,m}$ occurs in $x^{(\alpha)}_{m} = \int \kappa^{(\alpha)}_{i\,m}\, d\,\eta_{i}$ as the kernel in the integral, it is denoted as fundamental kernel of the *poly-metric*.

geodesic zero-line process This is a process where the square of the length element in a 6- or 8-dimensional Heim space is zero.

gravitational limit(s) There are three distances at which the gravitational force is zero. First, at any distance smaller than $R\_$, the gravitational force is 0. Second,

gravitophoton field Denotes a gravitational like field, represented by the metric sub-tensor, $g_{ik}^{(gp)}$, generated by a neutral mass with a smaller coupling constant than the one for gravitons, but allowing for the possibility that photons are transformed into gravitophotons. This field can be used to reduce the gravitational potential around a spacecraft.

graviton (Graviton) The virtual particle responsible for gravitational interaction.

Heim-Lorentz force Resulting from the newly predicted gravitophoton particle that is a consequence of the Heim space $\mathbb{R}^8$. A metric subtensor is constructed in the subspace of coordinates I^2, S^2 and T^1, denoted as hermetry form H_5, see [1, 5, 6]. The equation describing the Heim-Lorentz force has a form similar to the electromagnetic Lorentz force, except, that it exercises a force on a *moving body of mass m*, while the Lorentz force acts upon moving charged particles only. In other words, there seems to exist a direct coupling between matter and electromagnetism. In that respect, matter can be considered playing the role of charge in the Heim-Lorentz equation. The force is given by w $\boldsymbol{F}_{gp} = \Lambda_p e \mu_0 \boldsymbol{v}^T \times \boldsymbol{H}$. Here Λ_p is a coefficient, $\boldsymbol{v}$ the velocity of a rotating body (insulator) of mass *m*, and **H** is the magnetic field strength. It should be noted that the gravitophoton force is 0, if velocity and magnetic field strength are perpendicular. Thus, any experiment that places a rotating disk in a uniform magnetic field that is oriented parallel or anti-parallel to the axis of rotation of this disk, will measure no effect.

hermetry form (Hermetrieform) The word hermetry is an abbreviation of *hermeneutics*, in our case the semantic interpretation of the metric. To explain the concept of a hermetry form, the space $\mathbb{R}_6$ is considered. There are 3 coordinate groups in this space, namely $s_3 = (\xi_1, \xi_2, \xi_3)$ forming the physical space $\mathbb{R}^3$, $s_2 = (\xi_4)$ for space T^1, and $s_1 = (\xi_5, \xi_6)$ for space S_2. The set of all possible coordinate groups is denoted by $S = \{s_1, s_2, s_3\}$. These 3 groups may be combined, but, as a general rule (stated here without proof, derived, however, by Heim from conservation laws in $\mathbb{R}^6$, (see p. 193 in [2])), coordinates ξ_5 and ξ_6 must always be curvilinear, and must be present in all metric combinations. An allowable combination of coordinate groups is termed *hermetry form*, responsible for a physical field or interaction particle, and denoted by *H*. *H* is sometimes annotated with an index, or sometimes written in the form $H = (\xi_1, \xi_2, ...)$ where $\xi_1, \xi_2, ... \in S$. This is a symbolic notation only, and should not be confused with the notation of an n-tuple. From the above it is clear that only 4 hermetry forms are possible in $\mathbb{R}^6$. A 6 space only contains gravitation and electrodynamics. It needs a Heim space $\mathbb{R}^8$ to incorporate all known physical interactions. Hermetry means that only those coordinates occurring in the hermetry form are curvilinear, all other coordinates remain Cartesian. In other words, *H* denotes the subspace in which physical events can take place, since these coordinates are non-euclidean. This concept is at the heart of Heim's geometrization of all physical interactions, and serves as the *correspondence principle* between geometry and physics.

hermeneutics (Hermeneutik) The study of the methodological principles of interpreting the metric tensor and the eigenvalue vector of the subspaces. This semantic interpretation

of geometrical structure is called hermeneutics (from the Greek word to interpret).

hermitian matrix (self adjoint, selbstadjungiert) A square matrix having the property that each pair of elements in the *i*-th row and *j*-th column and in the *j*-th row and *i*-th column are conjugate complex numbers ($i \rightarrow -i$). Let A denote a square matrix and A^* denoting the complex conjugate matrix. $A^\dagger := (A^*)^T = A$ for a hermitian matrix. A hermitian matrix has real eigenvalues. If A is real, the hermitian requirement is replaced by a requirement of symmetry, i.e., the transposed matrix $A^T = A$.

homogeneous The universe is everywhere uniform and *isotropic* or, in other words, is of uniform structure or composition throughout.

inertial transformation (Trägheitstransformation) Such a transformation, fundamentally an interaction between electromagnetism and the gravitational like gravitophoton field, reduces the inertial mass of a material object using electromagnetic radiation at specific frequencies. As a result of momentum and energy conservation in 4-dimensional spacetime, $v/c = v'/c'$, the Lorentz matrix remains unchanged. It follows that $c < c'$ and $v < v'$ where v and v' denote the velocities of the test body before and after the inertial transformation, and c and c' denote the speeds of light, respectively. In other words, since c is the vacuum speed of light, an inertial transformation allows for *superluminal speeds*. An inertial transformation is possible only in a 8-dimensional Heim space, and is in accordance with the laws of SRT. In an Einsteinian universe that is 4-dimensional and contains only gravitation, this transformation does not exist.

isotropic The universe is the same in all directions, for instance, as velocity of light transmission is concerned measuring the same values along axes in all directions.

partial structure (Partialstruktur) For instance, in $\mathbb{R}_6$, the metric tensor that is hermitian comprises three non-hermitian metrics from subspaces of $\mathbb{R}^6$. These metrics from subspaces are termed partial structure.

poly-metric The term poly-metric is used with respect to the composite nature of the metric tensor in 8D Heim space. In addition, there is the twofold mapping $\mathbb{R}^4 \rightarrow \mathbb{R}^8 \rightarrow \mathbb{R}^4$.

quantized bang According to Heim, the universe did not evolve from a hot big bang, but instead, spacetime was discretized from the very beginning, and such no infinitely small or infinitely dense space existed. Instead, when the size of a single *Metron* covered the whole (spherical volume) universe, this was considered the beginning of this physical universe. That condition can be considered as the mathematical initial condition and, when inserted into Heim's equation for the evolution of the universe, does result in the initial diameter of the original universe [1]. Much later, when the *Metron* size had decreased far enough, did matter come into existence as a purely geometrical phenomenon.

transformation operator or sieve operator (Sieboperator) The direct translation of Heim's terminology would be *sieve-selector*. A transformation operator, however, converts a photon into a gravitophoton by making the coordinate ξ_4 Euclidean.

unitary matrix (unitär) Let A denote a square matrix, and A^* denoting the complex conjugate matrix. If $A^\dagger := (A^*)^T = A^{-1}$, then A is a unitary matrix, representing the generalization of the concept of orthogonal matrix. If A is real, the unitary requirement is replaced by a requirement of orthogonality, i.e., $A^{-1} = A^T$. The product of two unitary matrices is unitary.

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