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# Reconsidering Gravity as Dynamic Phenomenon

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## Abstract

The purpose of this paper is to explore gravity as a dynamic phenomenon where the gravitational effects described by the Schwarzschild metric are transferred to changes in the quantities of time, length, velocity, acceleration, mass, energy, force as well as the electric and magnetic field constant. These changes are assumed to be physically real and not just a superficial effect of the used coordinate system. Using these malleable quantities various calculations can be done in ordinary orthogonal space again which were regarded as requiring curved space, as demonstrated by applying those malleable quantities to the typical tests of general relativity. This endeavour also uncovers how the formula for Newtonian gravity has to be extended to properly explain the perihelion precession of planets. Moreover, formerly concealed connections between Newtonian gravity and the theory of general relativity are revealed, in particular gravitational potential energy is identified as a change in mass energy. Thereafter a quantum gravity approach is put forward, as originally proposed by John A. Macken, which provides clues to how gravity can be expressed on the quantum level with a classical wave based approach that uses the 'acoustic' impedance of space. In that context the electrostatic and magnetic force are also reexamined, since they exhibit an unexpected mathematical similarity to gravity.

*Keywords: gravity; gravitational potential; space; general relativity; Schwarzschild metric; special relativity; time dilation; Planck units; Planck force; quantum physics; light speed; relativistic mass; refraction; waves; perihelion precession; light bending; redshift*

## 1 Introduction

Ever since the theory of general relativity has been seemingly affirmed beyond doubt by experimental evidence, the notion that an unified as well as curved space-time is responsible for gravity is not questioned any more by most physicists, particularly since special relativity and classical Newtonian gravity can also be derived from the equations of general relativity as limiting cases. The general theory of relativity is certainly a useful tool that brought up new ideas about space, time and the evolution of our universe, but its suppositions are not proven irrefutably. For example, time is phenomenologically distinct from space and there is no good conceptual justification for treating time like an additional spatial dimension, except that it works out nicely mathematically. Moreover, experimental evidence for the physical reality of curved space is still sparse since proving it requires very sensitive experiments and therefore the most compelling evidence for spacetime curvature still seems to be the perihelion precession of the planet Mercury, which could not be explained satisfactorily before general relativity, and gravitational light bending. There are, however, ways to explain the typical tests of general relativity in other ways as will be demonstrated later on. To achieve this it is necessary to derive dynamic quantities for time, length, velocity, energy and mass from the line element of the Schwarzschild metric, which here is considered to be applicable in general to static and spherically symmetric bodies, and not only to black holes. For those bodies the Schwarzschild radius is simply not reachable because it lies inside the object. Naturally, the question that follows from assuming malleable quantities is what mechanism allows those dynamic properties to arise? We definitely need to look for a framework that is already dynamical in nature and a wave based quantum gravity, which is embedded in some kind of medium that can also carry gravitational waves and light, might be what is needed. However, it should be emphasized that this paper does not disavow any physical effects predicted by general relativity theory. Before venturing deeper into this paper, though, it is sensible to first establish a few prerequisites.

## 2 Prerequisites

The Planck units are used extensively in the quantum gravity sections of this paper, in particular the Planck mass  $m_l$ , Planck length  $l_l$  and the Planck force  $F_l = c^4/G$ , which may also be called the super force. This is a term coined by Salvatore Pais that emphasizes the extreme strength of the Planck force. The definitions of the Planck units, as well as the values of the natural constants used in this paper, can be found in appendix A.

### 2.1 Relativistic particle energy

The total special relativistic energy for an object with rest mass  $m$  that possesses a velocity  $v$  can be stated as  $E_\gamma = \sqrt{(mc^2)^2 + (\gamma mvc)^2}$ , whereby the relativistic Lorentz factor is defined as  $\gamma = 1/\sqrt{1 - v^2/c^2}$  and light speed is denoted as  $c$ . For spin  $\frac{1}{2}$  particles which possess a Compton wavelength  $\lambda_c = h/(mc)$  it is also possible to define their total relativistic energy using their Compton wavelength and their de Broglie wavelength  $\lambda_{dB} = h/(mv)$ , but it is more sensible to use their frequency counterparts  $f_c = c/\lambda_c$  as well as  $f_{dB} = c/\lambda_{dB}$  and to combine those into a novel frequency  $f_\gamma = \sqrt{f_c^2 + \gamma^2 f_{dB}^2}$ , which I refer to as the Lorentz frequency, for describing total special relativistic energy, as originally shown in (1).

$$E_\gamma = h\sqrt{f_c^2 + \gamma^2 f_{dB}^2} = hf_\gamma \quad (2.1)$$

The last equation suggests that the special relativistic energy of a spin  $\frac{1}{2}$  particle is stored intrinsically to the particle, contrary to the currently prevalent opinion in physics. This assertion might also be related to the notion of Doppler shifted waves, as proposed by John A. Macken (4)(5). Moreover, it is shown in (1), (3), (4) and (5) that spin  $\frac{1}{2}$  particles possess an equatorial perimeter speed of  $c$ , from which it follows that a spin  $\frac{1}{2}$  particle's relativistic radius is given by  $r_\gamma = c/(2\pi f_\gamma)$  or that its size is at least proportional to that radius by a constant factor. This, in turn, leads to the controversial situation that electrons should be bigger than protons, a topic which is also discussed in the aforementioned papers. In case a spin  $\frac{1}{2}$  particle is at standstill  $r_\gamma$  equals the so called reduced Compton wavelength  $\lambda_c/2\pi$ , since its de Broglie frequency will be zero, and its Lorentz frequency  $f_\gamma$  simply equals its unchanging Compton frequency  $f_c$ . Moreover, spin  $\frac{1}{2}$  particles should exhibit a Lorentz frequency increase as they move faster since then their total relativistic energy  $E_\gamma$  is increasing, which in turn implies that they are shrinking as they move faster since their equatorial perimeter speed cannot exceed light speed  $c$ .

### 2.2 Properties of space

The energy density of space itself is given by

$$\rho_s = \frac{1}{2} \frac{m_l}{l_l^3} = 2.57759 \times 10^{96} \text{ kg/m}^3 \quad (2.2)$$

as proposed in (1). This huge energy density is consistent with the so called zero point energy of quantum physics which presumably is caused by tiny Planck oscillators that space is comprised of. Subsequently, the "acoustic" impedance of space itself, in which gravitational waves are propagating with light speed  $c$ , evaluates to

$$Z_s = \rho_s c = \frac{c m_l}{2 l_l^3} = \frac{c^3}{2G l_l^2} = 7.72742 \times 10^{104} \text{ s Pa/m} \quad (2.3)$$

as originally shown in (2). Moreover, the impedance of space can also be specified without the Planck units, in which case it takes on the form  $Z_s = 1/(2\hbar) (c^3/G)^2$ . The gigantic value resulting from these formulas for  $Z_s$  implies that space has a huge stiffness, which is why even gravitational waves that were caused by black holes are barely detectable by highly sophisticated measurement equipment.

Physics literature usually denotes the impedance of space as  $c^3/G$ , for example in (11), which is also the expression that John Macken uses in his works (4)(5). This alternative expression for the impedance of space is equivalent to the one stated in equation 2.3 when using it in wave equations together with a dimensionless strain amplitude instead of an amplitude which is defined in an unit of length. In this paper, however,  $Z_s$  is always used as expressed in equation 2.3 so that an ordinary amplitude, specified in an unit of length, can be used for wave equations that involve  $Z_s$ .

Interestingly, the impedance of space can also be specified in terms of the Hubble mass  $m_H$  and Hubble radius  $r_H$ , i.e.  $c^3/G \cong 2cm_H/r_H$  and  $Z_s \cong 4\pi c^2 m_H^2/(r_H^2 \hbar)$ . Whether these relations are exact, or only approximate, remains to be seen. In any case, however, the various formulations for the impedance of space indicate that the microscopic quantum world, the macroscopic world as well as the cosmological world are connected through the impedance of space.

## 2.3 Scope

This paper operates within a space-time as described by the so called Schwarzschild metric, from a general relativity point of view, i.e. the gravitational effects of rotating masses are not covered. Consequently, the appropriate line element is associated with a non-rotating non-moving spherically symmetric homogenous and dominant central mass  $M$  which can be stated in polar coordinates as follows,

$$ds^2 = - \left(1 + \frac{2\Phi}{c^2}\right) c^2 dt^2 + \left(1 + \frac{2\Phi}{c^2}\right)^{-1} dr^2 + r^2 d\Theta^2 + r^2 \sin^2(\Theta) d\phi^2 \quad (2.4)$$

whereby  $\Phi$  denotes the classical Newtonian gravitational potential

$$\Phi = -GM/r \quad (2.5)$$

Using the following dimensionless factor to quantify gravitational effects

$$\Gamma = 1/\sqrt{1 - 2GM/(r c^2)} \quad (2.6)$$

the aforementioned line element can also be rewritten as follows

$$ds^2 = -(1/\Gamma^2) c^2 dt^2 + \Gamma^2 dr^2 + r^2 d\Theta^2 + r^2 \sin^2(\Theta) d\phi^2 \quad (2.7)$$

whereby the factor  $\Gamma$  practically equals 1.0 far away from the central mass  $M$  and slowly increase in value towards that mass. In close vicinity to the Schwarzschild radius  $r_s = 2GM/c^2$  associated with a mass  $M$  the value of  $\Gamma$  starts to increase faster until it finally reaches positive infinity at  $r_s$ . The region inside a black hole is not treated in this paper.

## 3 Dynamic gravitation

Using the aforementioned line element it is possible to explore how the quantities of frequency, time duration, energy, length, speed, acceleration, mass and force are changing inside the gravitational field of a mass  $M$  and to derive the appropriate scaling factors. This endeavour is motivated by the presumption that those changes are physically real, which in the case of gravitational time dilation is universally accepted by physicists and proven experimentally. Consequently, it is only logical to extend that notion to other physical quantities. Please note that in the following sections the subscript  $f$  always denotes a physical quantity infinitely far away from the gravitational field of  $M$  and the subscript  $\Gamma$  denotes a physical quantity within its gravitational field, whereby the mass  $M$  always denotes a non-rotating non-moving dominant spherical mass with a homogeneous density. Linear approximations are always preceded by a  $\cong$  sign hereafter.

### 3.1 Time

As proven experimentally clocks run slower near a large mass than far away from it. The following table contains an example of this gravitational time dilation for an extreme black hole scenario with  $\Gamma = 10$ .

	Near	←	Far
Frequency	1 Hz	$1/\Gamma$	10 Hz
Period	1 s	$\Gamma$	0.1 s

Table 1: Example with  $\Gamma = 10$

This table shows that while a needle watch completes 10 turns far away from a black hole it only does complete 1 turn close to the black hole, as observed from far away, when  $\Gamma = 10$ . From this example we can infer that frequencies change as follows inside the gravitational field of a mass  $M$ :

$$f_\Gamma = f_f / \Gamma \cong \left(1 - \frac{GM}{r c^2}\right) f_f \quad (3.1)$$

Since a certain time period and its associated frequency are always inversely related a time duration  $\Delta t$ , like a full clock period, changes inside the gravitational field of a mass  $M$  according to:

$$\Delta t_\Gamma = \Delta t_f \Gamma \cong \left(1 + \frac{GM}{r c^2}\right) \Delta t_f \quad (3.2)$$

### 3.2 Energy

The factor  $\Gamma$  can also be formulated in terms of an escape velocity  $s = \sqrt{2GM/r}$  as follows for a scenario with a central non-rotating non-moving homogeneous spherical mass  $M$ .

$$\Gamma = \frac{1}{\sqrt{1 - s^2/c^2}} \quad (3.3)$$

Interestingly, this equation looks very similar to the Lorentz factor  $\gamma$ , which is also used for special relativistic energy calculations.

$$\gamma = \frac{1}{\sqrt{1 - v^2/c^2}} \quad (3.4)$$

This congruence gives rise to the supposition that  $\Gamma$  should be relevant for describing the presumed change in the quantity of energy inside a gravitational field. Since energy terms of the form  $E = hf$  are applicable to spin  $\frac{1}{2}$  particles as well as photons, and Planck's constant  $h$  is assumed to be independent of gravity, it can be inferred using equation 3.1 that energy must in general scale as follows inside a gravitational field:

$$E_\Gamma = E_f/\Gamma \cong \left(1 - \frac{GM}{rc^2}\right) E_f \quad (3.5)$$

Extending equation 2.1 in the same way the mass energy of a spin  $\frac{1}{2}$  particle can be expressed as follows,

$$E_\Gamma = hf_\gamma/\Gamma = h\sqrt{f_c^2/\Gamma^2 + (\gamma^2/\Gamma^2)f_{dB}^2} = h\sqrt{(1 - s^2/c^2)f_\gamma^2} = hf_\Gamma \quad (3.6)$$

whereby  $f_\gamma$ ,  $f_c$  and  $f_{dB}$  keep their respective meaning and are therefore defined in the absence of a gravitational field. A decreasing mass energy due to gravity seems to be concerning at first glance, but this change is assumed to be undetectable locally, as discussed later on, and moreover lost mass energy is accounted for by a changing gravitational potential energy, as shown in section 5.1.

### 3.3 Length

Since the scaling behaviour of length should be inverse to the scaling of a time duration, according to the line element described by equation 2.7, a reasonably small length element  $\Delta d$  should scale as follows inside the gravitational field of a mass  $M$  under consideration of equation 3.2.

$$\Delta d_\Gamma = \Delta d_f/\Gamma \cong \left(1 - \frac{GM}{rc^2}\right) \Delta d_f \quad (3.7)$$

This result implies that a ruler which had a length of 1 m outside of a gravitational field shrinks to 0.1 m at a location where  $\Gamma = 10$  over the extend of that ruler, as observed from outside of the gravitational field. In this interpretation for the effect of gravity on length there is no need for a curved space and thus the three dimensions of space can be regarded as remaining orthogonal inside a gravitational field. Consequently, from the perspective of an object falling into a gravitational field it appears as if the whole universe is expanding.

### 3.4 Velocity

A velocity  $v = \Lambda f$  can be calculated using a wavelength  $\Lambda$ , which qualifies as a length element, and a frequency  $f$ . Subsequently, considering equation 3.2 and 3.7 it can be said that any given velocity scales as follows in the gravitational field of a mass  $M$  when assuming no net acceleration influence due to gravity or other forces.

$$v_\Gamma = v_f \frac{1}{\Gamma} \frac{1}{\Gamma} = v_f/\Gamma^2 \cong \left(1 - \frac{2GM}{rc^2}\right) v_f \quad (3.8)$$

Since the  $\Gamma$  factors don't cancel out here a velocity which should be constant according to classical physics is effectively getting reduced inside a gravitational field, as observed from outside the gravitational field. This also implies that a moving object which gets very close to a black hole horizon is freezing in its motion, as observed from far away.

The scaling behaviour for velocity is universal and therefore also applies to light rays. Consequently, the scaling behaviour for the speed of light in a gravitational field of a mass  $M$  is described as follows, whereby the letter  $c$ , without any subscript, still denotes the usual constant speed of light to avoid confusion and to retain the common convention, but  $c$  now has to be defined in the absence of a gravitational field to be unambiguous, i.e.  $c = c_f$ .

$$c_\Gamma = c/\Gamma^2 \cong \left(1 - \frac{2GM}{rc^2}\right) c \quad (3.9)$$

Distances measured using light rays will thus change, i.e. deeper inside a gravitational field they become shorter, in accordance with the findings of the previous section. However, since measurement devices themselves also experience changes in length and time inside a gravitational field it is not possible to measure the slowdown of light locally. For example, imagine a rocket flying at constant speed in a region of space with  $\Gamma = 2$ , for which special relativistic time dilation is negligible (i.e.  $\gamma \cong 1$ ), to traverse a certain distance measured in meters that is established using a light ray that travels for a certain time duration. The rocket's velocity will be 1/4th compared to the speed it would have outside of the gravitational field, however, a clock inside the rocket is running at a halved rate, compared to outside the gravitational field, and the distance is also half as long comparatively. Thus these effects cancel out for an observer inside the rocket, which should also be the case locally for all other scaling behaviours caused by a gravitational field. Whilst the slowdown in the speed of light is not measurable locally the bent trajectory of light that passes by close to a large mass is likely the result of that change in the speed of light. To illustrate this purpose the last equation can be easily reformulated into a refractive index  $n$  which can be used to calculate said light bending - see section 4.2 for more details.

$$n = \frac{c}{c_\Gamma} = \Gamma^2 \cong \left(1 + \frac{2GM}{r c^2}\right) \quad (3.10)$$

A higher refraction index  $n$  usually, but not always, denotes a denser medium and the linear approximation of  $n$  shows that the refractive index is increasing towards a gravitational source  $M$ . If this implies that the energy density of space is increasing towards a mass  $M$  is not clear yet and we should be careful to not take the optical analogy too far, as that might be misleading.

The knowledge about a changing speed of light now allows to consider what happens to the size of a spin  $\frac{1}{2}$  particle, whose radius inside a gravitational field, as observed from outside of it, must be given by  $r_\Gamma = c_\Gamma / (2\pi f_\Gamma)$ , which is a logical extension of the special relativistic radius  $r_\gamma = c / (2\pi f_\gamma)$ . Consequently, the size of a spin  $\frac{1}{2}$  particle also scales like a length element as specified by equation 3.7, i.e. it shrinks as observed from outside of the gravitational field it is in.

### 3.5 Mass

Since mass can be stated as  $m = E/c^2$  the scaling behaviour for a mass  $m$  inside the gravitational field of a mass  $M$  is given as follows under consideration of equation 3.5 as well as 3.9.

$$m_\Gamma = m_f \frac{1}{\Gamma} \frac{\Gamma^4}{1} = m_f \Gamma^3 \cong \left(1 + \frac{3GM}{r c^2}\right) m_f \quad (3.11)$$

Thus objects effectively gain mass as they move deeper into a gravitational field, as observed from outside of the gravitational field.

### 3.6 Local force

Since force can be stated as  $F = E/\Delta d$  the scaling behaviour for a force  $F$  inside the gravitational field of a mass  $M$  is given as follows under consideration of equation 3.5 as well as 3.7.

$$F_\Gamma = F_f \frac{1}{\Gamma} \frac{\Gamma}{1} = F_f \quad (3.12)$$

Interestingly, force is an unchanging quantity, whereas even energy is changing within a gravitational field. For example, when a space probe is leaving the gravitational field of a planet by using a chemical thruster that can only operate with an unchanging chemical reaction the force of that thruster will remain constant during the space probe's journey, as observed locally as well as from outside of the gravitational field.

However, there is something strange going on with the Newtonian gravitational force  $F_g = G M m/r^2$ , which seems to violate the independence for a force from  $\Gamma$  unless  $G$  gets adapted too. Sticking to the convention that  $\Gamma$  is linked to the mass  $M$  and that force should be unchanging the adapted equation for the Newtonian gravitational force then looks as follows when writing the  $\Gamma$  factors explicitly.

$$F_g = \frac{G}{\Gamma^5} \frac{M}{1} \frac{\Gamma^3 m_f}{1} \frac{\Gamma^2}{r_f^2} \quad (3.13)$$

This arrangement implies that the gravitational constant  $G$  varies with  $1/\Gamma^5$ . However, this simple approach could be flawed since the expression  $\Gamma/r_f$  might be an inappropriate measure for distance as  $\Gamma$  varies with distance from  $M$ . Therefore section 3.3 also stated that equation 3.7 only applies to reasonably small length elements over which  $\Gamma$  is practically constant.

### 3.7 Acceleration

Since acceleration can be stated as  $a = F/m$  the scaling behaviour for an acceleration  $a$  inside the gravitational field of a mass  $M$  is given as follows under consideration of equation 3.11 as well as 3.12 when assuming no net jerk influence due to changing gravity or other changing forces.

$$a_{\Gamma} = a_f / \Gamma^3 \cong \left(1 - \frac{3GM}{r c^2}\right) a_f \quad (3.14)$$

This equation, together with the gravitational scaling of mass, implies that objects get more inert as they go deeper into a gravitational field, as observed from outside of the gravitational field.

### 3.8 Electric & magnetic field constant

Since the electric field constant  $\epsilon_0$  and magnetic field constant  $\mu_0$  are related to light speed  $c$  by  $1/c^2 = \epsilon_0 \mu_0$  the electric and magnetic field constant must also change inside a gravitational field when considering equation 3.9. Subsequently, we get  $c_{\Gamma}^2 = c^2 / \Gamma^4 = 1/(\Gamma^2 \epsilon_0) 1/(\Gamma^2 \mu_0)$ , when assuming a symmetrical distribution of the  $\Gamma$  factor, which in turn leads to the following equations:

$$\epsilon_{\Gamma} = \Gamma^2 \epsilon_0 \cong \left(1 + \frac{2GM}{r c^2}\right) \epsilon_0 \quad (3.15)$$

$$\mu_{\Gamma} = \Gamma^2 \mu_0 \cong \left(1 + \frac{2GM}{r c^2}\right) \mu_0 \quad (3.16)$$

An identical result was obtained by Harold Puthoff using a polarized vacuum approach (13).

### 3.9 Alternative to $\Gamma$

Kris Krogh devised an alternative for  $\Gamma$  which uses Euler's number and also applies to a non-rotating non-moving dominant homogeneous spherical mass  $M$  (8).

$$\exp\left(\frac{GM}{r c^2}\right) = \exp\left(\frac{-\Phi}{c^2}\right) \cong \Gamma \quad (3.17)$$

This alternative to  $\Gamma$  might turn out to be interesting for further research on gravity, as its approximation differs from the approximation of  $\Gamma$  for powers of  $r$  beyond one.

## 4 Tests

### 4.1 Redshift & blueshift

The gravitational change of a length segment as specified in equation 3.7 matches with the equation for gravitational redshift, i.e.

$$z + 1 = \frac{\lambda_f}{\lambda_{\Gamma}} = \Gamma \quad (4.1)$$

whereby  $\lambda_{\Gamma} = \Delta d_{\Gamma}$  denotes the wavelength as sent out by an emission source inside a gravitational field and  $\lambda_f = \Delta d_f$  denotes the wavelength received far away from that gravitational field. A photon moving out of a gravitational field will thus obtain a longer wavelength during its journey, i.e. it will redshift.

### 4.2 Light deflection

The refraction index  $n$  can also be calculated by considering the motion of a light ray in a gravitational field by using the line element as specified in equation 2.4 or 2.7 to describe that motion. To simplify the calculation a straight motion can be chosen with an angle  $\Theta$  such that  $\sin^2(\Theta)$  is zero and  $d\phi = 0$ , i.e. a radial movement with  $\Theta = 0^\circ$ . Moreover, considering that for a light ray  $ds^2 = 0$  and using velocity  $v = dr/dt$  the line element can be reshaped into a refractive index  $n$ . Due to the spherical symmetry of the Schwarzschild metric the obtained result must hold true everywhere outside of the Schwarzschild radius associated with a mass  $M$ .

$$\begin{aligned} \left(1 + \frac{2\Phi}{c^2}\right) c^2 dt^2 &= \left(1 + \frac{2\Phi}{c^2}\right)^{-1} dr^2 \\ \left(1 + \frac{2\Phi}{c^2}\right)^2 c^2 &= \frac{dr^2}{dt^2} \\ n = \frac{c}{v} &= 1 / \left(1 - \frac{2GM}{r c^2}\right) = \Gamma^2 \end{aligned} \quad (4.2)$$

This result matches exactly with equation 3.10, which means that the Schwarzschild metric can be regarded as a description of an optical medium with a changing refractive index  $n$  and therefore any gravitational light bending calculation based on the refractive index  $n$  has to produce results that are equivalent to other calculation approaches which use the framework of general relativity theory. Calculations using the refractive index  $n$  thus have to result in the typical gravitational light bending angle  $\theta$  for light rays moving past a non-rotating stationary homogeneous spherical mass  $M$  at a distance  $r$ , which is given by the following equation.

$$\theta = \frac{4GM}{r c^2} \quad (4.3)$$

The refractive index  $n$  was first used by Robert Dicke to correctly calculate the deflection angle for light passing by our sun (6). This is a topic that is covered extensively by Alexander Unzicker, for example in (9). There Unzicker explains that Albert Einstein also attempted to use a refraction index to calculate the amount of light deflection around our sun before he developed his theory of general relativity (12). Einstein's result using a refraction index was exactly half of the correct value that he predicted later on by using general relativity, which was because Einstein only took light's gravitational frequency change into consideration but missed the change in wavelength. Thus his expression for the reduced speed of light in a gravitational field was slightly off, i.e.  $[1 - GM/(r c^2)] c$ . Today, however, it is pretty much forgotten that Einstein was taking the notion of a variable speed of light due to gravity very seriously. There are also lots of other papers available which calculate the refractive index using general relativity, like (14) which treats gravity as a purely refractive phenomenon. However, these derivations are often more complicated than the derivation done here in equation 4.2 and their respective authors usually refrain from interpreting the refractive index as evidence for space being a physical medium which constitutes a preferred frame and has substance to it.

### 4.3 Perihelion precession

Calculating the precession of Mercury's perihelion still stands as one of the most significant tests of Einstein's general theory of relativity. This section will present a classical approach which doesn't require curved space and still achieves the same result. The mass of our sun is designated here as  $M$ , Mercury's mass is denoted as  $m$  and  $r$  is specifying the distance between our sun and Mercury.

Mercury's kinetic energy  $T$  expressed in polar coordinates is given by the following equation since Mercury moves in a plane and subsequently  $\dot{\Theta} = 0$  can be used.

$$T = m(\dot{r}^2 + r^2\dot{\phi}^2)/2 \quad (4.4)$$

Usually, a calculation of Mercury's perihelion precession based on Newtonian physics is not giving the same result as a general relativity based calculation and the reason behind that failure is a wrong gravitational potential energy term, as shown hereafter. From black hole calculations it is known that the gravitational potential limit of a Schwarzschild black hole is  $-c^2/2$  whereas the gravitational potential limit of an extreme Kerr black hole which spins at the speed of light is given by  $-c^2$  (2). A similar doubling approach can be tried by constructing a gravitational potential energy formula which incorporates the motion of Mercury around our sun as follows, whereby an expression is sought which only relies on  $r$  for practicality.

$$-V = \frac{GMm}{r} \left(1 + \frac{v_t^2}{c^2}\right) = \frac{GMm}{r} + \frac{GMm}{r} \left(\frac{r\dot{\phi}}{c}\right)^2 = \frac{GMm}{r} + \frac{GMm}{1} \frac{r\dot{\phi}^2}{c^2} = \frac{GMm}{r} + \frac{GMmh^2}{c^2 r^3} \quad (4.5)$$

Here Mercury's tangential speed is  $v_t = r\dot{\phi}$ , its specific angular momentum is  $h = r^2\dot{\phi}$  and the minus sign in front of  $V$  indicates an attractive force. Moreover,  $V$  should not be confused with the ordinary effective potential  $V_{eff} = -GMm/r + mv_t^2/2$  which has another meaning.

The expressions for  $T$  and  $V$  can then be used to setup the relativistic Lagrangian as follows.

$$\begin{aligned} L/\Gamma &= T/\Gamma - V/\Gamma \\ L &= m(\dot{r}^2 + r^2\dot{\phi}^2)/2 + GMm/r + GMmh^2/(c^2 r^3) \end{aligned} \quad (4.6)$$

Here the  $1/\Gamma$  terms account for any changes of the involved physical quantities due to the gravitational field of  $M$ , but these terms can simply be cancelled out. The remaining equation is identical to one that is treating the situation as perceived from outside of the gravitational field of our sun.

Applying the Euler-Lagrange equation with respect to  $\phi$  gives the following result,

$$\begin{aligned} \frac{d}{dt} \frac{\partial L}{\partial \dot{\phi}} &= \frac{\partial L}{\partial \phi} \\ \frac{d}{dt} (mr^2\dot{\phi}) &= 0 \end{aligned} \quad (4.7)$$

which means that Mercury's angular momentum  $mr^2\dot{\phi}$  is constant because the product of these variables doesn't change with time. Applying the Euler-Lagrange equation with respect to  $r$  gives the following equation of motion.

$$\begin{aligned}\frac{d}{dt} \frac{\partial L}{\partial \dot{r}} &= \frac{\partial L}{\partial r} \\ \frac{d}{dt} (m\dot{r}) &= \frac{\partial}{\partial r} \left( m\dot{r}^2 + mr^2\dot{\phi}^2/2 + GMm/r + GMmh^2/(c^2r^3) \right) \\ \ddot{r} &= \frac{\partial}{\partial r} \left( r^2\dot{\phi}^2/2 + GM/r + GMh^2/(c^2r^3) \right) \\ \ddot{r} &= r\dot{\phi}^2 - GM/r^2 - 3GMh^2/(r^4c^2)\end{aligned}\tag{4.8}$$

Mercury's mass  $m$  was assumed to be constant here and could therefore be cancelled out. Special relativistic effects will be discussed later on in this section.

Using  $u = 1/r$ ,  $\ddot{r} = (d/dt)(du^{-1}/dt)$ , specific angular momentum  $h = r^2\dot{\phi}$  (which also characterizes Kepler's second law since  $dA/dt = h/2$ ), the chain rule in the form of  $d/dt = \dot{\phi}(d/d\phi) = hu^2(d/d\phi)$  and the quotient rule in the form of  $du^{-1}/dt = -u^{-2}(du/dt) = -h(du/d\phi)$  it is possible to obtain a standard differential equation from equation 4.8 which is not dependent on time and thus avoids any time dilation issues of special relativity or general relativity.

$$\begin{aligned}-h^2u^2(d^2u/d\phi^2) &= h^2u^3 - GMu^2 - 3GMu^4h^2/c^2 \\ -u^2(d^2u/d\phi^2) &= u^3 - GMu^2/h^2 - 3GMu^4/c^2\end{aligned}\tag{4.9}$$

$$\frac{d^2u}{d\phi^2} + u = \frac{GM}{h^2} + \frac{3GMu^2}{c^2}\tag{4.10}$$

This is the same result as obtained from a derivation that is directly using the Schwarzschild metric, which shows that the perihelion precession of Mercury can, in principle, be calculated without a curved space. It should be noted though, that equation 4.10 is only valid for a weak gravitational field, i.e. when  $GM/(rc^2) \ll 1$ , according to physics literature. Stronger gravitational fields would require additional terms on the right side of that equation. Moreover, a modified gravitational potential energy term was necessary, as specified by equation 4.5, to achieve the desired result. This suggests that the gravitational potential energy for an orbiting planet also depends on its tangential velocity, not just its position, and that an increasing tangential velocity is deepening the gravitational well a planet is in. In case of Mercury the added  $v_t^2/c^2$  term results in values around  $2.6 \times 10^{-8}$  as Mercury moves along its orbit, which is a small number but still the additional contribution to  $V$  amounts to approximately  $2.0 \times 10^{25}$  J on average. But what is the deeper physical cause for the extra  $1 + v_t^2/c^2$  term? Finding an explanation that doesn't depend on space curvature is obviously crucial for the hypothesis of this paper.

The gravitational force which corresponds to equation 4.5 can also be written as follows

$$F_{go} = \frac{GM}{r^2} \left[ m \left( 1 + \frac{v_t^2}{c^2} \right) \right]\tag{4.11}$$

and according to general relativity theory all kinds of energy are gravitating, as embodied in its stress – energy – momentum tensor. Thus the kinetic energy of Mercury should indeed increase its gravitational attraction to our sun. Extending Newtonian gravity to include the special relativistic mass for one of the masses, i.e. using  $m\gamma$  instead of  $m$ , implements this line of thinking and gives the following result.

$$\frac{GM}{r^2} m\gamma = \frac{GM}{r^2} m \left/ \sqrt{1 - \frac{v^2}{c^2}} \right. \cong \frac{GM}{r^2} \left[ m \left( 1 + \frac{1}{2} \frac{v^2}{c^2} \right) \right]\tag{4.12}$$

The resulting approximation is quite similar to  $F_{go}$  when assuming that Mercury's total velocity  $v$  satisfies  $v \cong v_t$  as its tangential velocity  $v_t$  accounts for most of its total velocity  $v$  (between 97.8% and 100%). However, even with a relativistic mass there is still a missing factor of  $\frac{1}{2} v^2/c^2$ , which means that the extra energy is twice as large as the special relativistic mass accounts for, i.e.  $m$  needs to scale with  $\gamma^2$  instead of  $\gamma$ . Consequently, the generalized sought-after gravitational force is given by the following formula:

$$F_{gr} = \frac{G}{r^2} m_1 \gamma_1^2 m_2 \gamma_2^2 \cong \frac{G}{r^2} \left[ m_1 \left( 1 + \frac{v_1^2}{c^2} \right) \right] \left[ m_2 \left( 1 + \frac{v_2^2}{c^2} \right) \right]\tag{4.13}$$

A possible candidate for the extra  $\gamma$  factor is special relativistic time dilation, in case that the slower local time on Mercury, compared to a stationary observer in our solar system, is increasing the gravitational attraction between our sun and Mercury. Admittedly, this notion is speculative, since special relativity does not deal with gravity, which is why equation 4.13 should be checked experimentally, maybe through the use of a cyclotron, to clarify if special relativity is responsible for the extra term in  $V$ . In any case, however, the kinetic

energy of Mercury definitely increases its gravitational attraction to our sun.

Interestingly, the kinetic energy  $T$ , as described by equation 4.4, did not require a special relativistic extension to calculate Mercury's perihelion precession correctly. The presumed reason is that for  $T$ , contrary to the classical expression for a gravitational potential energy, the influence of Mercury's motion is already accounted for, at least approximately, and Mercury's practically non-relativistic speed of around 0.016% of light speed  $c$  is varying less than 2.2%. A simple approach to reduce the calculation error in  $T$  would be to correct Mercury's mass  $m$  by the average applicable Lorentz factor, i.e. by  $\gamma(v = 47.4 \text{ km/s}) = 1.0000000125$ . However, the resulting mass difference would be well below the precision to which Mercury's mass is known as of now. For very strong gravitational fields the mass difference might become relevant, though, in case that the affected planet survives the associated gravitational tidal forces.

Using the already mentioned expression  $G \cong c^2 r_H / (2 m_H)$  from (2) it is also possible to express  $V$  in a form that does not exhibit  $G$ , which is a desirable feature for moving towards an alternative theory of gravity.

$$V \cong -\frac{1}{2} \frac{r_H}{r} \frac{M}{m_H} \left( mc^2 + mv_t^2 \right) \quad (4.14)$$

In case that our observable universe qualifies as a Schwarzschild black hole this expression for  $V$  would be exact. A somewhat similar expression can be found using the escape speed  $s = \sqrt{2GM/r}$ .

$$V = -\frac{1}{2} \frac{s^2}{c^2} \left( mc^2 + mv_t^2 \right) \quad (4.15)$$

Equation 4.14 should be appealing to friends of Mach's principle since it relates the gravitational potential energy of  $V$  to all the masses in our universe. However, that equation may also be written in terms of the Planck mass  $m_l$  and Planck length  $l_l$ , i.e.  $V = -(l_l/r) (M/m_l) (mc^2 + mv_t^2)$ .

## 5 Newtonian gravity reexamined

### 5.1 Gravitational potential energy

The following equation quantifies the classical gravitational potential energy that is released when a test mass  $m_t = 1.000 \text{ kg}$  is moved inside the gravitational field of earth, with  $m_E = 5.972 \times 10^{24} \text{ kg}$  being the mass of earth and  $r_{near} = 6371 \text{ km}$  being the radius of earth, from a position  $r_{far} = r_{near} + 10.000 \text{ km}$  to the surface of the earth.

$$\Delta E = \frac{-G m_E m_t}{r_{far}} - \frac{-G m_E m_t}{r_{near}} = \left( \frac{1}{r_{near}} - \frac{1}{r_{far}} \right) G m_E m_t = 98.043 \text{ kJ} \quad (5.1)$$

So roughly 100 kilojoules of energy are released according to Newtonian gravity as the test mass is moved to a lower gravitational potential, i.e. the surface of earth. To make a connection to general relativity the last equation can also be written as follows:

$$\Delta E = \left[ \frac{G m_E}{r_{near} c^2} - \frac{G m_E}{r_{far} c^2} \right] m_t c^2 = \left[ \left( 1 - \frac{G m_E}{r_{far} c^2} \right) - \left( 1 - \frac{G m_E}{r_{near} c^2} \right) \right] m_t c^2 \quad (5.2)$$

Using the following linear approximation

$$1/\Gamma = \sqrt{1 - 2GM/(r c^2)} \cong 1 - GM/(r c^2) \quad (5.3)$$

it is possible to rewrite  $\Delta E$  as

$$\Delta E = \left[ \frac{1}{\Gamma_{far}} - \frac{1}{\Gamma_{near}} \right] m_t c^2 = 98.046 \text{ kJ} \quad (5.4)$$

whereby  $\Gamma_{near}$  denotes  $\Gamma$  for  $r = r_{near}$  with  $M = m_E$  and  $\Gamma_{far}$  denotes  $\Gamma$  for  $r = r_{far}$  with  $M = m_E$ . It can be seen that the results of equation 5.2 and 5.4 are quite close and they get even closer for larger separation distances. Moreover, the results also get closer when treating  $m_t$  as a variable mass in the Newtonian calculation. The remaining deviation between the result of equation 5.1 and 5.4 is presumably largely due to the used linear approximation as stated in equation 5.3.

The calculation presented in this section is based upon a related example in John A. Macken's work where he claims that time dilation is responsible for the gravitational potential energy (4), which can be said rightfully so since frequency  $f$  as well as energy  $E$  both scale with  $1/\Gamma$  and are directly related via  $E = hf$ . This effectively means that when a spin  $\frac{1}{2}$  particle is moving towards the earth's surface it loses mass energy, due to the reduction in its frequency  $f_\Gamma$ , and since this change in its mass energy is not directly

detectable locally that change is accounted for as a lowered gravitational potential energy in classical physics calculations. In case that this particle is in free fall its lost mass energy will be converted to kinetic energy and thus the overall energy remains conserved. This notion also provides a simple explanation for the physical origin of gravitational potential energy which cannot be accounted for satisfactorily in Newtonian physics otherwise, because contrary to electric fields the potential energy here is not linked to an energy in the field.

## 5.2 Normalized potential gradient

Another fascinating example from John A. Macken shows that Newtonian gravity calculations contain concealed gradient calculations, akin to the maths of space curvature. For a similar example we consider the gravitational force between earth's mass  $m_1 = m_E$  and a proton with mass  $m_2 = 1.67262 \times 10^{-27}$  kg at a distance  $r_{far}$ , which is given by:

$$G \frac{m_1 m_2}{r_{far}^2} = 2.487 \times 10^{-27} \text{ N} \quad (5.5)$$

Next it will be shown that the same force can be calculated with a totally different approach. However, the alternative approach requires at least one spin  $\frac{1}{2}$  particle and thus the alternative approach cannot be applied to arbitrary situations without some tweaks.

A classical gravitational potential at  $r$  can be normalized by dividing it through  $-c^2$  since  $-c^2$  is the gravitational potential limit in our universe (2). Macken called such a normalized gravitational potential the gravitational magnitude  $\beta$  which can be written in the following ways for a mass  $M$  and a distance  $r$ .

$$\beta = -\Phi/c^2 = \frac{GM}{r c^2} \cong \Gamma - 1 \quad (5.6)$$

This dimensionless parameter will always have a value between 0 and 1. Calculating it for our example situation with  $M = m_1$  and  $r = r_{far}$  gives the following concrete value:

$$\beta_1 = \frac{G m_1}{r_{far} c^2} \times \frac{1}{c^2} = 2.709 \times 10^{-10} \quad (5.7)$$

It is also possible to calculate how the gravitational magnitude changes at  $r$ , which is simply the gradient of the gravitational magnitude  $\beta$  at  $r$ . The gravitational magnitude has a  $1/r$  factor in it whose derivative with respect to  $r$  is simply  $-1/r^2$  and therefore  $d\beta/dr = -\beta/r = -GM/(r^2 c^2)$ . Treating  $\beta$  as a gravitational potential, i.e. working with its negatives values, then gives:

$$-d\beta_1/dr = \beta_1/r_{far} = 1.655 \times 10^{-17} / \text{m} \quad (5.8)$$

Using this gradient it can be estimated by how much the gravitational magnitude  $\beta_1$ , which is caused by the earth's gravitational field in our example, is changing over the confines of our example proton. As already mentioned in section 2.1 the reduced Compton wavelength  $r_c = \lambda_c/2\pi$  is used as a measure of a spin  $\frac{1}{2}$  particle's size in this paper. More correctly  $r_c$  describes half of its size, since it denotes a radius, but incidentally this is the appropriate measure for the calculation in this section. The change in the gravitational magnitude at a distance  $r$  caused by a mass  $m_j$  over the confines of a spin  $\frac{1}{2}$  particle's mass  $m_k$  can then in general be approximated as follows whereby  $r_{ck}$  denotes the reduced Compton wavelength of the mass  $m_k$ .

$$\Delta\beta_j = \frac{G m_j}{r^2 c^2} \times r_{ck} \quad (5.9)$$

The reduced Compton wavelength of a proton is  $2.1031 \times 10^{-16}$  m and therefore in our example with  $j = 1$  and  $k = 2$  the approximate gravitational magnitude change caused by  $m_1$  at  $r = r_{far}$  over the size  $r_{c2}$  of the mass  $m_2$  is given by:

$$\Delta\beta_1 = \beta_1/r_{far} \times r_{c2} = 3.500 \times 10^{-33} \quad (5.10)$$

The force that keeps a spin  $\frac{1}{2}$  particle together can be estimated by multiplying its mass with its centripetal acceleration, whereby its centripetal acceleration is assumed to arise from an equatorial perimeter rotation which occurs at light speed  $c$ . For a proton, which in our example is associated with mass  $m_2$ , this approach gives the following force:

$$F_{s2} = m_2 \times c^2/r_{c2} = c\hbar/r_{c2}^2 = 7.148 \times 10^5 \text{ N} \quad (5.11)$$

In case of a proton the strength of this force closely matches with the expected strength of the strong force, which is why the subscript letter  $s$  was used to refer to this force. Moreover, as discussed in (1) and (3) the strong force seems to be the near field behaviour of gravity and therefore it makes sense that this force appears in the calculations done here.

Finally, multiplying  $F_{s2}$  with  $\Delta\beta_1$  results in the gravitational force of equation 5.5, whereby this match is symbolically, and not just numerically, since the involved terms cancel out in exactly the right way.

$$F_{s2} \times \Delta\beta_1 = 2.487 \times 10^{-27} \text{ N} \quad (5.12)$$

Macken compares this congruence with a mirror effect, i.e. a spin  $\frac{1}{2}$  particle experiences a physically real change in its surrounding space which leads to a kind of reflection, comparable to incoming light being partially reflected by a mirror that it encounters. The strength of the reflection by a spin  $\frac{1}{2}$  particle seemingly depends on the force that holds the affected particle together and the gravitational magnitude change over the particle's size. However, the problem with the mirror analogy is that it suggests a repulsive force. Macken also suggested that  $\Delta\beta$  quantifies a change in the rate of time, i.e. masses move towards regions with slower time and indeed in our example  $\Delta\beta$  is approximately equal to the difference of two approximated  $1/\Gamma$  factors, i.e.  $[1 - Gm_1/((r_{far} + r_{c2})c^2)] - [1 - Gm_1/(r_{far}c^2)] \cong \Delta\beta_1$  (note: the small value of  $r_{c2}$  and the relatively large value of  $r_{far}$  can lead to precision problems within a used calculation software). Since  $E = hf$  this can be rephrased as masses moving towards states of lower energy, which is a common scheme in physics and in accordance with the findings of section 3.2 and 5.1. Admittedly, this line of thought is not elaborated enough yet to qualify as a satisfactory explanation for the attractive nature of gravity. However, regarding gravity as a refraction phenomenon, as shown in (14), might offer a pathway for explaining the attractive nature of gravity. This notion would also fit with what is presented in section 6.2 and 6.3.

## 6 Quantum forces

The previous sections were portraying a very dynamic behaviour of physical quantities in a gravitational field and the question that follows from this is what mechanism could provide such dynamics? Curved space-time, as envisioned by general relativity theory, does not seem to fit, or at least this theory is interpreting the physical situation in a very different way. One viable candidate could be a wave based quantum gravity approach as proposed by John A. Macken in (5)(4), whose fundamentals will be presented and assessed in the following sections. Macken uses two main starting points in his works, one is an analogy of matter with light waves trapped between two mirrors and the other is the equation for the intensity of a planar gravitational wave. It should be noted, though, that some of Macken's claims differ from what was presented here before, in particular the scaling factors for the various physical quantities due to gravity, but that does not invalidate what gets presented from his work hereafter.

The starting point for examining quantum gravity in this paper is also the equation for the intensity of a planar gravitational wave as derived from general relativity theory, which can be defined as follows,

$$I_{gw} = \frac{1}{8\pi} l_i^2 \left( \frac{\Delta L}{L} \right)^2 \omega^2 Z_s \quad (6.1)$$

whereby  $\omega$  is the angular frequency of the gravitational wave and the term  $\Delta L/L$  is a dimensionless factor that accounts for the stretching of space due to a gravitational wave. Here  $L$  denotes a reference length transverse to the wave's propagation direction and  $\Delta L$  refers to the change of that length due to the gravitational wave. The usual formulation for the intensity of a gravitational wave does not contain an explicit amplitude, since the impedance term  $c^3/G$ , that is appropriate for strain amplitudes, is normally used (11) instead of the unacquainted "acoustic" gravitational impedance  $Z_s$ . As shown in the upcoming sections gravity might be transmitted by a sea of "background" waves whose natural amplitude is the Planck length  $l_i$ . Therefore, equation 6.1 contains the Planck length  $l_i$  as the unstretched amplitude and the effective wave amplitude is thus given by  $l_i (\Delta L/L)$ . Another small difference to the usual equation for the intensity of a planar gravitational wave is the proportionality constant, which here is  $1/8\pi$  instead of  $1/16\pi$ , in order to obtain identical results between the different formulations.

### 6.1 Strong force

Previously, in equation 5.11 a force was calculated which presumably holds the proton together. That formula can be generalized to a strong force  $F_s$  for spin  $\frac{1}{2}$  particles which possess a Compton wavelength  $\lambda_c$ . This force can be written in many ways as shown here.

$$F_s = m^2 c^3 / \hbar = m \times c^2 / r_c = Gm_l^2 / r_c^2 = e^2 / (4\pi\epsilon_0 \alpha r_c^2) = c \frac{e}{\sqrt{\alpha}} \frac{\mu_0 (e/\sqrt{\alpha}) f_c}{2r_c} = c\hbar / r_c^2 \quad (6.2)$$

Interestingly, one variant involves the Planck mass  $m_l$ , but the potential meaning of this occurrence is not the focus here. The relationship between a spin  $\frac{1}{2}$  particle's mass  $m$  and its radius  $r_c$  is given by

$$r_c = c / (2\pi f_c) = \lambda_c / 2\pi = \hbar / (mc) \quad (6.3)$$

whereby the relativistic cases, and their relation to frequency, were already stated before, i.e.  $r_\gamma = c / (2\pi f_\gamma)$  and  $r_\Gamma = c / (2\pi f_\Gamma)$ . Doing a simple comparison of forces reveals that  $F_s$  matches quite closely with the nuclear strong force for the proton and neutron, since  $F_s$  is approximately  $10^{38}$  times stronger than Newtonian

gravity. For example, a calculation for the proton, with  $m_p$  being the proton's mass and  $r_{cp}$  being the proton's radius, yields

$$\frac{Gm_l^2}{r_{cp}^2} \bigg/ \frac{Gm_p^2}{r_{cp}^2} = \frac{m_l^2}{m_p^2} = 1.69 \times 10^{38} \quad (6.4)$$

Thus  $F_s$  really deserves its name and this result even indicates that the strong force is the near field behaviour of gravity when a particle's rotational effects on space are included too (1). Another calculation reveals that using the Planck length  $l_l$  as radius  $r_c$  the strong force  $F_s$  evaluates to the gigantic Planck force  $F_l = \hbar/l_l^2 = c^4/G = 1.21 \times 10^{44}$  N, which will play an important role in the following sections and is called the super force by the physicist Salvatore Pais. For reasons touched upon in appendix B the Planck force can also be regarded as the primordial force or pristine force of our universe.

Analogous to the equation for the intensity of a planar gravitational wave the Planck force can be defined as the force caused by a planar wave with Amplitude  $A_o = l_l$ , a proportionality constant  $k_s = 1$ , an angular frequency  $\omega = \omega_l = c/l_l = 1/t_l$ , which is the inverse of the Planck time  $t_l$ , and the "acoustic" impedance of space  $Z_s$  (equation 2.3). Additionally, the wave's propagation velocity  $v$  in space is assumed to be light speed  $c$  and the relevant cross section is assumed to be  $A = 2l_l^2$ , due to reasons presented in (1) where a possible geometric structure of space was discussed. This then leads to the following force equation:

$$F_l = k_s A_o^2 \omega^2 Z_s A / v = l_l^2 \omega_l^2 Z_s (2l_l^2) / c = c^4 / G \quad (6.5)$$

It is assumed here that the last equation describes the base layer of space, i.e. that space is composed of tiny oscillators which are also responsible for the so called zero point energy of quantum physics. Moreover, these oscillators are assumed to form standing waves in the confines of the observable universe.

Curiously, spin  $1/2$  particles also seem to be able to emit similar waves since using  $\omega = \omega_c = 2\pi f_c$  and  $A = 2r_c^2$  also produces the Planck force, as shown in the following equation:

$$F_l = l_l^2 \omega_c^2 Z_s (2r_c^2) / c = c^4 / G \quad (6.6)$$

The amplitude is again  $l_l$ , but the frequency and the relevant cross section have changed compared to equation 6.5. Subsequently, due to the much lower angular frequency the intensity of waves emitted by spin  $1/2$  particles must be much lower than the intensity associated with the proposed fundamental oscillators, which makes sense. The next section will show how the waves described by equation 6.5 and 6.6 are related to gravity as we observe it, as a continuation of the groundwork that has been laid out here.

Equation 6.1 could also be relevant for the waves associated with the proposed fundamental oscillators, but in that case  $\Delta L/L$  is not applicable and must therefore be set to 1. Using that stipulation the modified planar wave intensity  $I_m = l_l^2 \omega^2 Z_s / 8\pi$  and the Planck force  $F_l$  can be related for the relevant cross section area  $2l_l^2$  by  $I_m \times 2l_l^2 / c = F_l / (8\pi) = 1/\kappa$ , whereat the symbol  $\kappa$  denotes the Einstein constant  $8\pi G/c^4$  which is a conversion factor between space curvature and energy density in the Einstein field equations of general relativity theory. This correlations show that general relativity can be connected to the quantum wave model introduced here on at least one level, which provides some first credence to the chosen approach.

## 6.2 Gravitational force

The starting point point for this section is the classical Newtonian gravity as stated hereafter for two masses  $m_1$  and  $m_2$  at some distance  $r$ .

$$F_g = G \frac{m_1 m_2}{r^2} \quad (6.7)$$

Intriguingly, this equation can be formulated in terms of the Planck force  $F_l$  as follows for two spin  $1/2$  particles.

$$F_g = F_l \frac{F_{s1}}{F_l} \frac{F_{s2}}{F_l} \frac{1}{r/r_{c1}} \frac{1}{r/r_{c2}} \quad (6.8)$$

Here  $F_{sn}$  means  $F_s$  for  $m = m_n$  and  $r_{cn}$  refers to the reduced Compton wavelength  $r_c$  of the mass  $m_n$ , whereby  $n$  is 1 or 2. This equation offers a number of interesting insights into classical Newtonian gravity:

- The reference quantity for the gravitational force seems to be the Planck force  $F_l$
- There is a deeper connection connection between the gravitational force and the strong force.
- The contribution to the gravitational force caused by each of the involved masses, i.e.  $F_{s1}/F_l$  and  $F_{s2}/F_l$ , is also relative to the Planck force  $F_l$ .
- When explicitly stating these force contributions, like it was done in equation 6.8, the strength of the gravitational force does not simply scale with  $1/r^2$  anymore, instead it scales inversely with distance measured in multiples of the reduced Compton wavelength of the involved particles, denoted by  $r_{c1}$  and  $r_{c2}$ , i.e.  $1/(r/r_{c1})$  and  $1/(r/r_{c2})$ .

- Using the same notation as in equation 5.9 it can be inferred for the special case of two spin  $\frac{1}{2}$  particles that the change of gravitational magnitude is given by

$$\Delta\beta_j = F_{sj} r_{cj} r_{ck} / (F_l r^2) = \frac{r_{ck}}{r_{cj}} \frac{1}{r^2/l_l^2} = \frac{m_j}{m_k} \frac{1}{r^2/l_l^2} \quad (6.9)$$

such that  $F_g = F_{sk} \times \Delta\beta_j$ . Surprisingly, the equation for  $\Delta\beta_j$  has become pretty simple, especially if the two involved particles are of the same type.

Equipped with that knowledge, and that of the previous section, it is now sensible to switch over to Macken's equations for the gravitational force.

Macken uses a particular notation which utilizes the following two dimensionless factors:

$$A_B = \frac{1}{r_c/l_l} = \sqrt{\frac{F_s}{F_l}} \quad (6.10)$$

$$N = \frac{r}{r_c} \quad (6.11)$$

$N$  obviously quantifies a distance  $r$  in terms of multiples of the measure for a particle radius, i.e. the reduced Compton wavelength  $r_c$ .  $A_B$  quantifies the relative size of a fundamental Planck oscillator compared to a spin  $\frac{1}{2}$  particle, which incidentally is also a measure for the relative strength of  $F_s$  and  $F_l$ . Macken's work features different equations for expressing Newtonian gravitational force, whereby the most encompassing and understandable one is the following equation,

$$F_g = \left[ \frac{A_{B1}^2}{N_1} \frac{A_{B2}^2}{N_2} \right] F_l \quad (6.12)$$

which is structurally comparable to equation 6.8. Here  $A_{Bn}$  means  $A_B$  for  $r_c = r_{cn}$  and  $N_n$  means  $N$  for  $r_c = r_{cn}$ , whereby  $n$  is again 1 or 2. Macken claims that the squared  $A_B$  terms are indicative of gravity being a second order effect of the waves emitted by spin  $\frac{1}{2}$  particles, inspired by the fact that the upcoming equation 6.25 features a lower power for  $A_B$  - a notion which cannot be judged finally from what was presented so far.

Equation 6.12 is an intriguing way to state the gravitational force, but to get a better understanding of what it might mean physically the terms have to be expanded. Expanding only the  $F_l$  part first gives two possible variants:

$$F_g = \left[ \frac{A_{B1}^2}{N_1} \frac{A_{B2}^2}{N_2} \right] l_l^2 \omega_l^2 \frac{c^3}{2G l_l^2} (2l_l^2) \frac{1}{c} \quad (6.13)$$

$$F_g = \left[ \frac{A_{B1}^2}{N_1} \frac{A_{B2}^2}{N_2} \right] l_l^2 (\omega_{c1} \omega_{c2}) \frac{c^3}{2G l_l^2} (2r_{c1} r_{c2}) \frac{1}{c} \quad (6.14)$$

Of these two variants equation 6.14 should be the relevant one, since it is highly unlikely that spin  $\frac{1}{2}$  particles can emit waves with a frequency of  $\omega_l$ . Doing an expansion of equation 6.14 gives the following two sensible equations:

$$F_g = l_l^2 (\omega_{c1} \omega_{c2}) Z_s \left[ 2 \frac{1}{r/l_l} \frac{1}{r/l_l} \right] \frac{1}{c} \quad (6.15)$$

$$F_g = l_l^2 \left( \frac{\omega_{c1} \omega_{c2}}{\omega_l} \right)^2 Z_s \left[ 2 \frac{r_{c1}}{r/l_l} \frac{r_{c2}}{r/l_l} \right] \frac{1}{c} \quad (6.16)$$

Which of these two equations is the physically relevant one is something that is not fully clear yet. Presumably it is equation 6.16, which incidentally seems to be absent from Macken's work, since its cross section term still contains  $r_{c1}$  and  $r_{c2}$ . The effective angular frequency of that equation is given by  $\omega = \omega_{c1} \omega_{c2} / \omega_l$ . The rather clumsy term  $2 r_{c1}/(r/l_l) r_{c2}/(r/l_l) = 2 r_{c1} r_{c2} (r/l_l)^{-2}$  likely denotes the reduction of the effective cross sectional area due to the separation between the two objects in gravitational attraction, which is likely describing a loss of intensity since the described wave, or the waves, dissipate with increasing distance  $d$  as they spread out over an increasing spherical area. The wave's amplitude and frequency are seemingly unchanged as the wave spreads.

Section 5.2 was exploring how the gravitational magnitude  $\beta$  changes over the size of a particle, whereby this change is presumably related to a change in the experienced time of the affected particle. The following equation shows several ways to calculate this value using the wave equations that were presented beforehand.

$$\Delta\beta_j = \frac{F_g}{F_{sk}} = F_g \frac{c}{\hbar \omega_{ck}^2} = l_l^2 \frac{\omega_{cj}}{\omega_{ck}} Z_s \left[ 2 \frac{1}{r/l_l} \frac{1}{r/l_l} \right] \frac{1}{\hbar} = l_l^2 \frac{\omega_{cj}^2}{\omega_l^2} \frac{c^3}{2G l_l^2} \left[ 2 \frac{r_{cj}}{r/l_l} \frac{r_{ck}}{r/l_l} \right] \frac{1}{\hbar} = \frac{\omega_{cj}}{\omega_{ck}} \frac{1}{r^2/l_l^2} \quad (6.17)$$

In case one wants to compare Macken's work with this work it should be noted again that Macken's equations are slightly different since he uses a strain amplitude instead of an explicit amplitude of one Plank length. The equations in question, i.e. the ones presented in this paper which explicitly feature the "acoustic" impedance of space  $Z_s$ , can be made comparable easily, though, by cancelling out a factor of  $2l_i^2$  from the respective equation. This notice also applies to the next section.

### 6.3 Electric force

To properly classify Macken's equations it is insightful to also look at the classical electrostatic force  $F_e$  between two fundamental charges  $e$ , which may have different polarity and are separated by a distance  $r$ .

$$F_e = \frac{1}{4\pi\epsilon_0} \frac{e^2}{r^2} = \frac{\alpha}{4\pi\epsilon_0} \frac{q_i^2}{r^2} \quad (6.18)$$

In his work Macken shows that the electric force can also be formulated in a way that is surprisingly similar to equation 6.12 (4)(5). It is necessary, though, to also incorporate the Sommerfeld constant  $\alpha$  to get the correct calculation results. Macken presents different variants for the electric force in his work, like in the case of gravity, whereby the most encompassing and understandable equation is the following one.

$$F_e = \alpha \left[ \frac{A_{B1}}{N_1} \frac{A_{B2}}{N_2} \right] F_l \quad (6.19)$$

The last equation is applicable to charged spin  $\frac{1}{2}$  particles with a Compton wavelength  $\lambda_c$ , i.e. the proton, electron, positron and muon. Doing some rearrangements the last equation can also be brought into a form that is similar to equation 6.8.

$$F_e = \alpha F_l \sqrt{\frac{F_{s1}}{F_l}} \sqrt{\frac{F_{s2}}{F_l}} \frac{1}{r/r_{c1}} \frac{1}{r/r_{c2}} \quad (6.20)$$

The similarities of the previous two equations to equation 6.12 and 6.8 are highly puzzling as there is no justification in contemporary physics why these similarities should exist. This in turn indicates that the gravitational force as well as the electric force are manifestations of the same underlying phenomenon, which arguably has a wave like nature. Admittedly, equation 6.25 and 6.20 cannot explain the attractive and repulsive effect that electric charges can have, but still the revealed similarities are remarkable. Please also note that the square root of a value smaller than one actually is greater than this value, e.g.  $\sqrt{0.5} \cong 0.7071$ , which is why the electric force as stated in equation 6.20 is stronger than the gravitational force as stated in equation 6.8 for a comparable situation.

Again, like done for gravity beforehand, there are two ways to expand  $F_l$ . Doing that expansions for equation 6.25 results in

$$F_e = \alpha \left[ \frac{A_{B1}}{N_1} \frac{A_{B2}}{N_2} \right] l_i^2 \omega_l^2 \frac{c^3}{2G l_i^2} (2l_i^2) \frac{1}{c} \quad (6.21)$$

$$F_e = \alpha \left[ \frac{A_{B1}}{N_1} \frac{A_{B2}}{N_2} \right] l_i^2 (\omega_{c1} \omega_{c2}) \frac{c^3}{2G l_i^2} (2r_{c1} r_{c2}) \frac{1}{c} \quad (6.22)$$

whereby equation 6.22 seems to be the physically relevant one as spin  $\frac{1}{2}$  particles are presumably not able to emit waves with an angular frequency  $\omega_l$ . Doing a full expansion for  $F_e$  using equation 6.25 gives only one sensible equation since the  $A_B$  terms are to the power of one and subsequently the radius  $r_c$  in  $N$  and  $A_B$  cancels out.

$$F_e = \alpha l_i^2 (\omega_{c1} \omega_{c2}) Z_s \left[ 2 \frac{r_{c1}}{r/l_i} \frac{r_{c2}}{r/l_i} \right] \frac{1}{c} \quad (6.23)$$

The last equation is seemingly absent from Macken's work, like equation 6.16.

What was shown so far suggests that the electric force as well as the gravitational force are both wave phenomena, but there must be some telling distinctions in their equations to explain their different behaviour and strength. Comparing equation 6.16 and 6.23 reveals such a difference: in equation 6.16 the resulting angular frequency is always positive, whereas in equation 6.23 a negative overall frequency term is theoretically possible when assuming that  $\omega_c$  can have positive and negative values. Subsequently, equation 6.23 is able to describe attractive as well as repulsive behaviour, as expected from the electric force.

In Macken's formulation of the gravitational and electric force the primary cause for the difference in their respective strength are the powers of the  $A_B$  terms. As already said previously, Macken therefore claims that the gravitational force is some kind of second order wave effect. If that really can be concluded from the distinct powers of  $A_B$  is not a simple question. Please see Macken's work (4) for more information on that topic. What can be inferred from the presented material, though, is that the strength difference between the electric and gravitational force depends on how the size of a spin  $\frac{1}{2}$  particle is associated with the respective force, i.e. when considering equation 6.10 gravity depends on  $1/(r_c^2/l_i^2)$  and the electric force depends on

$1/(r_c/l_i)$ , which in turn suggests that the electric force is inversely proportional to the circumference of a spin  $\frac{1}{2}$  particle and gravity is inversely proportional to its surface area. This difference could be a clue for how these two forces operate physically and what makes them different, in case the second order wave effect notion is discarded. In my own previous work I assumed that the fundamental oscillators come in two species (1)(3), which may or may not fit with what was presented here for the electric force. However, this assumption could provide a way to establish different modes of operation and explain what a negative frequency means in the context of a spin  $\frac{1}{2}$  particle. Physically seen, positive and negative frequencies could be related to a rotation handedness of spin  $\frac{1}{2}$  particles.

The mysterious presence of the Sommerfeld constant  $\alpha$  in the electric force equations could have a similar role like it has for hydrogen, where the electron's equatorial perimeter velocity is reduced from a value of  $c$ , for a free electron, to  $\alpha c$ , as it wraps itself around a proton (1)(3). In the presented equations for the electric force the Sommerfeld constant  $\alpha$  can also be applied to a velocity by reducing the angular frequency of a spin  $\frac{1}{2}$  particle from  $\omega_c = c/r_c$  to  $\sqrt{\alpha}\omega_c = \sqrt{\alpha}c/r_c$ , so that the intrinsic centripetal force of a spin  $\frac{1}{2}$  particle and an imaginary electric force for two fundamental charges would be in balance at a particle's radius  $r_c$ , i.e.  $\alpha F_s = m(\sqrt{\alpha}c)^2/r_c = e^2/(4\pi\epsilon_0 r_c^2)$ , which likely is no coincidence and reminiscent of the situation with hydrogen. Expressing the reduced speed explicitly gives the following equation for the electric force:

$$F_e = l_i^2 \left[ \frac{c\sqrt{\alpha}}{r_{c1}} \frac{c\sqrt{\alpha}}{r_{c2}} \right] Z_s \left[ 2 \frac{r_{c1}}{r/l_i} \frac{r_{c2}}{r/l_i} \right] \frac{1}{c} \quad (6.24)$$

The physical reason for this frequency reduction may be that the super fast rotation of a spin  $\frac{1}{2}$  particle distorts the space around it which subsequently somehow shields the real electric charge from a far away observer in exactly the right amount to achieve the mentioned force equilibrium, for reasons not yet fully understood.

Alternatively, the electric charge on the surface of a spin  $\frac{1}{2}$  particle might move slower than the overall particle which presumably has a rotation speed of  $c$  at its equatorial perimeter, i.e. the electric current lags behind somehow. In any case, the Sommerfeld constant  $\alpha$  seems to arise from equilibrium situations, which would explain why this constant exists and what it really means.

In the case of gravity there seems to be a similar situation: in close vicinity to a spin  $\frac{1}{2}$  particle its unshielded mass, which presumably takes into account additional rotational energy, apparently corresponds to the Planck mass  $m_i$  instead of what we consider to be the respective particle mass (see equation 6.4), a circumstance that contemporary physics seemingly interprets as the nuclear strong force to explain what holds a fundamental particle together while assuming a much lower mass than  $m_i$ . The shielded mass hypothesis is also hinted at by the puzzling mass energy relation  $mc^2 = Gm_i^2/r_c$ .

## 6.4 Magnetic force

Extending John Macken's notation for the special case of two fundamental charges  $e$  moving parallel or anti-parallel to each other with a speed  $v$  the magnitude of the magnetic force between these charges is given by the following equation when the vector  $\hat{r}$ , which describes their relative separation, is orthogonal to their direction of motion (i.e. they are directly opposite to each other).

$$F_m = \alpha \left[ \frac{A_{B1}}{N_1} \frac{A_{B2}}{N_2} \right] \left[ \frac{v_1}{c} \frac{v_2}{c} \right] F_l \quad (6.25)$$

This expression can be obtained from the magnetic part of the Lorentz force law in combination with the Biot Savart law, whereby in our special case any involved cross product evaluates to 1. Moreover, another noteworthy expression for the magnetic force is shown in appendix B. The preparatory work that lead to these unusual expressions of the magnetic force was done in (1).

Using the angular de Broglie frequency  $\omega_{dBn} = mv_n c/\hbar$  for a charged spin  $\frac{1}{2}$  particle with mass  $m$  moving at velocity  $v_n$  the previous equation can also be expressed as a wave equation.

$$F_m = \alpha l_i^2 (\omega_{dB1} \omega_{dB2}) Z_s \left[ 2 \frac{r_{c1}}{r/l_i} \frac{r_{c2}}{r/l_i} \right] \frac{1}{c} \quad (6.26)$$

Astoundingly, this form is very similar to equation 6.23, whereby only the angular Compton frequencies are exchanged with the respective angular de Broglie frequencies. Being able to express the electrostatic and magnetic force in the same form suggests that their wave based expression is physically meaningful.

## 6.5 Inertial mass correction

Phenomena which so far could not be explained by the theory of general relativity, like the rotation speed of spiral galaxies and dark energy, might be explained by changing inertia, as Michael McCulloch advocates

for in his works. His approach is also suggesting a wave phenomenon behind these mysterious gravitational anomalies that, according to McCulloch, arise because there is a limit for gravitational wavelength between a mass in space and the cosmic horizon, which in turn has some effects on inertial mass and gravity.

According to McCulloch there is an upper limit to the wavelength between an accelerated object and the horizon of the observable universe, which is given by  $2c^2/a$  for an acceleration  $a$ . This wavelength limit might be the lowest possible harmonic of the gravitational waves which were proposed before. As a consequence, McCulloch claims, inertial mass must be modified and the equivalence principle  $m_i = m_g$  for the inertial mass  $m_i$  and gravitational mass  $m_g$  of an object gets violated. The inertial mass correction factor, that I denote here as  $\eta$ , is stated in (10) as

$$\eta = \left(1 - \frac{2c^2}{ad}\right) \quad (6.27)$$

whereby  $d$  is the distance between a cavity's confines, which in the absence of an artificial cavity is twice the Hubble radius, i.e.  $d = 2c/H_0$ , and  $a$  denotes a mass's acceleration. This correction factor is usually irrelevant since it is extremely close to 1, but it becomes relevant as it goes lower for artificial cavities, like two closely placed parallel metal plates, and ultra low accelerations, like at the edges of a spiral galaxy.

Moreover, an interesting side effect of the inertial mass correction is that any gravitational attraction should exhibit a residual acceleration of  $2c^2/d = 2c^2/(2c/H_0) = cH_0$ , as claimed in chapter 7.1 of (10). Calculating this residual acceleration with a Hubble radius of  $1.25 \times 10^{26}$  m gives a value of  $7.2 \times 10^{-10}$  m/s<sup>2</sup>. The same result can be obtained using the Hubble mass  $m_H$  and Hubble radius  $r_H$ , i.e.  $cH_0 = 2Gm_H/r_H^2$ , when presuming that the observable universe is a Schwarzschild black hole, or at least close to being one. Moreover, there is also the alternative expression  $cH_0 = c^2/r_H$  which follows from  $H_0 = c/r_H$ .

In closing it should be remarked that the result for the residual acceleration seems to be related to the acceleration constant  $a_0 \cong 1.2 \times 10^{-10}$  m/s<sup>2</sup> of the modified Newtonian dynamics hypothesis (MOND) since these acceleration values are quite close and their proportionality constant is seemingly an integer factor, i.e.  $a_0 = cH_0/6.0 = c^2/(6.0 r_H) = Gm_H/(3.0 r_H^2)$ .

## 7 Discussion

Several  $\Gamma$  based factors were provided in section 3 that quantified how various physical quantities scale inside a gravitational field compared to being so far away from the gravitational field that its effects are negligible. The presented supplementary linear approximations of these scaling factors were also obtained by Dehnen, Hönl and Westpfahl in (7), by Krogh in (8) and by Puthoff in (13), for those relations that were derived by them using different approaches than the one applied here. Clearly, these agreements support the scaling factors put forward in this paper. Macken, however, derived different factors in his work (4) which presumably are not able to correctly quantify gravitational light bending.

The presented scaling factors should work quite well even for stronger gravitational fields, when the respective  $\Gamma$  factor is utilized instead of the associated linear approximation. In case the gravitational field becomes so strong that its influence on  $\Gamma$  even varies over a fundamental particle's confines, the presented scaling factors become inappropriate. That situation should be rather unattainable, though, since it was shown in section 3.2 that gravity should shrink fundamental particles, so that they become substantially smaller in a strong gravitational field, but in such circumstances general relativity would also not be able to make correct predictions for particles anymore.

This paper also analysed a classical calculation of Mercury's perihelion precession. However, Mercury's equation of motion, as described by equation 4.8 or 4.10, wasn't obtained by adding  $\Gamma$  factors to any of the relevant equations as these factors cancelled out in equation 4.6. Instead the associated Newtonian gravitational potential energy had to be extended (see equation 4.5) to give a potential function that is also known from general relativity theory. It was shown that the extra potential term, which features Mercury's tangential velocity  $v_t$ , might be caused by special relativistic mass and special relativistic time dilation, which both seem to increase the gravitational attraction of Mercury to our sun. However, the associated gravitational force equation 4.13 would need to be checked experimentally to verify that line of thinking. The effect that a rotating mass has on space and gravity, which wasn't considered in this paper, would likely also result in additions to the Newtonian gravitational force.

Moreover, according to general relativity literature the obtained equation of motion for Mercury is not sufficiently correct for strong gravitational fields where  $GM/(rc^2) \ll 1$  isn't true anymore. Possible causes for issues with strong gravitational fields in the calculation presented in section 4.3 are that the difference between using  $v$  or  $v_t$  was not fully explored, as  $v \cong v_t$  was assumed, and that  $T$  did not feature a correction for special relativistic mass increase. Moreover, even the time derivative  $d/dt$  itself may become an issue if the meaning of time varies noticeably over the size of a planet.

As it was already mentioned in section 3.4, the propagation speed of light is claimed to slow down slightly near a substantial mass but a local observer would not be able to measure that effect since any used measurement device is affected too by gravity. This clandestine behaviour of light also gives rise to questions about the validity of special relativity, which too has some inherent issues that are usually blanketed. Special relativistic time dilation, for example, may actually result from a Doppler effect in a medium which constitutes a unique absolute reference frame that is obscured by the circumstance that we can't measure the one way speed of light. This inability is not merely a technical issue, but a conceptual problem. However, Prof. Unnikrishnan claims to have measured the speed of light experimentally (15) with the result that it travels with a different velocity away from an observer and towards him, i.e. it adheres to Galilean transformation instead of Lorentzian transformation. Moreover, special relativity rests on the arbitrary claim that the proper length of an object is measured in any inertial frame, but the measurement of proper length may be reserved for the already mentioned unique absolute reference frame. Special relativistic space-time, i.e. Minkowski space-time, may thus not be physically real, which in turn indicates that curved space-time might not be physically real too, since Minkowski space-time is a special case of it. From an energy conservation point of view it is also not feasible to uphold a purely relativistic view of our universe, since there is a huge difference in total energy if a single object moves with near light speed through a static universe or if the remaining universe moves with the same speed past that object at rest. Intelligible lectures on the issues with the theory of special relativity can also be found on the YouTube channel "dialectphilosophy".

One of the main questions addressed in this paper was if space curvature can be avoided in calculations, as curved space might not be physically real. Arguably, this paper showed that various calculations can be made without using the concept of space curvature which yield the same results as a treatment with the framework of general relativity theory. In addition to this evidence a number of conceptual arguments can also be brought forward against the existence of a curved space.

- The Schwarzschild radius can be calculated using classical Newtonian escape velocity when also assuming an universal speed limit  $c$ , i.e.  $c = \sqrt{2GM/r}$  gives the Schwarzschild radius when rearranging for radius  $r$ . This is a smoking gun that is hard to dismiss on technical grounds.
- If gravity really means that an object in free fall just follows its geodesic equation, then obstructing that object in its path should eliminate the gravitational effect on it, because there should be no force or pressure that pushes it against the obstruction. Since this is not the case gravity has to be a force, despite what is universally proclaimed nowadays.
- Why and how exactly mass bends space is an unresolved mystery. General relativity theory is incomplete regarding that subject.
- Shrinking particles are conceptually equal to proper volume decreasing inside a gravitational field, because rulers are made of particles.
- The theory of general relativity does not explain the gravitational constant  $G$  itself, which may be an emergent constant since it seemingly can be explained in terms of all the masses present in our observable universe (2). Moreover, section 3.6 suggested that even the gravitational constant  $G$  is changing inside a gravitational field.
- The observable universe turns out to be a black hole, or at least it is close to being one, when calculating the mass of the observable universe using ordinary Cartesian space and the measured average energy density (2). The fact that we do not observe strong space curvature in our vicinity thus speaks against the notion of a curved space.
- A refractive index for space, which implies a variable speed of light, can be used to explain gravitational light bending and refraction usually implies a physical medium with changing properties.
- The so called Shapiro delay can also be calculated using a refractive index for space, since it has the same causes as gravitational light bending.
- The perihelion precession of a planet can be calculated in a classical fashion, as shown in section 4.3.
- A number of gravitational effects only require gravitational time dilation to be explained, like the gravitational redshift of light and GPS time delay. These effects therefore don't provide support for the notion of a bent space since time dilation can exist independent of curved space.
- The rotation curves of spiral galaxies, and other anomalies, indicate that something is not right with the framework of general relativity theory. The issue at hand might not be to find dark matter or dark energy, but a systemic problem with the theory of general relativity itself.
- The similarity between Macken's wave equations for classical Newtonian gravity and the electric force are indicating a medium of space whose forces are based on waves.
- Newtonian gravity can be obtained for the surface of a Schwarzschild black hole using the Bekenstein-Hawking entropy, the Unruh temperature and the equipartition theorem (1), as originally shown by Eric Verlinde using a model of a holographic and entropic gravity.

- The equivalence principle, which general relativity rests on, may not hold true in all situations, as discussed in section 6.5.
- There seems to be a link between the strong force and gravity. A side effect of this is that the proton's true mass appears to be the Planck mass  $m_i$  from the perspective of classical Newtonian gravity.
- The incompatibility of contemporary quantum physics with general relativity theory may indicate that bent space is not a sensible physical concept.

That list can probably be prolonged, which in turn reinforces the idea that it is sensible to question the underlying assumptions of general relativity theory and to explore how the gravitational effects derived from general relativity theory can be described without having to assume space curvature or a unified space-time.

Unbeknownst to many people Albert Einstein did not dismiss the notion of an aether, even after introducing general relativity. In a talk that he gave at the university of Leiden in 1920 Einstein focused on the history of the notion of an aether. During the final remarks of that talk he said that special relativity even demands the existence of an aether to enable the existence of light clocks and rulers. General relativity, even according to Einstein himself, can also be interpreted as describing an aether. Einstein back then only insisted on the limitation that an aether must not be composed of flowing corpuscles, like it was common with the notions of an aether at that time. The wave based quantum gravity concept presented in this paper fulfils that requirement since the proposed aether waves are not producing an overall net flow of the medium of space.

In this paper spin  $\frac{1}{2}$  particles are considered to be dynamic self sustaining entities made of space, or made of the substance of space itself, instead of them being something that is merely positioned in space and fundamentally different in its essence from space (1)(3)(4)(5). This notion was not discussed in this paper, as it was not the focus here. However, this unified view on particles and space should fit nicely with the notion of dynamically changing physical properties inside what is commonly called a gravitational field as there must be an immediate relation between particles and space to enable such dynamics. How that mechanism works exactly, and what really constitutes time, is not clear yet, though.

In case space is filled with oscillators and/or waves, as it was discussed in this paper, space is inherently energetic and subsequently it also makes sense to assume that some kind of gravitational temperature exists. Such a measure already exists for the horizon of Schwarzschild black holes in the form of the Hawking temperature and interestingly it is possible to extend that notion to spin  $\frac{1}{2}$  particles and gravitational fields, as already discussed in (1) and (3).

## 8 Conclusions

From what was presented in this paper it can be concluded that it should be possible to find an alternative theory for gravity that does not require a curved space-time if such theory transfers the effects that general relativity describes into the physical quantities of time, length, energy, mass, etc. Subsequently, these quantities become relative in the sense that they are dependent on a position in a gravitational field. It was shown that for a local observer inside a gravitational field the shifts in the physical quantities mostly remain clandestine and that the physical laws stay invariant. The aforementioned gravitational shifts only become readily apparent when physical processes take place over larger distances or in the vicinity of massive objects, like with gravitational redshift of light or gravitational time dilation. One local manifestation, though, is the gravitational potential energy that was shown to be an effect of varying mass due to gravity, something that Newtonian physics lacked a concrete physical mechanism before. Moreover, the equation for Newtonian gravitational force must be extended to account for special relativistic effects, which in turn allows to obtain Mercury's perihelion precession correctly using a classical calculation approach. Considering special relativistic mass and kinetic energy for gravitational attraction makes sense since every form of energy should be gravitating as learnt from general relativity theory. Thus, for situations with two non-spinning masses that are moving with a velocity  $v$  the equation of Newtonian gravity for flat space has to be extended as follows.

The dynamic notion of gravity which was presented in this paper ultimately calls for a dynamic foundation to provide a mechanism for the required variability in the various physical quantities, which might be realizable through the presented wave based quantum gravity, and it also calls for the comeback of some kind of aether which can be the substrate for microscopic quantum effects and ordinary macroscopic behaviour as well as cosmological evolution.

For convenience the  $\Gamma$  scaling factors which were derived in this paper for various physical quantities are summarized in the following table.

Quantity	Near ← Far	Approximation
Force (local)	1	1
Time period	$\Gamma$	$1 + 1GM/(rc^2)$
Electric constant $\epsilon_0$	$\Gamma^2$	$1 + 2GM/(rc^2)$
Magnetic constant $\mu_0$	$\Gamma^2$	$1 + 2GM/(rc^2)$
Mass	$\Gamma^3$	$1 + 3GM/(rc^2)$
Frequency	$1/\Gamma$	$1 - 1GM/(rc^2)$
Energy	$1/\Gamma$	$1 - 1GM/(rc^2)$
Length element	$1/\Gamma$	$1 - 1GM/(rc^2)$
Velocity (incl. $c$ )	$1/\Gamma^2$	$1 - 2GM/(rc^2)$
Acceleration	$1/\Gamma^3$	$1 - 3GM/(rc^2)$

Table 2: Scaling factors

Since the effect of gravity on time is physically real the other gravitational effects must be physically real too.

## Appendix A Natural Constants

### A.1 Classical expressions

Light speed	$c = 2.9979 \times 10^8 \text{ m/s}$
Planck constant	$h = 2\pi\hbar = 6.6261 \times 10^8 \text{ J/Hz}$
Gravitational constant	$G = 6.6743 \times 10^{-11} \text{ m}^3/(\text{s}^2 \text{ kg})$
Electric field constant	$\epsilon_0 = 8.8542 \times 10^{-12} \text{ F/m}$
Magnetic field constant	$\mu_0 = 1.2567 \times 10^{-6} \text{ mT/A}$
Fundamental charge	$e = 1.6022 \times 10^{-19} \text{ C}$
Sommerfeld constant	$\alpha = e^2/(2ch\epsilon_0) \cong 1/137$
Magnetic flux quantum	$\phi_e = h/2e$
Planck length	$l_l = \sqrt{\hbar/c} \times \sqrt{G/c^2} = \sqrt{\hbar G/c^3} = 1.6162 \times 10^{-35} \text{ m}$
Planck mass	$m_l = \sqrt{\hbar/c} \times \sqrt{c^2/G} = \sqrt{\hbar c/G} = 21.765 \mu\text{g}$
Planck time	$t_l = \sqrt{\hbar/c} \times \sqrt{G/c^2} \times \sqrt{1/c^2} = \sqrt{\hbar G/c^5} = l_l/c = 5.3912 \times 10^{-44} \text{ s}$
Planck charge	$\pm q_l = \pm e/\sqrt{\alpha} = \pm 1.876 \times 10^{-18} \text{ C}$
Planck force	$F_l = c^4/G = 1.21 \times 10^{44} \text{ N}$

### A.2 Expressed using the Planck force

Gravitational constant	$G = F_l l_l^2/m_l^2$
Electric field constant	$\epsilon_0 = F_l/(4\pi\alpha) e^2/l_l^2 = F_l/4\pi q_l^2/l_l^2$
Magnetic field constant	$\mu_0 = 4\pi\alpha/F_l l_l^2/(e^2 c^2) = 4\pi/F_l l_l^2/(q_l^2 c^2)$

### A.3 Expressed as emergent properties

#### A.3.1 Expressed in base units of quantized spacetime

Light speed	$c = l_l/t_l$
Gravitational constant	$G = c^2 l_l/m_l$
Sommerfeld constant	$\alpha = e^2/q_l^2$
Electric field constant	$\epsilon_0 = e^2/(2\alpha ch) = q_l^2/(2ch)$
Magnetic field constant	$\mu_0 = 2\alpha h/(e^2 c) = 2h/(q_l^2 c)$
Planck force	$F_l = ch/l_l^2$

#### A.3.2 Expressed using cosmological values

Hubble constant	$H_0 \cong 74.3 \text{ km/s/Mpc}$
Hubble radius	$r_H = c/H_0 \cong 1.25 \times 10^{26} \text{ m}$
Hubble mass	$m_H \cong 8.4 \times 10^{52} \text{ kg}$
Gravitational constant	$G \cong (c^2/2) r_H/m_H$ (note: this is effectively a rearranged Schwarzschild mass equation)
Planck length	$l_l \cong \sqrt{\hbar/c} \times \sqrt{r_H/(2m_H)}$
Planck mass	$m_l \cong \sqrt{\hbar/c} \times \sqrt{(2m_H)/r_H}$
Planck time	$t_l \cong \sqrt{\hbar/c} \times \sqrt{r_H/(2m_H)} / c$

## Appendix B Forces in terms of the Planck force

The main four fundamental forces reveal the following pattern when expressed in terms of the Planck force  $F_l$ , aka the super force, for the special case of two spin  $\frac{1}{2}$  particles.

Force	Formula
Strong	$F_l l_l^2/r^2$
Electric	$\alpha F_l l_l^2/r^2$
Magnetic	$\alpha F_l l_l^2/r^2 v_1 v_2/c^2$
Gravitational	$F_l l_l^2/r^2 m_1 m_2/m_l^2$

Table 3: Forces of spin  $\frac{1}{2}$  particles

The following notes apply to this table:

- The Planck force seems to be the reference for the main four fundamental forces and to be the strongest possible force. This gives rise to the speculation that the Planck force was the first force in our universe from which the other forces descended in some way.
- The depicted formula for the strong force is an approximation that is applicable in close vicinity to the border of a proton or neutron. Equation 6.2 denoted the special case of  $r = r_c$ . The strong force may exist for electrons too, but due to a substantially different particle size its effect seems to be practically irrelevant for electrons.
- The relevance of the Sommerfeld constant  $\alpha$  for electromagnetism is immediately obvious.
- The stated formulas for the electric and magnetic force only apply to electrically charged particles.
- The stated magnetic force is for the special case of two fundamental charges  $e$  moving in parallel or anti-parallel to each other, whereby the sine term of any involved cross product from the Lorentz force law evaluates to 1. This implies that the relative separation vector  $\hat{r}$  is orthogonal to both trajectories.
- Distance  $r$  is relevant in multiples of the Planck length  $l_l$ , i.e.  $1/(r/l_l)$ . This circumstance supports the notion that the Planck length is the smallest possible length in our universe.
- If the Planck units were not fundamentally meaningful the equations in the table above should contain arbitrary correction factors.

## Appendix C Newtonian gravity in terms of escape speed

Newtons gravitational force  $F_g = GM_1 M_2/r^2$  for two homogeneous spherical masses  $M$  with a distance  $r$  between their centres can also be expressed in terms of escape velocity  $s = \sqrt{2GM/r}$  as follows.

$$F_g = \frac{1}{4} F_l \frac{s_1^2}{c^2} \frac{s_2^2}{c^2} \quad (\text{C.1})$$

This equation highlights the following points:

- Light speed  $c$  is the velocity limit in our universe, since  $s/c$  normalizes  $s$  with respect to  $c$ .
- The Newtonian gravitational force can never reach the Planck force  $F_l$  because of the factor  $1/4$ . A gravitational force stronger than  $F_l/4$  requires additional gravitational effects not taken into account by Newtonian gravity, like a (rapidly) rotating mass.
- The term  $s^2/c^2$  can be seen as a comparison of gravitational potentials, because the units for squared velocity and a gravitational potential are equal, i.e.  $\text{m}^2/\text{s}^2 = \text{J}/\text{kg}$ .
- Subsequently, the gravitational potential limit in our universe is given by  $-c^2$ , as described in more detail in (2).
- The repeated division by  $c^2$  makes it immediately obvious why the gravitational force is relatively weak when used in scenarios which don't involve black holes.

In case that space is interpreted as a flowing medium with actual currents, as some aether theories propose, the escape velocity  $s$  should denote the flow of that medium towards gravitational sources, which makes sense since this is the velocity that an object would need to overcome to fully leave the region of influence of a gravitational source. Moreover, a flowing medium could also account for the meaning of  $\Delta\beta$  as presented in section 5.2. For rotating masses the escape speed should be greater than the static case as described by the presented formula for  $s$ .

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