Gravitation, Energy and Time (GET)

By Alexander Gustavsson and Sven Johansson

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Abstract

The recent period has been exciting in physics and cosmology. The hypotheses of dark matter and dark energy etc. are great challenges for science. These observations might open for new perspectives on physics and current theories may need to be reconsidered. The document is an attempt to do that.

In *Gravitation, Energy and Time* (GET) energy is used as the common denominator to explain gravitation. The core of GET is based on the following main assumption:

Matter decay and continuously radiates gravitational particles (gravitons) in all directions – which is the origin of gravitation.

In GET all aspect of gravitation is explained by local energy interaction. The model may be seen as a hybrid between Newtonian physics and additions from modern physics. The dynamic vector field of gravitons, generated from matter, creates a dynamic landscape of energy that rules the movements of other objects in space.

Plausible arguments show that GET is in line with the classical predictions in GR, which are: perihelion precession of Mercury, deflection of light by the Sun and gravitational redshift of light. GET provides an alternative formula for time dilation in the regime of non-relativistic velocities and weak gravitational fields. Time effects for GPS satellites due to gravitation and speed are calculated with correct results. Newton's law of universal gravitation and the strange unit of the gravitational constant G can be derived and explained from first principles in GET.

The major prediction in GET is unexpected mass loss for all objects in the Universe. The increase of the astronomical unit (AU), the shrinking of Mercury and the Moon, mass of white dwarfs, slowdown of pulsars, the secular decrease of the geocentric gravitational constant for the Earth ($GM_{\oplus}$) and several other observations support this prediction. If matter decay into gravitons it will affect most of the dynamic behavior of the Universe. Therefore, GET also comes with a number of other interesting predictions. One such prediction is an alternative explanation of dark matter where the shape of large structures are crucial. Another prediction is that black holes may contain much more mass than expected.

One of the greatest challenges in physics is to merge quantum physics and GR. Since GET is based on a quantified model, it opens for a bridge to quantum physics. The results in GET are exciting and fit well into modern physics. If true, gravitation will reclaim its place as the fourth fundamental force in the Universe.

1 Introduction

The document[1] describes a new theory of gravitation where local energy interactions are used to explain all aspects of it. In 2005 we formulated the main assumption in GET that has never changed since then. Over the years the theory has been extended in order to give a better picture of how gravitation may work on a deeper level[2].

The two most important theories of gravitation are:

- Newton's law of universal gravitation, $F = G\frac{m_1 m_2}{r^2}$ (NG), is generally in agreement with observations in the limit of weak gravitational fields and non-relativistic velocities.[1] It's based on the assumption that forces are the cause of gravitation. However, NG does not explain the finite speed (c) of gravitation, gravitational redshift of light, gravitational lensing, gravitational time dilation, perihelion precession of Mercury, the correct value of light deflection by the Sun, the existence of black holes etc. At least it has to be refined in order to be in line with current observations and modern physics.

- Einstein's theory of general relativity, $G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$ (GR), is the current theory that, up to date, best fits observations with high precision.[2][3] GR describes a bent space-time geometry on the left-hand side of the equation and the energy that distorts the space-time on the right-hand side. It's an accurate mathematical model that includes the properties above that NG lacks. However, GR is not yet compatible with quantum physics and the theory may require a refinement in order to agree with new observations such as dark matter and dark energy.

A new theory of gravitation has to be consistent. It also has to agree with current observations and provide new predictions that cannot be explained by GR.

The Sun radiates particles out in space where the most familiar are photons. An enormous number of neutrinos[4] are also radiated. We do not see and feel neutrinos since they interact very weakly with matter. Imagine, in a similar way, that the cause of gravitation is that all *matter decay slowly and continuously radiates gravitational particles in all directions*. Further, envision these particles mediate the attractive force of gravitation. These lines capture the essence of GET. In GET radiated gravitons will *create a dynamic landscape of energy in space*. The vector field of gravitons can be interpreted as energy potentials at local points in space and time that determines how matter will move. The energy potentials correspond to the bent space-time geometry in GR.

GET is based on simple and clean principles that includes parts from NG, special relativity (SR) and extensions of the Standard Model. The line of reasoning throughout the document is based on energy, space and time – which are key concepts in physics. Elementary particles, described by the Standard Model, are energy packages with certain properties.[5] The Universe is filled with energy, which interacts in space at certain points in time. Our view is that all events should be described as local[3] energy interactions.

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[1] The document has been improved in a series of steps (since 2005) and this is an updated version of: *Gravitation, Energy and Time (GET)* v. 2.2 (2023)[1].
[2] When we refer to observations and other theories, we try to do that in an accurate way, but interpretations of the theories, the observations and the description of GET are obviously our own view.
[3] The word 'local' means a specific point in space and time.

The main assumption in GET is:

> *Matter decay[4] and continuously radiates gravitational particles[5] (gravitons) in all directions – which is the origin of gravitation.*

The assumption above is concerning the *emitters* of gravitation. Since matter cause gravitation, protons and neutrons must be emitters and perhaps also leptons (such as electrons). The graviton[6] is a postulated force carrier particle of gravitation in extensions of the Standard Model.[7] The same particle[6] is also used to explain gravitation in GET. In order to describe the gravitational force, the receiving object also has to be considered. This aspect is discussed later in the document.

The idea of a force carrier particle gives a physical explanation how gravitation is communicated. Since gravitation probably propagates with the speed of light (c), a massless particle such as the graviton is the natural choice. In GET matter will send out invisible gravitons in all directions similar to stars emitting light. The gravitational force is *very weak* because the decay of mass into gravitons follows a *very slow* process.

The energy (transferred by the gravitons) required for the motion of the planets (or any other objects) must origin from the masses. One may think that the mass of the planets and the Sun (except its radiation due to the fusion processes) never change. But is that really certain? The gravitational mass loss process is probably *very slow*, since even a small mass loss result in a huge amount of energy (according to $E = mc^2$ [8]), and therefore it will be difficult to detect. Thus, there is a possibility of unexpected gravitational loss of matter that has not yet been detected.

The key assumption in GET is that mass continuously decays, and a crucial question to ask is what *amount* of radiated energy is reasonable*?* The parameter[7] $\lambda_d = \frac{|\dot{M}|}{M}$ is introduced to denote the decay rate. Due to empirical constraints, presented in the next section, the decay rate should be somewhere in the range $1 \times 10^{-14} \leq \lambda_d \leq 5 \times 10^{-12}\ y^{-1}$. The value is also constrained by logic, presented later in the document.

The document continues with three major parts. A new theory of gravitation must as a start point be able to reproduce, and preferably also explain, the NG formula. The first part of the document is an attempt to do that. In NG objects attract each other by forces in an unknown way, but in GET the origin of the forces is explained using a model where energy is *constantly transferred between the objects*. The emission of gravitons from matter creates *a landscape of energy that determine how objects will move in space*. This process is the essence of the GET model. In the second part the classical cases of GR and time dilation are addressed. The result is the same as in GR but the underlying explanation is different. It's also shown that energy is the mutual cause for time dilation due to speed and gravitation. In the third part cases from modern physics and cosmology, such as black holes, gravitational waves, dark matter etc., are discussed based on the GET model. In the last section potential problems with the GET model are presented.

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[4] We have outlined some ideas on how it *may* work on the quantum mechanical level.
[5] Gravitons carry away the energy equal to the rest mass energy of the decaying particles.
[6] We assume the particle is the graviton, but it may be another particle not yet described by other theories.
[7] λ_d is defined to be a positive number even though $\dot{M}$ is negative. The reason is that the focus in GET is on the radiated energy from matter, which is a positive number.

2 Observations of Mass Loss

In this section a selection of observational arguments that support the picture of gravitational mass decay are presented[8].

It's important to emphasize that the basis of mass decay in GET can be viewed from two perspectives. The first perspective is to view it as a stand-alone assumption for how gravitation works (no matter how the actual mechanism works). Then observations of unexpected mass loss linked to gravitation will determine if this assumption turns out to be true or not. The second perspective would be to view it as a prediction (or rather a consequence by logic) based on the line of reasoning from the previous section where arguments were presented that energy is required to create a gravitational force. This section will focus on the *first perspective*.

The following observations support the assumption of unexpected mass loss:

1. **AU increases[9] [9].** The distance between the Earth and the Sun increases much more than expected each year. Measurements of the AU have shown that the distance between the Earth and the Sun (ΔAU) increases by 15 [+/- 4 cm] y^{-1} [10], but other measurements indicate that this value (used below) is 7 [+/- 2] cm y^{-1} [11][10] The radiation of energy due to the fusion processes in the Sun can only contribute to a change in the distance *(ΔAU_f)* of 0.338 cm y^{-1}.[12] Is it possible that an unknown source of radiation (i.e. gravitational mass decay) from the Sun is the reason?

   The fusion processes can only partly explain the increase of the AU. The mass loss $\dot{m}_f$ due to the fusion processes in the Sun is 4.28 × 10^9 kg/s which corresponds to a fraction mass loss Δm_f = 6.79 × 10^{-14} y^{-1}, where $\Delta m_f = \dot{m}_f \,/M$, and M is the mass of the Sun. Let Δm_g be the fractional change of mass due to gravitational radiation, where $\lambda_d = \dot{m}_g \,/M$. According to section 2 from the source [13], $\Delta AU/AU = \Delta m_{sun}$, which gives:

   $$\frac{\lambda_d}{\Delta m_f} = \frac{\Delta AU - \Delta AU_f}{\Delta AU_f} \text{ where}$$

   $$\lambda_d = \frac{(7 - 0.338)}{0.338} \times 6.79 \times 10^{-14} \approx 1.3 \times 10^{-12}\, y^{-1}$$

   If AU increases due to unexpected mass loss, then the value of that loss would be within the predicted range in GET. Though more data and analyses are required to verify the increase of AU. More information about this topic can be found at the sources [14] and [15]. The mass loss of the Earth should also be a part of the calculation, but the effect should be negligible (see also [16] and [17]). The orbits for all planets in the solar system increase as a result of mass loss due to fusion processes in the Sun. However, no accurate data have been found to claim an *unexpected* gravitational mass loss.

2. **Mercury shrinks**. Recent observations show that Mercury shrinks.[18] [19] If decay due to gravitation is assumed to be the main reason, it corresponds to the calculated mass decrease estimated in GET. However, the shrinking process might be caused by a combination of cooling and gravitational mass loss.

   Mercury's radius has shrunk Δr = 2-4 km during its lifetime[20], which is about 4.6 billion years[21]. If we assume that the surface did cool to rock after 300 million years and that the volume of Mercury has a uniform density

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[8] We would like to credit Alexey Bobrick for observation 4, 5, 6 and 7.
[9] The AU has, due to its increasing value over time, been redefined to become a fixed constant; therefore, it is more appropriate to talk about the distance between the Sun and the Earth.
[10] The magnitude of the increase is still controversial, but a substantial additional drift that cannot be explained by the fusion process seems very likely.

(in reality it consists of an iron core and a surface of rock). Using the radius of Mercury, r = 2 440 km[22], $\Delta r = 3$ km and omitting the constants the decrease of the mass per year is[11]:

$$\lambda_d = \frac{1-\left(\frac{\Delta V}{V}\right)^3}{T} = \frac{1-\left(\frac{2.44\times10^3-3}{2.44\times10^3}\right)^3}{4.3\times10^9} = 8.6\times10^{-13}\,y^{-1}$$

The radius of the Moon has decreased with 100 m in 800 million years.[23] That corresponds to $\lambda_d = 2.2\times10^{-13}\,y^{-1}$. Recent observations show that Mars[24], Jupiter[25] and the asteroid Ceres[26][27] also shrink. Jupiter is shrinking much more than the expected rate in GET. The reason might be a combination of gravitational radiation and other effects. A speculative but interesting question to ask is if the movement of the tectonic plates is a result of a slowly shrinking Earth?

3. **Secular decrease of $GM_\oplus$.** Data from the geodynamic satellites Lageos 1 and Lageos 2 shows that the secular drift[12] for Lageos is about $(-8.6\pm0.5)\times10^{-12}\,y^{-1}$.[28] However, other monthly data analysis from the Lageos satellites indicates the secular trend to be $-3.31\times10^{-13}\,y^{-1}$.[29] If G does not change over time, then mass loss from the Earth must be the cause. The magnitude of the loss is within the predicted range in GET and the result strongly indicates that gravitation is caused by mass decay.

   Thus, a restrained result is $\lambda_d = 3.31\times10^{-13}\,y^{-1}$

The following observations also indicate unexpected mass loss, but are more indirect and therefore more complex to analyze:

4. **White dwarf stars.** The observed sizes of all known white dwarf stars indicate that they might lose mass within the predicted range in GET.

   There is an interesting implication of mass decay[13] on the properties of white dwarfs (WD). White dwarfs have a maximal possible mass of $M_{\text{WD,max}} = 1.4\ M_\odot$ If a white dwarf has mass above this limit, then it immediately collapses under its own gravity. If a white dwarf were produced in the early Universe, then it's mass by the present day would be at most $M_{\text{WD,max,curr}} = (1-\lambda_{\text{d}}T_{\text{WD}})\ M_{\text{WD,max}}$. This is because the mass initially was at most $M_{\text{WD,max}}$, which was then followed by mass decay. For example, if a white dwarf was born 10 Gyr ago, then at present day its mass would have to be no larger than $0.9-0.99M_{\text{WD,max}} = 1.26-1.39\ M_\odot$. It is very interesting to note that the most massive single white dwarf that has been found has a mass of $1.35\ M_\odot$[30]. And moreover, when masses of all known single white dwarfs are considered, there are quite many below $1.35\ M_\odot$[31], and none above. This may possibly be due to mass decay, which has decreased all the original masses of the white dwarfs, this way introducing a gap between their masses and the maximal possible mass $M_{\text{WD,max}}$. An additional question is why there are not any white dwarfs, formed recently, with a mass larger than $1.35\ M_\odot$?

   The result above points to a potential mass loss of $\lambda_d = \frac{1-\frac{1.35}{1.4}}{10^{10}} = 3.6\times10^{-12}\,y^{-1}$

   Another observation, related to white dwarfs, is a study of the white dwarf luminosity function and the distance of the well-studied open Galactic cluster NGC 6791. According to the abstract in [32] the upper limit of a secular

[11] The calculation is of course very rough and gives only a hint on what the value might be.
[12] The article in the reference list has disappeared on the Internet and unfortunately it can't be found anywhere else.

variation of the gravitational constant is $1.8 \times 10^{-12}\ y^{-1}$. The data is probably based on $G\dot{M}_{\odot}/GM_{\odot}$. This is not a proof of mass loss but it's interesting that it's within the same range that the assumption of mass loss in GET.

5. **Hubble constant.** The present-day debate about the value of the Hubble constant, may be partly explained by decay of mass.

   The estimates of the Hubble constant between the early Universe and present-day observations differ by up to 10 %.[33] The source for the difference in the measurements is unclear, and there is no common agreement about it. While quite many scenarios have been proposed. One is the explanation model based on 'dark radiation' component which is assumed to have appeared since the early universe. In particular, Hamaguchi et al (2017) [34] have calculated that the tension in the Hubble constant can be explained if 12% of dark matter had turned into radiation over the Universe lifetime (their equation 8). Rather strikingly, this is very close to the numbers expected in GET for mass[35] loss.

   It will correspond to a mass loss of $\lambda_d = \frac{0.12}{13.8 \cdot 10^9} = 8.7 \times 10^{-12}\ y^{-1}$

6. **Earth insolation.** The sun is heating up, but if its mass has decreased it results in less heating.

   The change in solar insolation may be important for habitability on the Earth. Stars, including the Sun, obey mass-luminosity relation[36], which states that the luminosity L of a sun-like star (and the Sun) is proportional to its mass M to the power four (i.e. more massive stars are very bright). The solar lifetime $T_{\odot} = 4.6$ Gyr. This way, we may expect that due to mass decay solar luminosity has changed by:

$$\frac{L_{\text{now}}}{L_{\text{init}}} = \left(\frac{M_{\odot,\text{ now}}}{M_{\odot,\text{ init}}}\right)^4 = \left(1 - T_{\odot}\right)^4 \tag{2.1}$$

   This way, the current luminosity of the Sun is between 0.81 and 0.98 the initial value. We can conclude that from mass decay it follows that the Sun was hotter and closer. The insolation F (flux of solar radiation) reaching the Earth is calculated as $F = \frac{L}{4\pi a^2}$. And this way, mass decay made insolation to change by:

$$\frac{F_{\text{now}}}{F_{\text{init}}} = \frac{L_{\text{now}}}{L_{\text{init}}}\left(\frac{a_{\text{init}}}{a_{\text{now}}}\right)^2 = \left(1 - \lambda_{\text{d}} T_{\odot}\right)^6 \tag{2.2}$$

   Mass decay makes the Sun, therefore, to illuminate the Earth at 73 to 97 per cent of the initial rate. The derived numbers are in an interesting agreement with the nuclear evolution of Sun, which predicts that as the Sun evolves, it burns nuclear fuel in its interior progressively faster. Theory of stellar evolution, which doesn't account for mass decay in the Sun, predicts that the Sun must have become about 25 per cent hotter compared to its initial luminosity[37]. This way, mass decay in GET makes the Sun shine less upon the Earth, and stellar evolution makes it shine more, and both effect next to cancel each other out. This may be certainly seen to support GET, since the formation and evolution of life on Earth is much easier to explain under nearly constant illumination.

   Quote from Spalding et al (2018) [38] "Models of the Sun's long-term evolution suggest that its luminosity was substantially reduced 2-4 billion years ago, which is inconsistent with substantial evidence for warm and wet conditions in the geological records of both ancient Earth and Mars." This is called the "faint young Sun paradox". The authors say that the paradox could be resolved if the Sun 'somehow' lost a few percent of its mass over its lifetime.

   Let's say that "a few present" corresponds to 2% (arbitrary value), $\lambda_d = \frac{0.02}{4.6 \cdot 10^9} = 4.3 \times 10^{-12}\ y^{-1}$

7. **Pulsar PSR J0437-4715** and other binaries slow down its binary orbit, potentially due to mass decrease. GET would predict for this pulsar a yearly orbital increase of:

$$\Delta P_{\mathrm{PSR\ J0437-4715}} = 5.74\ \mathrm{d}\left(\frac{1}{(1-\lambda_{\mathrm{d}}\times\mathrm{yr})^2} - 1\right),$$

which[14] evaluates to between 0.9 μs/yr and 9.9 μs/yr by assuming the following decaying rate $1\times10^{-12} \leq \lambda_d \leq 5\times10^{-12}\ y^{-1}$. In the same study[39] the authors quote that they have subtracted from the solution an excess period decay of $(3.2 \pm 5.7)P\ \mathrm{s}^{-1} = 5.0 \pm 8.9$ μs/yr (which is equation 3 in [104]). The authors interpret it as a possible sign of a decrease in the gravitational constant G, which makes the orbital period *increase* at a rate of 5.0 ± 8.9 μs/yr on top of the GR solution. This extra increase strikingly agrees with the *increase* in the range of $0.9 -\ 9.9$ μs/yr expected from mass decay. Combined with the data for Hulse-Taylor binary, this pulsar provides a very strong evidence for mass decay. The authors also discuss in the same section of the article that observations of other binary pulsars give the anomalous extra period decay correction of no less than the value they have found. Moreover, the authors also mention that this may be related to the observed change in AU.

The result from this part is an interval $1\times10^{-12} \leq \lambda_d \leq 5\times10^{-12}\ y^{-1}$

Another binary pulsar, the Hulse-Taylor pulsar, exhibit an anomalous component of orbital decay, which may be explained by mass decay in GET. The in spiral may be caused by a mass loss and explain the 2.5% (due to space limits the derivation of the value is not shown here) difference from GR.

An analysis of binary pulsar in [40], shows a result where the lower limit for secular decrease of G is $2.8\times10^{-13}\ y^{-1}$ which is very interesting because it's much larger than the highest limits secular decreases of G from other sources.

8. **Variations in $GM_{\odot}$.** There are two recent observations stating even stricter constraints on the range[15] of mass loss if G is constant (according to the sources it's not specified if G and/or M change). The first source [41] states the range $(-5.0 \pm 4.1)\times10^{-14}\ y^{-1}$ and the second source [42] states $(-6.13 \pm 1.47)\times10^{-14}\ y^{-1}$

Thus, a restrained result is $\lambda_d = (5.0 \pm 4.1)\times10^{-14}\ y^{-1}$

The list presented above shows there are a number of observational supports for unexpected mass loss. According to the line of reasoning above the gravitational decay rate is probably somewhere within the range $1\times10^{-14} \leq \lambda_d \leq 5\times10^{-12}\ y^{-1}$. An arbitrary value $\lambda_d = 1\times10^{-12}\ y^{-1}$ (which is within this range) is used throughout the document.

[14] The derivation of the formula is available in an extended version of GET.
[15] In GET G is assumed to be a true constant that does not change.

3 GET related to NG

3.1 The energy aspect of gravity

In GET matter continuously decay and emits gravitons in all directions. The gravitons are the force carrier particles for gravitation and when they reach other objects, they will cause an attractive pull. Figure 1 illustrates the basic GET model. It will be presented more in detail later.

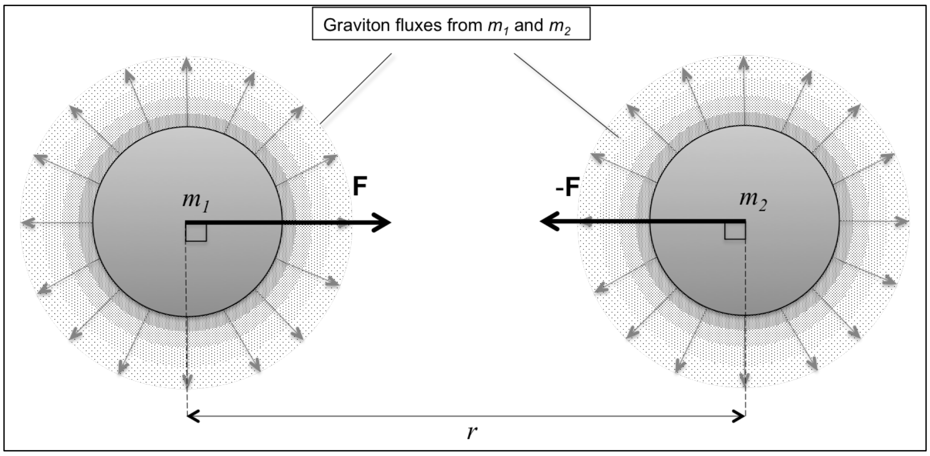

Figure 1. The force F is built up by the vector sum of all gravitons emitted from m_1 that reach m_2. Similarly, the force -F is built up by the vector sum of all gravitons emitted from m_2 that reach m_1. For non-extreme cases two objects will attract each other according to NG.

According to NG the gravitational force between two masses is:

$$F = G\frac{m_1 m_2}{r^2}\ [\mathrm{N}] \tag{3.1}$$

In GET the vector field[16] of gravitons will transfer the force between the two objects m_1 and m_2. Assume the two objects will ***be at rest*** at the beginning. Then the gravitational force F will act on both of them according to:

$$F = \frac{dp}{dt}\ [\mathrm{N}] \tag{3.2}$$

The momentum *p* during one second ($\Delta t = 1$ below), given that F is a constant, will be:

$$p = \int_t^{t+\Delta t} F\mathrm{d}t = F\Delta t = F \times 1 = F\ [\mathrm{kgms^{-1}}] \tag{3.3}$$

[16] The vector field of gravitons can also be seen as a "flux of gravitons" that is the total energy for all gravitons per square area and time unit. The field is *always* a dynamic flow of gravitons moving at the speed c. The preferable unit for the graviton flux is $\mathrm{W/m^2}$. This concept is described more in detail in section 3.7.2.

Gravitons carry a certain amount of energy. *Assume that all*[17] *gravitational energy sent out from* m_1 that reach m_2 *will be transferred into kinetic energy (leading to an attractive pull on* m_2*).* Compare this situation with a photon entering a black body. In this case all energy from the photon will be transferred into kinetic energy that will increase the temperature of the body. In order to determine how the gravitational transfer process actually works quantum physics has to be considered which is beyond the current scope of this document.

For non-relativistic velocities and in the regime of weak gravitation, the classical formulas for kinetic energy can be used (the relativistic case will be presented later):

$$E_{kin} = \frac{mv^2}{2} = \frac{p^2}{2m} \text{ [J]} \tag{3.4}$$

Rearranging the formula gives:

$$p = \sqrt{2E_{kin}m} \text{ [kgms}^{-1}\text{]} \tag{3.5}$$

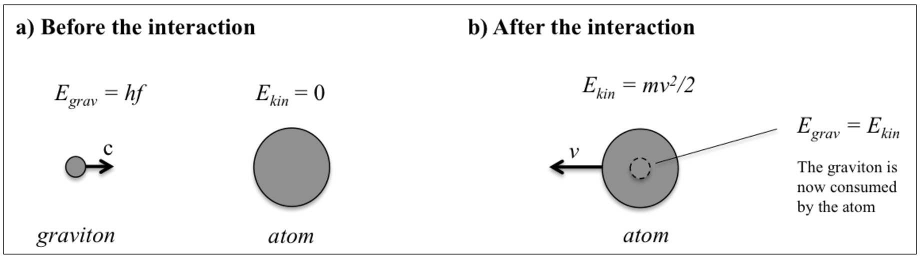

Figure 2. After the interaction the graviton is fully consumed by the atom. Thus, the atom has increased its kinetic energy equal to the total energy of the graviton.

The concepts introduced above will now be applied[18] on the solar system[19] in order to calculate the values of momentum and energy. The line of reasoning should also be applicable in general for any other similar system[20] in the Universe. In reality all planets in the solar system are moving in (slightly elliptical) orbits around the Sun. But imagine, as a thought experiment, the planets would be stopped (by an external force) for a moment. In that case the force from the Sun *would still be the same.* The momentum and kinetic energy in the radial direction towards the Sun would then be possible to calculate in a simple way. The force and momentum are calculated from equations (2.2) and (3.3). The energy that the Sun will transfer to the planets (via radiated gravitons) is calculated from equation (3.4). The radial force F is caused by the power P (the tangential kinetic energy of a planet is zero according to the thought experiment). The velocity v in Figure 2 is in this case the radial component v_r. In appendix 8 there is a derivation of p and P for the case of circular motion. The final result in that case is identical to the result of equation (2.5). For the case of circular motion, where the energy for a planet stays constant, gravitons will *pull matter* when they are consumed, but *push matter* when they are emitted (see [43]).

The momentum and energy for Mercury according to (2.1), (2.3) and (2.4) are:

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[17] The Compton scattering process may serve as a framework for the transfer of momentum from gravitons to matter. According to this process an energy transfer rate of 99.99% is possible for photons.[17] [17] It's unknown how the graviton-matter interaction process actually works, but perhaps it has some similarities to Compton scattering.
[18] The line of reasoning is also applicable for linear motion which is the case described above.
[19] The solar system is chosen since the data is most reliable for this system.
[20] The line of reasoning should be valid in any case where the distance between the objects is very large.

$$F = G\frac{m_1 m_2}{r^2} = 6.67 \times 10^{-11}\frac{1.98 \times 10^{30} \times 3.3 \times 10^{23}}{(5.79 \times 10^{10})^2} = 1.30 \times 10^{22} \text{ [N]}$$

$$p = F \times 1 = 1 \times 1.30 \times 10^{22} \text{ [kgms}^{-1}\text{]}$$

$$E_{kin} = \frac{p^2}{2m} = \frac{(1.30 \times 10^{22})^2}{2 \times 3.3 \times 10^{23}} = 2.56 \times 10^{22} \text{ [J]}$$

$$P = \frac{E_{kin}}{\Delta t} = \frac{2.56 \times 10^{22}}{1} = 2.56 \times 10^{22} \text{ [W]}$$

The same calculations are made for the other planets (and the Moon). The result is presented in Table 1.

Table 1. Data for the first four rows is fetched from [44].

	Mercury	Venus	Earth	Moon[21]	Mars	Jupiter	Saturn	Uranus	Neptune
Mass [10^{24} kg]	0.33	4.87	5.97	0.073	0.642	1898	568	86.8	102
Dist. from Sun [10^6 km]	57.9	108.2	149.6	0.384	227.9	778.6	1433	2872	4495
Orbital period [days]	88.0	224.7	365.2	27.3	687.0	4331	10747	30589	59800
Orbital velocity [km/s]	47.4	35.0	29.8	1.0	24.1	13.1	9.7	6.8	5.4
p [kgm/s]	1.30e22	5.53e22	3.54e22	1.97e20	1.64e21	4.16e23	3.71e22	1.40e21	6.68e20
P [W]	2.56e20	3.14e20	1.05e20	2.66e17	2.09e18	4.56e19	1.21e18	1.13e16	2.19e15

Based on the gravitational force (NG) the momentum and power[22], transferred from the Sun to the planets (the two last rows in the table), is calculated. Since the core of GET is based on energy transfer, it's essential to know the required energy needed for the planets to stay in their orbits[23].

The formulas above can be used in the classical regime of non-relativistic velocities and weak gravitational fields.

3.2 A basic construction of the GET model

The main assumption in GET is that gravitation is caused by force carrier particles (gravitons) radiated from all matter that slowly decays in the Universe. The key parameter for this process is the mass decay rate λ_d. Matter decay into gravitons that carry away the energy equal to the transformed rest mass energy of the decaying particles (according to $E = mc^2$). The power P_M of the radiating gravitational energy from an object *M* is:

$$P_M = \lambda_d M c^2 \text{ [W]} \tag{3.6}$$

[21] The Earth is the central object in this case.
[22] The energy level of an object in a circular orbit stays constant, but an *exchange* of energy is needed.
[23] The energy level of the planets stays constant, but we claim (contrary to the common view) that energy *exchange* is necessary.

Before presenting the further steps in the force model of GET we will discuss some concepts that hopefully will help to better understand how the model has been developed[24]. There are also important requirements that determines the limitations of the model.

From the NG formula it follows that a mathematical model requires that a spherical body should be possible to replace with a point mass at its center. A good choice would be the mathematical description of the radiation of gravitons around a spherical body. The variables are the mass, the position of its center and the way it radiates.

We introduce the quantity graviton flux $j_M(R)$ from a *spherical object* at distance R. The flux is spherically symmetric, i.e. the radiation mechanism is similar to how light is emitted from the Sun in all directions. The quantity can be expressed in the following way:

$$j_M(R) = \frac{\lambda_d M c^2}{4\pi R^2}\,[\mathrm{Wm}^{-2}] \tag{3.7}$$

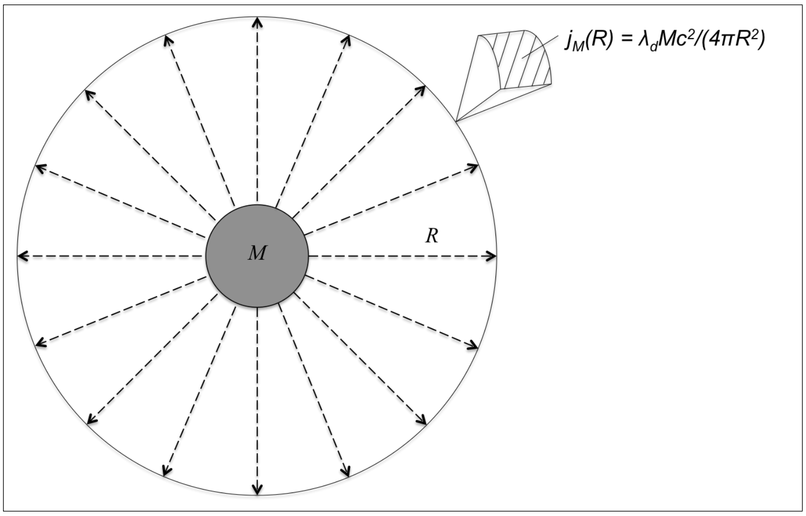

Figure 3. The energy radiated from M is equally spread on the spherical area at distance R.

Formula (3.7) complies to the requirements above and is the representation in GET of spherical masses in space. It's also equivalent, by rearranging variables and multiply both sides with G, with the NG equation for acceleration due to gravitation.

$$\frac{G4\pi j_M(R)}{\lambda_d c^2} = \frac{GM}{R^2} = a(R)\ [\mathrm{ms}^{-2}] \tag{3.8}$$

From here it's simple to show that GET is compatible with NG on the first level of complexity. A test mass m_0 at distance R from M combined with Newton's law $F = m_0 a$ gives:

$$F = \frac{G4\pi j_M(R) m_0}{\lambda_d c^2} = \frac{GMm_0}{R^2}\ [\mathrm{N}] \tag{3.9}$$

which is the NG formula. This model is a first step, and it will be refined later.

[24] The focus here is mostly on the logical structure rather than the chronological order of the development.

3.3 A direct hit model will not work

A simple model would be that the Sun radiates gravitons in all directions and that gravitons are captured by the bodies of the planets[25]. The capture area will then be the cross-section area of the planet. It's simple to show that this model cannot be correct according to the following arguments:

a) A theoretical argument is that according to NG, which is a very accurate model for the planets in the solar system, the mass of each object can be replaced by a point mass. If matter would be replaced by a point mass, then the cross-section area would be almost zero and the energy needed to constitute the required force would not be sufficient at all.
b) The compositions and the density of the planets in the solar system are very different. The inner planets are iron/stone planets and the outer planets giant gas planets. The capture area differs a lot, in relation to their masses, and because of that the model would be inconsistent.
c) Binary neutron stars exchange a massive gravitational force but will have a very small capture area and cannot capture enough energy from its companion star in such model.

The most energy demanding planet in the solar system is Mercury, which is used as an example of the argument in b) above. Let's calculate the needed decay rate from the Sun to create sufficient energy, by direct radiation, onto the cross-section area of Mercury.

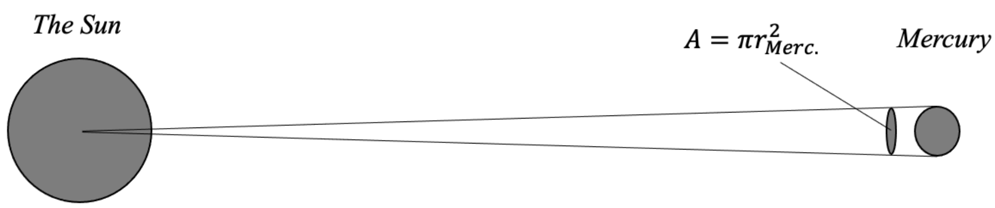

Figure 4. If a direct hit model is used, then the energy sent out from the Sun within the cross-section area of Mercury will not be sufficient for Mercury's motion.

The equation (3.7) from above is used where M is the mass of the Sun and R is the distance to Mercury. P_{Mm} denotes the required energy for Mercury's motion which was calculated in Table 1 in section 3.1. The radius of Mercury is retrieved from the source [45]. The power captured by Mercury should be the power radiated from the Sun that hits the planet cross-sectional area.

$$P_{Mm} = \pi r_{\text{Merc.}}^2 \frac{\lambda_d M c^2}{4\pi R^2} \Rightarrow$$

$$\lambda_d = \frac{4R^2 P_{Mm}}{r_{\text{Merc.}}^2 M c^2} = \frac{4 \times \left(5.79 \times 10^{10}\right)^2 \times 2.57 \times 10^{20}}{(2.44 \times 10^6)^2 \times 1.99 \times 10^{30} \times c^2} \times 3.16 \times 10^7 = 1 \times 10^{-10}\ y^{-1}$$

This decay rate (and the corresponding power) would be way too high, and the Sun would disappear in about 10 billion years which of course is unreasonable.

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[25] The solar system is used as an example to illustrate the mechanism. The line of reasoning is also valid for any other system where the central object is much heavier than the other objects and the distance between the objects is large.

3.4 Capture areas for planets must be bigger than their real sizes

According to previous section, the sphere where a planet captures its energy must be bigger than its real size. That leads to the next major assumption in GET. When two graviton fields interact, they must deflect inward to strengthen the energy that will reach a planet. A graviton-graviton field interaction is the major key to a solution of the energy required for the planets. It can be summarized as one main cornerstone in GET:

Interacting graviton vector fields will deflect inward.

Since a direct hit model cannot work then the next question is: How big must the capture areas for the planets be in order to capture sufficient energy from the Sun? Assume theoretically that all gravitons passing through a cross-section area $A_c = \pi r_c^2$ will create the power[26] $2P_m$ to hold the planet m in its orbit. R = radius from the Sun, r_c = capture radius[27]. Then the following equation must hold (assuming that $R \gg r_c$):

$$j_M(R)\pi r_c^2 = 2P_m \Leftrightarrow \frac{\lambda_d M c^2}{4\pi R^2}\pi r_c^2 = 2P_m \Rightarrow$$

$$r_c^2 = \frac{8R^2 P_m}{\lambda_d M c^2} \Rightarrow r_c = \frac{R}{c}\sqrt{\frac{8P_m}{\lambda_d M}}\,[\mathrm{m}] \qquad (3.10)$$

The value r_c can now be calculated for all the planets by using P_m for each planet from Table 1 in section 3.1 and use an arbitrarily value of λ_d (in this case $\lambda_d = 1 \times 10^{-12}\, y^{-1}$).

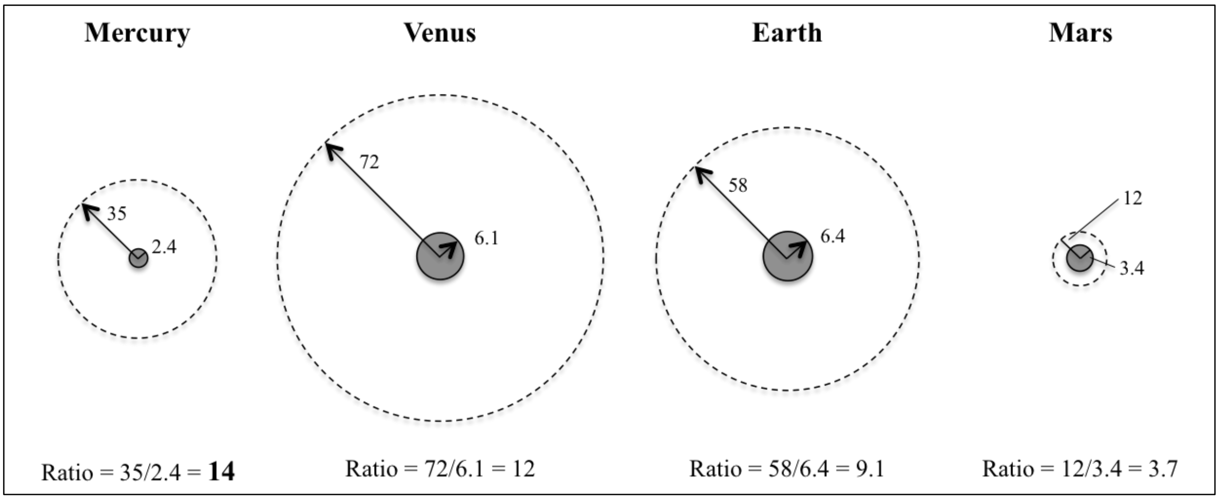

Figure 5. Illustrates how big the capture radius (scale 10^6 m) must be for each of the inner planets in the solar system in order to keep them in their orbits. It's assumed that all energy within each capture area will contribute to the motion.

[26] The needed power is approximately doubled to due to losses. More details are presented later.
[27] The radius r_c is an approximation. The effective radius is a bit smaller, explained in figure 7 and section 3.7.3.

Figure 5 illustrates the relative size of the virtual spheres where the inner planets capture the energy to keep them in orbit. The size, relative to the mass, decreases with the distance from the Sun. If a minimum value of λ_d is used ($\lambda_d = 5 \times 10^{-14}\ y^{-1}$) then the capture radius will become bigger and the shadowing effects will be higher. But the fraction of the capture radius for Venus and its distance to the Sun will still be *only 0.003*. Thus, the shadowing effects around the planets will still be extremely small. It's important to emphasize the term "shadow effects" does not mean that any gravitons will be consumed in a circular orbit case. The gravitation field from the Sun will be equally strong on the back side of the planet but with a slightly modified shape. However, in the case of elliptical motion (which is a more accurate description of planetary motions) gravitons will be consumed at the acceleration phase and emitted at the deceleration phase. Therefore, the strength of the gravitational field from the Sun will appear to be slightly weaker on the back side at the acceleration phase and, conversely, slightly stronger on the back side at the deceleration phase.

3.5 An important and interesting relationship

In the previous section the P_{m} values were fetched from Table 1. The same power values may also be derived for circular motion of the planets in an alternative way. The numerical results will be the same, but the expression is $P_{\mathrm{m}} = \frac{\pi m v_t^3}{R\, N_T}$ where v_t is the tangential speed for a planet, R is the distance from the planet to the Sun and N_T is a *numeric scale factor with no unit* (number of seconds for one orbit). More details on how the expression is deduced can be found in Appendix 8. Substituting P_{m} in the expression above gives:

$$r_{\mathrm{c}}^2 = \frac{2^3 \pi m R v_t^3}{\lambda_d M c^2 N_T} \tag{3.11}$$

By substitute $v_t^3 = \left(\frac{2\pi R}{T}\right)^3$ the equation can be simplified to:

$$r_{\mathrm{c}}^2 = \frac{2^6 \pi^4 m R^4}{\lambda_d M c^2 N_T T^3} \tag{3.12}$$

Using the result from above, then the product $j_M(R) j_m(r_{\mathrm{c}})$ becomes:

$$\begin{aligned} k_{jMjm} = j_M(R) j_m(r_{\mathrm{c}}) &= \frac{\lambda_d M c^2}{4\pi R^2} \frac{\lambda_d m c^2}{4\pi r_c^2} = \frac{\lambda_d M c^2}{4\pi R^2} \frac{\lambda_d m c^2}{4\pi \dfrac{2^6 \pi^4 m R^4}{\lambda_d M c^2 N_T T^3}} = \\ &= M^2 \frac{\lambda_d^3 c^6 N_T}{2^8 \pi^6 T} \left(\frac{T^2}{R^3}\right)^2 \end{aligned} \tag{3.13}$$

Since M is a constant and $\frac{T^2}{R^3}$ is another constant according to Kepler's third law[46], then the expression above will also be a constant. Using $\lambda_d = 1 \times 10^{-12}\, y^{-1}$ an approximate value of the constant is $k_{\mathrm{jMjm}} = 3.3 \times 10^{10}$ [$\mathrm{W^2 m^{-4}}$]. Using the planet data from Table 1 in section 3.1, gives the same result for all planets. The numerical result is not a surprise, since it's a logical consequence of equation (2.13) given that Kepler's third law is valid. However, the result itself that equation (2.13) describes a constant for all the planets is of course very strong and can be seen as the underlying reason why NG and Kepler's third law actually work.

The capture area is determined when the product $j_M(R) j_m(r)$ reach a critical value! It seems that this value rules the orbits of all planets in the solar system (and also any other similar system in the Universe).

It's important to emphasize that the capture radius is the smallest possible radius that is theoretically required to get the necessary energy for the motion of the planet. In reality the actual radius will not have a sharp physical limit. Instead, the radius will statistically be slightly bigger than the capture radius but drop very fast when the distance gets even bigger. In reality the interaction process takes place in the total space between the two objects. However, the probability for interaction will rise very steep when the graviton field from the Sun meet the graviton field from the planet close to the capture radius. This view is also supported by computer simulations.

It's important to emphasize that if the planets can capture all energy from the central object according to these "capture areas" then the energy and momentum will comply to the NG forces.

3.6 Graviton-graviton field interaction

In GET the deflection of two interacting graviton vector fields is necessary and fundamental. It's needed to explain the transfer of energy between objects in the GET model. The assumption is not odd, since similar processes can be found in other parts of quantum physics. Gravitons should transfer an attractive force between matter by definition. The second case, graviton-graviton interaction, is also in line with accepted theories. For instance, the following quote capture these properties: "As a mathematical consequence, fermions exhibit strong repulsion when their wave functions overlap, but bosons exhibit attraction." [47]

Individual gravitons may carry different energy. The graviton-graviton field interaction is an elastic interaction which does not transfer any energy between the fields.

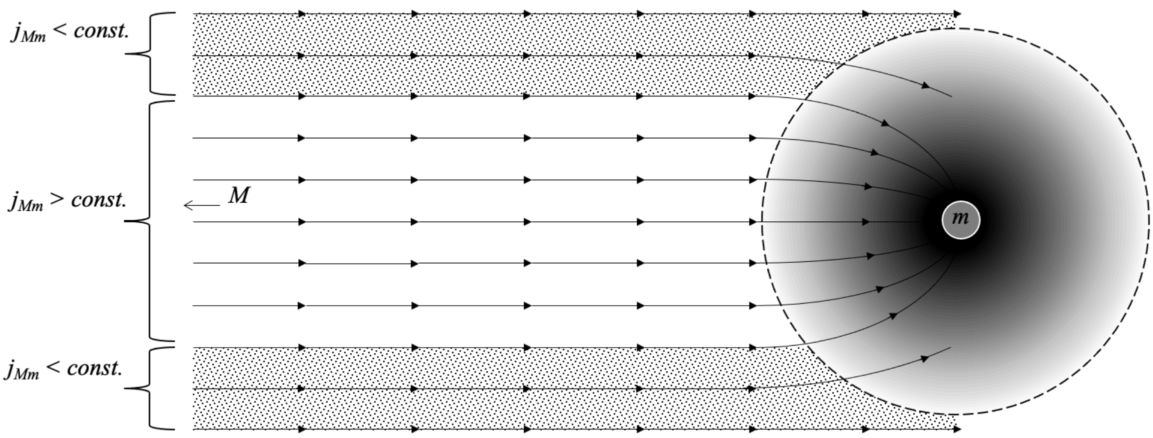

Figure 6. The graviton field deflects inward, when it interacts with the outgoing field of a planet.

A graviton field (graviton vector field) defines a dynamic landscape in space. The graviton field has a certain direction at particular points in space and changes due to movements and changes of mass[28]. If a graviton field enters the capture area it will be deflected inward and reach the object m from a radial direction and then interact with the mass m. The graviton field surrounding the receiving object will be almost unaffected because the magnitude is much larger than the graviton field from the emitting object. An analogy to this process can be a river with a bath tube drain. When water flow inside a circular area with a certain radius it will be sucked through the drain. The water outside this area will continue to flow down the river.

Since the gravitons carry an attractive force, their fields deflect inwards when they interact. There are other examples where the flow lines are bent. For example, a mass particle will follow a bent trajectory when entering a gravitational

[28] It's important to emphasize the graviton field is always dynamic. However, for a snapshot in time (or when the mass doesn't change or move) this field can be seen as a static field similar to the space-time geometry in GR or the gravitational field in NG.

field similar to the entering graviton field in Figure 6. Magnetic field lines between opposite magnetic poles will also be bent inward. It's also strengthened by the observation that photons deflect inwards when they enter a gravitational vector field. The only reasonable interpretation is a deflection due to interaction between photons and gravitons. The graviton-graviton field interaction is not an odd assumption, since other force carrier particles self-interact with each other. Here are some references of interactions for force carrier particles such as photon-photon[48][49] and graviton-graviton scattering[50][51][52]. These references are only presented in order to show that there are observations and theoretical arguments that strengthen the assumption that graviton-graviton vector field interaction may be possible.

3.7 A deeper level of the GET model

The first part of this section is focused on the mechanisms that determine the orbits of the planets in the solar system according to GET. The line of reasoning is valid for the special case where the central object is much heavier than the orbiting objects and the distance between the central object and the orbiting objects is large. Other cases such as objects close to each other, non-spherical objects, very small objects, equally heavy bodies etc. are not addressed in this section. The symmetry property in NG is not addressed here either.

3.7.1 Background

The aim of this section is to deduce[29] NG from the principles in GET. The starting point is two spherical masses, a central object (e.g. the Sun) and an orbiting object (e.g. a planet). The NG formula is:

$$F = G\frac{Mm}{R^2} \tag{3.14}$$

The formula is very *powerful and surprisingly simple!* One fundamental property of this formula is that the masses can be replaced by point masses at their mass center.

3.7.2 Concepts and models used

In order to explain NG from the principles in GET the following concepts and models are introduced (some of them have been used previously in the document, but here they are defined more precisely):

Active and passive mass. An *active mass* is defined to be the object that *generates* gravitation and a *passive mass* to be the object that is *affected* by gravitation. The terms are used to clarify which part of the process that is discussed, the emitting or the receiving part. All masses are both active and passive since they all radiate gravitons and receive fields of gravitons from other masses.

Graviton flux. All objects with rest mass continuously radiate gravitons in all directions. The power $P_m = m\lambda_d c^2$ for a mass m will decrease according to $j_m(r) = \frac{m\lambda_d c^2}{4\pi r^2}$ where $j_m(r)$ denotes the *gravitational flux*, i.e. the flow of gravitons through a surface at distance r from the mass center. The power will be equally spread out on a spherical surface which explains the factor $4\pi r^2$ in the denominator. The mechanism is similar to how a light bulb radiates light. For simplicity reasons the word *flux* shall in the following be understood as *gravitational flux.* The term *graviton vector field* is used to describe the overall flow of gravitons in space.

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[29] In GET there will be some deviations from NG not only related to modern physics (such as speed of gravitation, quantification of gravitation etc.) but also related to the classical regime. However, these deviations are not addressed in this section. The reason is that the overall goal is to show the compliance between NG and GET for standard cases.

Capture area. We introduce the concept *capture area* which is modeled as a half sphere with radius r_c surrounding the receiving object m. This area is defined by three criteria:

1) At the radius r_c it's assumed that *all* incoming gravitons, in a certain sector of the sphere, from M will interact with the outgoing gravitons from m, deflect inward and finally, after a series of interactions with the outgoing gravitons from m, reach the mass center of m *radially*. Since the outgoing number of gravitons, near the mass center of m, are much larger than the ingoing number, their direction will not be affected much in each interaction. The sum of all gravitons that reach m will transfer the power that creates the force (in the x direction) on m.
2) The area is adjusted to be the smallest possible where the power is sufficient to keep the object in its orbit.
3) Since the distance to M is very huge, the incoming flux will be parallel and therefore the area of interest is actually the cross-section area of a circle with radius r_c

The model is introduced to facilitate the understanding of the interaction process at the receiving object. The mechanism of the capture area is similar to a convex lens. It's important to emphasize that r_c is the smallest possible radius that is theoretically required to get the necessary energy for the motion of m. It's also essential to underline that r_c is (in practice) defined by the distance where the product of the two fluxes (for all circulating objects) reach a certain value! This result was presented in the previous section 3.4. In reality the actual radius will not have a sharp physical limit. Instead, the mean value for the radius, where the first interaction occurs, will statistically be slightly bigger than r_c but drop fast when the distance from m increases. In fact, the interaction process takes place in the entire space between the two objects, but the probability for interaction will rise very steeply when the flux from M meets the flux from m close to r_c. This picture is also supported by computer simulations.

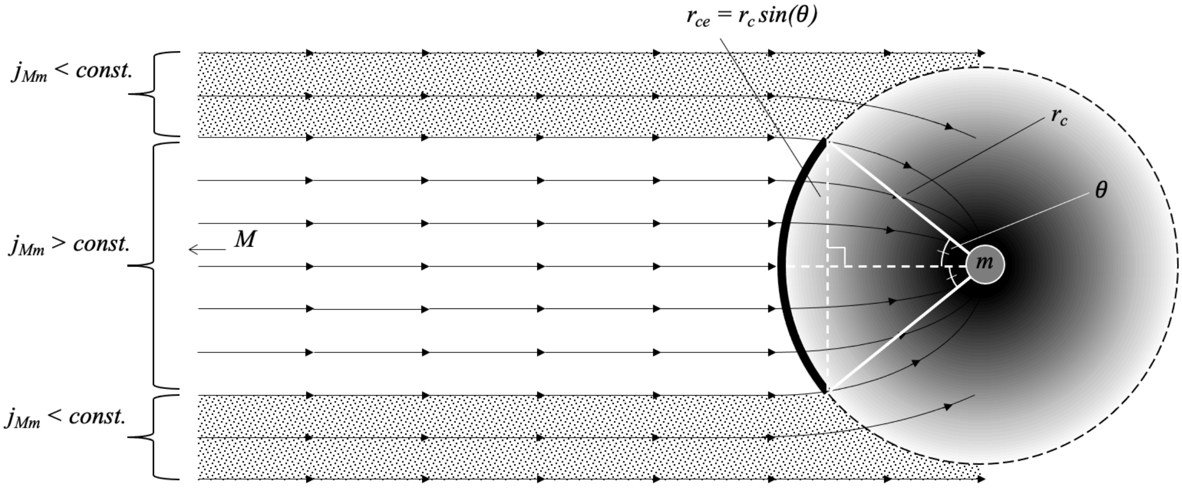

Figure 7. The gravitons from m_1 will deflect towards the center of m_2 when they meet outgoing gravitons from m. The incoming gravitons from M will be consumed by m and accelerate it towards M. Note that the capture area is just a theoretical concept. In reality there will be a series of interactions for each incoming graviton from m with a huge number of outgoing gravitons from m_1. Thus, the direction of the gravitons from M will rather follow an arc towards the center of m. The variables r_{ce} and θ are explained in the derivation step 6 in the next section.

3.7.3 Derivation of NG based on GET

The mathematical description of the active mass (i.e. the decaying process) is more or less straightforward, but the description of the receiving part is far more complex. The flux from a spherical object M can be described by the formula (see section 3.2):

$$j_M(R) = \frac{M\lambda_d c^2}{4\pi R^2} \text{ [Wm}^{-2}\text{] (this is a flux per area)} \quad (3.15)$$

In GET the representation of matter is a flux of gravitons emitted radially from its mass center. The goal is to find a model that explains the interactions between the fluxes from two masses. The reason why a simple model is discarded, and why a new model is necessary, was explained in the previous section. The force is manifested when the gravitons interact with atoms in each mass.

In order to build a more solid model two crucial questions need to be addressed:

1) How can a sufficient number of gravitons reach matter far away?
2) How can the gravitons be directed towards the mass center at the receiving object?

The first question is crucial to get the sufficient amount of energy for the motion of the orbiting object. The second question is necessary for the model to follow NG (otherwise masses cannot be replaced with their mass center).

Starting with a simple example with two objects, in this case M (e.g. the Sun) and m (e.g. any planet in the solar system). The flux from M, which decrease in power proportional to $1/R^2$ (where R is the distance from M), will cause a gravitational acceleration at the distance R. When the incoming gravitons come close to m they will interact with the outgoing flux which is much stronger at this distance. Gravitons from M, within the capture area, will interact with the flux from m and deflect inward towards the center of m in a *series of interactions* (according to the definition of the capture area). The deflection is a consequence of the crucial assumption in GET that graviton fields will deflect inward when they interact.

Statistically there will be almost no deflections for outgoing gravitons close to the object m. The reason is that the ratio, close to m, between the outgoing and ingoing flux usually is very high (i.e. the quotient $\frac{m}{r_c^2}/\frac{M}{R^2}$ is very high close to m where R and r_c denotes the distance from M and m respectively and $r_c \ll R$). Since the outgoing number of gravitons are much larger than the ingoing number, the outgoing graviton field will not be deflected by the ingoing graviton field in a substantial way.

Since the solar system (and its internal parts) moves constantly at high speed most of the interactions between the graviton fields must take place close to the center of the receiving objects. Thus r_c must be rather small in comparison to the distance to the central object.

Based on the framework described above the derivation of NG from GET is now presented. The case below focus on the mechanism when gravitons leave M and approach m:

1) $P_M = M\lambda_d c^2$ [W]
   P_M is the power of gravitons radiated from M,
   λ_d denotes the decay rate (which is the same for all objects with rest mass)

2) $P_m = m\lambda_d c^2$ [W]
   P_m is the power of gravitons radiated from m

3) $j_M(R) = \frac{P_M}{4\pi R^2}$ [W/m^2]
   Flux from M at distance R from its mass center.

4) $j_m(r_c) = \frac{P_m}{4\pi r_c^2}$ [W/m^2]
   Flux from m at distance r_c from its mass center.

5) $j_{Mm} = j_M(R) j_m(r_c) = \frac{P_M P_m}{4\pi R^2 4\pi r_c^2}$ [W/m²]

According to 5.6 the product j_{Mm} determines the interaction pattern when two fluxes meet. When j_{Mm} exceed a threshold value, which happens at the radius r_c, gravitons will deflect towards the center of m. An interesting observation is that j_{Mm} is very low between M and m but rises very steep close to the objects. At the radius of r_c the value is 10^5 times higher than in the middle between the objects. The interaction pattern in space have similarities to an interaction of a dipole.

The equation above is an approximation since the denominator should be $\frac{1}{4\pi(R-r_c)^2 4\pi r_c^2}$. But the approximation error is small, about 10^{-4} %, since $R \gg r_c$ for the planets.

It can be argued that the dimension of this quantity will not be power per square area. However, seen from a physical perspective, it has to be the case. The reason is that two fluxes (two graviton vector fields) in opposite directions will still be two fluxes in opposite directions, but deflected, after the interaction. The final dimension can be motivated using the value[30] of the dot product[53] and a unit vector[54]. Let $\mathbf{j_M}(R)$ denote the graviton vector field from M and $\mathbf{j_m}(r_c)$ the graviton vector field from m. Also assume the graviton vector fields are opposite[31], i.e. $\alpha = 180°$. Then the value of the dot product is: $|\mathbf{j_M}(R) \bullet \mathbf{j_m}(r_c)| = |\|\mathbf{j_M}(R)\| \|\mathbf{j_m}(r_c)\| \cos(\alpha)| = \left|\frac{P_M}{4\pi R^2}\frac{P_m}{4\pi r_c^2}\cos(180°)\right| = \frac{P_M P_m}{4\pi R^2 4\pi r_c^2}$ [no unit]. In order to get the right dimension, the expression has to be multiplied by the unit vector of the graviton vector field from M, i.e. $\widehat{\mathbf{j_M}}(R) = \frac{\mathbf{j_M}(R)}{\|\mathbf{j_M}(R)\|}\left[\frac{\mathrm{W}}{\mathrm{m}^2}\right]$. Thus, the dimension of the final product of the fluxes will be $j_{Mm} = |\mathbf{j_{Mm}}| = |\mathbf{j_M}(R) \bullet \mathbf{j_m}(r_c)| \frac{\mathbf{j_M}(R)}{\|\mathbf{j_M}(R)\|}$ [W/m²], which is the expected dimension.

We continue to study the flux towards m.

6) $A_c = k_1 \pi r_c^2$ [m²]
The incoming flux should be integrated over the capture area introduced above. The half sphere has the area of $2\pi r_c^2$ but since the incoming flux is homogenous and orthogonal to the x axis the integration area should be a flat area with a maximum area of πr_c^2. This area is an approximation that has been used until now. The actual area is even smaller since the product of the fluxes is too low at the edges of the area with size πr_c^2. The real efficient capture radius is $r_{ce} = r_c \sin\theta$ and the real area is $k_1 \pi r_c^2$ where $k_1 = \sin^2\theta$. The angle θ is the maximum angle between the fluxes where the product of the fluxes exceeds a critical value. See figure 7 for details.

7) $P_c = j_{Mm} A_c = \frac{k_1 P_M P_m \pi r_c^2}{4\pi R^2 4\pi r_c^2} = \frac{k_1 P_M P_m}{16\pi R^2}$ [W]

The total power of gravitons passing through the capture area A_c. The incoming field will be deflected in steps to a radial direction towards m. Note that P_c *is independent of the value of* r_c since r_c can be retracted from the formula. However, even though r_c can be retracted in the derivation it must have a fixed value. How this value can be determined was presented earlier. The sufficient information to determine the value of r_c is already hidden in the variables *M*, *m* and *R* - *which makes the NG formula much simpler!*

[30] The quantity of the final product j_{Mm} is assumed to be positive and therefore the absolute value of the dot product is calculated.
[31] In reality the angle between the gravitational vector fields will vary, but since the dimension aspect is only considered in this step it's for simplicity reasons arbitrary assumed the vectors are opposite.

8) $P_{\text{final\_x}} = k_1 k_2 P_c = \frac{k_1 k_2 P_M P_m}{16\pi R^2}$ [W]

The next step is to calculate the x component of the radial field. The exact value of this constant depends on the value of θ is for incoming gravitons (given by k_1) that finally reach the mass center of the receiving object. The numerical constant k_2 determines the final power in the x direction. An estimate is that the value of k_2 is within the interval [0.5, 0.95].

9) $P_{\text{final\_x}} = \frac{k_1 k_2}{16\pi} \frac{P_M P_m}{R^2} = \frac{k_1 k_2}{16\pi} \frac{M\lambda_d c^2\, m\lambda_d c^2}{R^2} = k_1 k_2 \frac{\lambda_d^2 c^4}{16\pi} \frac{Mm}{R^2}$ [W]

The total power of gravitons that interact with the mass m and create a force in the x direction[32].

10) $F = \frac{k_3}{c} k_1 k_2 \frac{\lambda_d^2 c^4}{16\,\pi} \frac{Mm}{R^2} = k_1 k_2 k_3 \frac{\lambda_d^2 c^3}{16\,\pi} \frac{Mm}{R^2} = G\frac{Mm}{R^2}$ [N], where $G = k_1 k_2 k_3 \frac{\lambda_d^2 c^3}{16\pi}$

To get the force (in the x direction) we divide by c. Since gravitons are massless particles similar to photons and travel with speed c, it's natural to use the same formulas[55] ($p = \frac{E_g}{c} \Longrightarrow F = \frac{P}{c}$) to transform power into a force. *But there is an important difference*. The force caused by photon pressure is very low. A graviton must transmit a much higher force, similar to a photon when seen as a force carrier for the electromagnetic force. A new constant k_3 is added to capture the interaction factor of the graviton, which must be very strong!

By inserting the extra conversion factor [$kg^{-1}\,s^3$] from step 5 above the unit equations for F = $k_1 k_2 k_3 \frac{\lambda_d^2 c^3}{16\,\pi} \frac{Mm}{R^2}$ will be:

[N] = [$s^{-2}\,m^3\,s^{-3}$] [$kg^{-1}\,s^3$] [$kg^2\,m^{-2}$] = [$m^3\,kg^{-1}\,s^{-2}$] (G) [$kg^2\,m^{-2}$] = [$kg\,m\,s^{-2}$] = [N]

The unit of G from above is [$m^3\,kg^{-1}\,s^{-2}$] which is correct. The units of G have always been considered to be very strange. Now there is an explanation of their origin!

An alternative GET formula would be: $F = G_g \frac{P_M\, P_m}{R^2}$ [N] where $G_g = k_1 k_2 k_3 \frac{1}{c\,16\,\pi}$

The formula has the same structure as NG. The derivation shows the equivalence between a model of two objects radiating energy (GET) and a model where two masses interact in an unknown way (NG). The value of G is not possible to determine from the derivation above, but its subcomponents are identified. An interesting reflection is that the actual gravitational force in GET is the result of the interactions between the fluxes from each object rather than an abstract property of the masses themselves (without any explanation of the actual underlying mechanism). This deeper understanding of NG will extend beyond the solar system and have implications to large structures in the universe such as galaxies and galaxy clusters. These implications are discussed further in the document. Different cases that can occur regarding the dynamic motion of masses are discussed in Appendix 10.

3.8 A summary of the NG part of GET

GET is based on local energy interactions between particles that occur at certain places in space. The NG formula has a fantastic precision for calculating events caused by gravitation and it's not by chance! Before entering the more complex domain of GR it's important to really understand why NG works so well (despite its simplicity). In GET a

[32] There will also be forces in other directions, but they will be symmetric and balanced out. The interesting part here is the x component of the force, which is the only included component in the NG formula.

few modern concepts in physics are added in order to explain how “gravitational communication” actually works, i.e. the underlying mechanism behind gravity.

The process of the GET model is as following for two spherical objects with large distance in space:

Assumption. Matter decay slowly and emits force carriers’ particles (massless gravitons) in all directions. The list of observations that support the decay assumption is listed in section 2.

In GET the radiated gravitons build a symmetric spherical vector field around each object. The graviton field spreads in space and builds a landscape of energy (similar to the radiation of particles and light around the Sun).

In GET the masses in the NG formula are represented by the radiating sphere of gravitons for each mass. That gives a consistent way to handle the requirements that the masses should be possible to be replaced by masses in their mass center and be independent of the density of the bodies (this is an important feature in NG). The sphere of radiation can be approximated to have its origin at the mass center seen from a far distance.

The vector fields from the objects will meet in space between the objects. The probability for an interaction between the two fields rise sharply close to each object. We now look what happens close to m.

Energy calculations for the solar system shows that the graviton radiation from the sun would not be sufficient and consistent if the target area would be the real cross-section of the planets (the required energy to keep the planets in their orbits would be too small). The cross-section must be a bigger sphere surrounding each planet.

This can happen if the incoming field deflects inward when interacting with the outgoing field. It can be shown (analytically and by computer simulation) that the strength of the interaction is j_{Mm}. Furthermore, it can be shown that when it reaches a certain value (a constant for all planets!) the probability of interaction is sufficient to make most of the particles to deflect inward to the mass center of m. The critical value of j_{Mm} is a constant and has the same value for every planet in the solar system. This gives each planet the right energy to stay in its orbit! It's also an explanation for the laws by Kepler.

The remaining process is when the incoming flux of gravitons enter m from a radial direction. The gravitons will cause a pull on the receiving mass. We are only interested in the x component for the NG case. In addition, the correct unit of G is derived by an underlying chain of physical logic which is not the case in NG.

4 GET related to GR

In this section the relation between GET and the classical cases of GR are addressed. The connection between energy and time dilation due to speed and gravitation is also analyzed. All results should be the same as GR, but the underlying cause will differ. For the classical cases we use formulas from classical optics and SR. For time dilation SR and energy will be the crucial keys to explain an implicit relationship.

4.1 Classical predictions in GR Explained by GET

In GR there are three cases that explain how gravitation affects light (i.e. photons). In GET these cases are explained by the same underlying mechanism based on graviton-photon interaction. The cases are:

a. Deflection of light by the Sun. One of the early predictions in GR was that the light from a distant star should bend with 1".75, when passing a distance r from the Sun, instead of 0".87 predicted by NG. The value 1".75 is in accordance with observations.

Here is a quote from Eddington A. S. (1920) *Space, Time and Gravitation, Cambridge University Press*, 1987:[56]

Light moves more slowly in a material medium than in vacuum, the velocity being inversely proportional to the refractive index of the medium. The phenomenon of refraction is in fact caused by a slewing of the wave-front in passing into a region of smaller velocity. We can thus imitate the gravitational effect on light precisely, if we imagine the space round the sun filled with a refracting medium which gives the appropriate velocity of light. To give the velocity $1 - 2m/r$*, the refractive index must be* $1/(1 - 2m/r)$ *... Any problem on the paths of rays near the sun can now be solved by the methods of geometrical optics applied to the equivalent refracting medium. It is not difficult to show that the total deflection of a ray of light passing at a distance* r *from the center the sun is (in circular measure)* $4m/r$ *...*

The analogy suggested by Eddington (a true supporter of GR) above, gave the same calculated values as GR. In GET it is assumed that gravitation is caused by radiation of gravitons. That can be *interpreted as a medium*[33] *surrounding an object* (which we thought of before reading the article above). The density of the "graviton medium" will decrease as $1/r$ from the center of the gravitational source. Thus, the calculation for the bending of light can be done using standard methods in optics. The result will be identical to GR, but the underlying explanation is different.

b. Gravitational lensing. When photons pass heavy objects (such as stars) their paths will be bended similar to a convex lens. GR predicts this effect accurately. In GET photons will change their velocity vectors when they interact with a medium of gravitons (another case but similar to above) and will be spread around massive objects. The effect will probably be the same as in GR.

c. Redshift of light. Photons will be blue shifted when passing through a stronger gravitational field, and reversely red shifted when passing through a weaker field, according to observations. This effect is accurately predicted by GR. In GET the number of interactions between photons and gravitons increases when photons encounter a denser gravitational flux, and reversely decreases when the flux becomes weaker. In the first case the photons will be blue shifted when measured with a slow clock in the same medium, and reversely, in the second case the photons will be red shifted.

By using the formula $E = hf$[57], the frequency shift of a photon will be $f/f_0 = E/E_0$. The relation between energy and frequency is reversed compared to energy and time for matter with rest mass. If the interaction with gravitons ceases, the photon will return to its previous energy state.

Perihelion precession of Mercury[58]. The perihelion precession of Mercury is predicted accurately by GR. Mercury moves faster at perihelion compared to aphelion and it will be slightly heavier at the first state due to relativistic effects.[59] The consequence is an extra precession of the motion than what is predicted by NG. In GET matter will increase its mass when the speed increases due to energy absorption. The magnitude should be the same as in GR and therefore the perihelion precession of planets should be the same in GET.

Frame dragging. Due to the rotation of objects in space (the Earth for example), matter radiates gravitons like a "lawn-sprinkler" according to GET. This mechanism will probably produce the same frame dragging pattern as GR.

4.2 Relation Between Energy and Time

4.2.1 The definition of a second

The current definition of a second is: "the duration of 9 192 631 770 periods of the radiation corresponding to the transition of hyperfine levels of the ground state of the cesium-133 atom. This definition refers to a cesium atom at rest at a temperature of 0 K."[60]

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[13] Since gravitons travel with the speed of light it can be argued that the analogy to a material medium cannot be applied here. However, we believe this problem is not a major concern.

What determines the frequency of the radiation (of photons) above? Why is the accuracy dependent on a very low temperature of the clock? How come that time dilation is caused by both gravitation and speed? Are these three effects related in some way?

4.2.2 Time dilation due to speed

Three basic formulas from SR[61] are used to derive an interesting result. An important question to address is why the increase of mass and the slowdown of time *follow exactly the same relation*?

$$t_{\text{fast}} = \text{t}_{\text{slow}} \Big/ \sqrt{1 - \left(\frac{v}{c}\right)^2} \tag{4.1}$$

$$m_{\text{high}} = m_{\text{low}} \Big/ \sqrt{1 - \left(\frac{v}{c}\right)^2} \tag{4.2}$$

$$E = mc^2 \tag{4.3}$$

Dividing (4.1) with (4.2) and replace m by energy according to (4.3) gives:

$$\frac{t_{\text{fast}}}{t_{\text{slow}}} = \frac{E_{\text{low speed}}}{E_{\text{high speed}}} \tag{4.4}$$

The ratio for time dilation due to speed is exactly the inverse ratio of the energy! High energy gives slower time. This might be seen as an obvious relation since speed is the key factor in kinetic energy, but it's only the first step in our line of reasoning.

4.2.3 Time dilation due to gravitation

Before examine the gravitational aspect of time dilation we need to have a short discussion about the conventional definition of gravitational potential energy[62] which is:

$$U = -\frac{GMm}{r} \tag{4.5}$$

According to this definition the mechanical work will be positive if m moves towards M and reversely negative if m moves in the opposite direction. In GET gravitation is explained by flux of gravitons[34] from matter and our view is that the classical potential gravitational energy is just a theoretical construction[35]. According to GET the meaning

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[34] Flux of gravitons is defined to be gravitational energy per time unit and square area.
[35] The idea of the conventional gravitational potential energy in NG is that the energy it takes to put two objects apart can be regained again. While the objects are apart the energy will be "stored" as potential energy. The line of reasoning relies on the assumption that each object will constitute an attractive pull on each other without any cost upon infinite distances (without any

of gravitational energy will instead be the number of gravitons (the graviton flux) that reach an object during a certain time unit. This energy will always be positive and strongest close to matter. From now on $E_{\text{grav flux}}$ is used to denote this energy. This energy increases towards a denser graviton flux, i.e. closer to an object.

Now the focus will be on the gravitational aspect of time dilation. In the vicinity of a non-rotating massive spherically symmetric object the Schwarzschild equation for gravitational time dilation[63] is:

$$t_{\text{fast}} = t_{\text{slow}} \,/\, \sqrt{1 - \frac{2GM}{rc^2}} \tag{4.6}$$

Equation (4.6) can be rewritten in the following form:

$$t_{\text{fast}} = t_{\text{slow}} \,/\, \sqrt{1 - \left(\frac{v_{\text{escape}}}{c^2}\right)^2} \quad \text{if} \quad v_{\text{escape}} = \sqrt{\frac{2GM}{r}} \tag{4.7}$$

The equation (4.7) has exactly the same structure as the equation (Lorentz formula) for speed. However, in this case v_{escape} represents the escape velocity (see [64]) that is required for an object to leave the gravitational field caused by M. The equation has, using the substitution, the same structure as the formula for time dilation due to speed. Thus, the kinetic energy that corresponds to the escape velocity must equal the gravitational energy (i.e. the graviton flux) that affects the object. Applying the same substitution with energy instead of speed will end up with the same equation as for speed.

$$\frac{t_{\text{fast}}}{t_{\text{slow}}} = \frac{E_{\text{low grav flux}}}{E_{\text{high grav flux}}} \tag{4.8}$$

The conclusion is that the hidden factor behind the slowdown of time, for both speed and gravitation, is increased energy for a particle with rest mass!

There are two differences between the equation for gravitation compared to the equation for speed. The first compare the clock for an object far away from a gravitational source (where the time ticks at its maximum rate) with an object that is closer to a gravitational source (where the time moves slower). For speed the time for a moving object (where the time moves slower) is compared to a slower reference object where the speed is arbitrary set to zero. The second difference, where GET suggest this alternative definition, is that the gravitational energy $E_{\text{grav flux}}$ for an object is zero far away from a gravitational source and has an increasing *positive* value when the object gets closer to the gravitational source.

4.2.4 The combined time dilation for both speed and gravitation

Based on energy the combined formula for time dilation due to both speed and gravitation will be:

$$t_{\text{fast}} = t_{\text{slow}} \left(\frac{E_{\text{low speed}}}{E_{\text{high speed}}} + \frac{E_{\text{low grav flux}}}{E_{\text{high grav flux}}}\right) \tag{4.9}$$

Note! We do not change current equations or the values for time dilation (except the reversed sign according to the definition of gravitational flux)! The difference is that in GET the underlying mechanism is explained in another

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explanation of the underlying mechanism). In GET the explanation for this underlying mechanism is the graviton flux emitted from each object.

way. The conclusion is that *the Lorentz equation determines the relation between energy and time dilation for all objects.*

4.2.5 Consequences of the energy aspect of time dilation?

If the total energy level is known for a particle, then it's known how fast the internal clock ticks (relative to a reference clock for instance at the Earth). The fastest clock rate is when an elementary particle (with rest mass) is in its lowest possible energy state. The slowest clock rate is when its energy is approaching infinity (inside a black hole or when an object approaches the speed of light). More precisely, it's not only the speed but also the total kinetic energy that determines the clock rate. Beside gravitation and speed, other forms of energy such as temperature, pressure etc. also contribute to the total time dilation. This will be a kind of "generalized kinetic energy". The following example highlight the importance of cooling down atoms when measuring time: "Traditional cesium clocks measure room-temperature atoms moving at several hundred meters per second." [65]. According to SR the velocity will slow down time and therefore the atoms has to be cooled down to 0 K in order to give high precision results.

In GET only particles with rest mass have an internal notion of time, but massless particles do not. There are many observations that support this picture. For example, photons, which are massless particles, have no internal clock and no "time memory". But Muons for example, which are mass particles, decay slower due to high speed when approaching the Earth. This leads to a fundamental result in GET:

> *The origin of time dilation is the energy level, independent of the source of energy, for elementary particles with rest mass.*

4.2.6 A brief hypotheses of time dilation related to the quantum level

The reason why the "internal clock" for an elementary particle with rest mass will slow down due to an increase of energy level is unknown. But here is a *speculative proposal* of the cause:

The "internal clock" for elementary particles with rest mass is determined by the spin angular momentum. A higher spin angular momentum results in greater inertia and a slower internal clock (time dilation).

The proposal above is based on the following line of reasoning: An elementary particle is basically a wave which has a spin angular momentum and its inertia probably increases when the energy rises. This will slow down its frequency. The way an atom clock works is that it will be inside a field of micro wave radiation. At some frequency there will be a resonance and the Cesium atom will be excited to a higher energy level and then emit a photon with a certain frequency to return to its previous state. If the angular momentum changes the required energy and then the photon frequency might change.

To summarize:

- Time is a local scalar property for elementary particles with rest mass
- Massless elementary particles have no notion of time (i.e. photons do not age)
- A speculation – can the spin angular momentum for a particle (with rest mass) determine a certain frequency which will be the clock rate for the particle?
- The local time rate for an object is determined by its total energy level, i.e. the original energy and external energy sources that affect the object
- Space is three-dimensional but evolves with time
- The Lorentz equation determines the relation between energy and time dilation for all particles

The conclusion is that GET can be modeled using a three-dimensional[36] space. Time is linked to the gravitational energy landscape created by the gravitons in space and the (generalized) kinetic energy of an object. Time is a scalar property for matter in space. Time dilation is caused by the difference in the energy level of elementary particles. The energy flow of gravitons *and* the (generalized) kinetic energy of a particle will affect the particle's internal clock rate. *The underlying cause in both cases is the total energy for the particle.*

What does GET add to the current description of time dilation? At the moment GET does not change the current equations (except for the sign of potential energy above) and the values of time dilation – but unveil that the hidden factor that rules time dilation in general is energy. Massless particles such as photons have no notions of time. In empty space without baryonic mass, there are no clocks and no way to measure time. GET explains time dilation for speed, gravitation, temperature, pressure etc. using one common denominator – which is energy. In GET time dilation is a local scalar property for elementary particles with mass – maybe caused by the level of the spin angular momentum (speculation).

The energy perspective facilitates the understanding of time dilation. The twin paradox is one example that has caused a lot of debate and confusion over the years. In GET there is no paradox, and the solution is trivial. The twin that has experienced the highest energy level during the experiment will also be the youngest (i.e. the one that has experienced the journey). The explanation is that the combined energy level, due to higher speed but less gravitation (i.e. lower intensity of the gravitational flux), will be higher during the journey and therefore the time will move slower for that twin.

4.2.7 Example of the time dilation for a GPS satellite

The time runs at a different rate for orbiting satellites around the Earth due to differences in speed[37] and gravitation. The time dilation property has to be considered for applications such as the GPS system to work properly. For satellites in the GPS system the time runs about 7,200 ns slower/day because of the higher speed and 45,900 ns faster/day because of weaker gravitation. [66] According to formula (4.9) the time rate for an object (e.g. a satellite) is dependent only on its particle energy level. We will now show that time dilation for a GPS satellite is dependent on the differences in energy level only.

A GPS satellite has the following data[67]:

$\Delta t_{\text{speed}} = 7.214 \times 10^{-6}$ [s]	Decrease of the time rate/day due to speed
$\Delta t_{\text{gravitation}} = -45.850 \times 10^{-6}$ [s]	Increase of the time rate/day due to gravitation
$v_{\text{satellite}} = 3.874 \times 10^{3}$ [m/s]	Satellite's orbital speed
$r_{\text{satellite}} = 2.6541 \times 10^{7}$ [m]	Satellite's orbital radius
$r_{\text{earth}} = 6.357 \times 10^{6}$ [m]	Earth's mean radius
$M = 5.974 \times 10^{24}$ [kg]	Earth's mass
$t_{\text{earth}} = 8.640 \times 10^{4}$ [s]	Seconds per day
$G = 6.674 \times 10^{-11}$ [m^{3}kg^{-1}s^{-2}]	Gravitational constant
$c = 2.998 \times 10^{8}$ [m/s]	Speed of light in vacuum

[36] The space might be described by a four-dimensional model similar to GR if that turns out to be a convenient description.
[37] The time dilation due to speed is also calculated even though it is not the subject of this document. The reason is that we want to reinforce our general conclusion that time dilation is caused only by energy differences for objects (with rest mass) no matter what the energy source is.

Time dilation due to speed according to SR

$$t_{\text{earth}} = \frac{t_{\text{satellite}}}{\sqrt{1-\left(\frac{v_{\text{satellite}}}{c}\right)^2}} \tag{4.10}$$

Define $\Delta t_{\text{speed (SR)}} = t_{\text{earth}} - t_{\text{satellite}} \quad \Rightarrow \quad t_{\text{satellite}} = t_{\text{earth}} - \Delta t_{\text{speed (SR)}}$

$$t_{\text{earth}} = \frac{t_{\text{earth}} - \Delta t_{\text{speed (SR)}}}{\sqrt{1-\left(\frac{v_{\text{satellite}}}{c}\right)^2}} \quad \Rightarrow \quad \Delta t_{\text{speed (SR)}} = t_{\text{earth}}\left(1-\sqrt{1-\left(\frac{v_{\text{satellite}}}{c}\right)^2}\right) = \text{/ for one day /}$$

$$8.640 \times 10^4 \left(1-\sqrt{1-\left(\frac{3.874 \times 10^3}{2.998 \times 10^8}\right)^2}\right) = 7.213 \times 10^{-6}\ \text{s} = \Delta t_{\text{speed}}$$

Time dilation due to speed according to GET

$$\frac{t_{\text{earth}}}{t_{\text{satellite}}} = \frac{E_{\text{satellite}}}{E_{\text{earth}}} \tag{4.11}$$

Define $\Delta t_{\text{speed (GET)}} = t_{\text{earth}} - t_{\text{satellite}} \quad \Rightarrow \quad t_{\text{satellite}} = t_{\text{earth}} - \Delta t_{\text{speed (GET)}}$

$$\frac{t_{\text{earth}}}{t_{\text{earth}} - \Delta t_{\text{speed (GET)}}} = \frac{E_{\text{satellite}}}{E_{\text{earth}}} \quad \Rightarrow \quad \Delta t_{\text{speed (GET)}} = t_{\text{earth}}\left(1-\frac{E_{\text{earth}}}{E_{\text{satellite}}}\right) \tag{4.12}$$

Substitute using the SR formulas gives:

$$\Delta t_{\text{speed (GET)}} = t_{\text{earth}}\left(1-\frac{m_0c^2}{mc^2}\right) = t_{\text{earth}}\left(1-\frac{m_0}{m}\right) = t_{\text{earth}}\left(1-\sqrt{1-\left(\frac{v_{\text{satellite}}}{c}\right)^2}\right) = \text{/ for one day /}$$

$$8.640 \times 10^4 \left(1-\sqrt{1-\left(\frac{3.874 \times 10^3}{2.998 \times 10^8}\right)^2}\right) = 7.213 \times 10^{-6}\ \text{s} = \Delta t_{\text{speed}}$$

Time dilation due to gravitation according to GR[68]

$$t_{\text{satellite}} = t_{\text{earth}} \frac{\sqrt{1-\frac{2GM}{r_{\text{earth}}c^2}}}{\sqrt{1-\frac{2GM}{r_{\text{satellite}}c^2}}} \tag{4.13}$$

Define $\Delta t_{\text{gravitation (GR)}} = t_{\text{satellite}} - t_{\text{earth}} \quad \Rightarrow \quad t_{\text{satellite}} = t_{\text{earth}} + \Delta t_{\text{gravitation (GR)}}$

$$t_{\text{earth}} + \Delta t_{\text{gravitation (GR)}} = t_{\text{earth}} \frac{\sqrt{1-\frac{2GM}{r_{\text{earth}}c^2}}}{\sqrt{1-\frac{2GM}{r_{\text{satellite}}c^2}}} \quad \Rightarrow$$

$$\Delta t_{\text{gravitation (GR)}} = t_{\text{earth}}\left(\frac{\sqrt{1-\frac{2GM}{r_{\text{earth}}c^2}}}{\sqrt{1-\frac{2GM}{r_{\text{satellite}}c^2}}}-1\right) = \text{/ for one day /}$$

$$= 8.640\times 10^4\left(\frac{\sqrt{1-\frac{2\times(6.674\times10^{-11})\times(5.974\times10^{24})}{(6.357\times10^{6})c^2}}}{\sqrt{1-\frac{2\times(6.674\times10^{-11})\times(5.974\times10^{24})}{(2.6541\times10^{7})c^2}}}-1\right) =$$

$$= -45.85\times10^{-6}\ \text{s}\ = \Delta t_{\text{gravitation}}$$

Time dilation due to gravitation according to GET

$$\frac{t_{\text{satellite}}}{t_{\text{earth}}} = \frac{E_{\text{low grav flux}}}{E_{\text{high grav flux}}} \tag{4.14}$$

Define $\Delta t_{\text{gravitation (GET)}} = t_{\text{satellite}} - t_{\text{earth}} \quad \Rightarrow \quad t_{\text{satellite}} = t_{\text{earth}} + \Delta t_{\text{gravitation (GET)}}$

$$\frac{t_{\text{earth}} + \Delta t_{\text{gravitation (GET)}}}{t_{\text{earth}}} = \frac{E_{\text{low grav flux}}}{E_{\text{high grav flux}}} \quad \Rightarrow$$

$$\Delta t_{\text{gravitation (GET)}} = t_{\text{earth}}\left(\frac{E_{\text{low grav flux}}}{E_{\text{high grav flux}}}-1\right) \tag{4.15}$$

Using SR and the formula for potential energy gives:

$$\Delta t_{\text{gravitation (GET)}} = t_{\text{earth}}\left(\frac{m_0c^2}{m_0c^2+\Delta E}-1\right) = t_{\text{earth}}\left(\frac{m_0c^2}{m_0c^2+m_0MG\left(\frac{1}{r_{\text{satellite}}}-\frac{1}{r_{\text{earth}}}\right)}-1\right)$$

$$= t_{\text{earth}}\left(\frac{1}{1+\frac{MG}{c^2}\left(\frac{1}{r_{\text{satellite}}}-\frac{1}{r_{\text{earth}}}\right)}-1\right) = \text{/ for one day /}$$

$$= 8.640\times10^4\left(\frac{1}{1+\left(\frac{(5.974\times10^{24})\times(6.674\times10^{-11})}{(2.998\times10^{8})^2}\right)\left(\frac{1}{6.357\times10^{6}}-\frac{1}{2.6541\times10^{7}}\right)}-1\right)$$

$$= -45.85\times10^{-6}\ \text{s}\ = \Delta t_{\text{gravitation}}$$

The conclusion is that the results in SR and GR are the same as the energy model in GET.

5 GET related to modern physics

This section will address some of the modern cases in physics and cosmology based on the GET model. The assumption that vector fields of gravitons, and their interaction with matter such as self-interaction, is the underlying causes of all gravitation will change several of the explanations of interesting topics. The assumption of deflection of gravitational fields may give explanations, in a profound way, to the shapes and movements of large structures in space. Perfect spherical shapes will give no self-interactions, but structures as spiral galaxies and filaments will be affected by additional forces due to self-interactions.

5.1 Strong Gravitation Fields

5.1.1 Black hole

If the mass becomes larger than a certain limit, then the pressure from the self-gravitation will build up beyond the point where the electromagnetic and strong nuclear forces can't withstand the pressure. The result will be a collapse into a *black hole.* After the collapse gravitons are the only particles that will be able to radiate out from the black hole. The reason why gravitons still have to be emitted is that the gravitational appearance of the mass must be communicated to the external environment in some way. The last part is different from the current view which states that a black hole does not communicate anything to the external environment (except for Hawking radiation).

Black holes have interesting properties seen from a GET perspective. According to GR time will stop inside a black hole. In GET, the speed of time does not stop but it will run much slower. Gravitational decay rate will slow down significantly. If the time would stop then no decay of gravitons would occur and there would be no gravitation. Therefore, the mass of the black hole will appear to be lighter than it actually is. The conclusion is that a substantial part of all matter may be hidden in black holes! If true, this insight will have a fundamental impact on our understanding of the Universe.

5.1.2 Gravitational waves

The view in GET of gravitational waves is that they are bursts of gravitons that adds to the "normal flow" and has its origin in exceptional events like spiraling neutron stars, colliding black holes etc. There is no major difference in GET between "ordinary gravitation" and gravitational waves (burst of gravitons) since the underlying mechanism is the same. Detected gravitational waves, in LIGO etc., are added peaks of gravitons on top of the ordinary flow that reach the earth.

The example of elliptical motion in the previous section explains the creation of gravitational waves. When an object undergoes phases of acceleration and deceleration, it will cause a fluctuation of the gravitational field. Elliptical orbits for the planets are supposed to cause very small gravitational waves due to their small masses and the moderate change of speed.[69] The result will be very small fluctuations of the gravitational field. But when it comes to binary neutron stars, black holes etc. orbiting around their barycenter, the picture will be different. Big masses, extreme accelerations and decelerations, will create an oscillation pulse of the gravitational field. Since there will be two acceleration and two deceleration phases during one revolution the frequency will be two full oscillations per revolution, which comply to the current model in GR. Gravitational waves is then the oscillation of receiving and emitting gravitons in certain directions. During the deceleration phase a "jet flux of gravitons" are emitted as a short pulse in the opposite direction compared to the deceleration vector. The pulse decreases as $\frac{1}{r}$ in contrast to $\frac{1}{r^2}$ for normal gravitation since it's a focused jet flux.

In GET there are no calculations, on the magnitude of these waves. But the capture and release of energy and change in velocity for an object, is defined by the Lorentz equation. On top of the spherical radiation due to the normal decay, the objects will switch between acceleration (consume energy) and deceleration (radiate energy) etc.

5.1.3 Neutron stars and black hole mergers

Gravitational waves contain energy [70]. During the merge of two black holes or neutron stars, gravitational waves of high magnitude are radiated. In [71] the recent observations of mergers of black holes are presented. An interesting part is that the resulting black holes seems to contain about 5% less mass than the sum of the merged parts [72]. If 5% of the masses would disappear it would require a deceleration of the masses from a speed that would be a substantial part of the speed of light. That would require an orbital speed of the objects in a substantial part of the speed of light. The current explanation is that the missing mass explodes in a burst of gravitational waves. That can also be the case in GET where the gravitation waves are radiation sent out to decrease the speed in elliptical orbits. But another part of the explanation can be that the combined mass from the new object will have an increased time dilation due to higher energy. That will slow down the decay process of gravitons. The result is that the object communicates (by radiated gravitons) a less mass than its real mass.

For normal conditions the gravitation mass and inertial mass is the same. But an interesting consequence of this scenario is that a black hole might be much heavier than expected and should be even harder to move than expected.

5.2 GET and Dark Matter

The discovery that the distribution of velocities in galaxies does not follow the expected pattern according to current theories was a great surprise to physicists. The rotational speed should, according to GR, decrease with the inverse square root of the distance to the center of the galaxy, but instead the speed is observed to be almost constant.[73] The currently most accepted explanation is that unknown mass, dark matter add matter to the galaxies and explain the velocity distribution. Dark matter would add about 26.8% more matter to the Universe.[74] However, some scientists have questioned the current explanation and have suggested alternative theories for gravitation to explain the phenomenon (see [75]).

The current view of the distribution of dark matter for spiral galaxies is that, in the plane of the galaxy, there must be much more mass between and inside the spiral arms that glues the stars together. Perpendicular to the galaxy plane there should be a halo of dark matter but not as dense as inside the plane.[76]

The GET model of graviton-graviton field deflection, results in substantial changes from GR, for structures that are not spherical. For spherical objects gravitons does not deflect since all radiation is radial. A single star or a planet works approximately according to the NG model. But when it comes to large structures such as galaxies or cluster of galaxies the picture will change. For disc-like galaxies gravitons will deflect back to the galaxy and create additional forces inwards the center of the galaxy (i.e. the sign of dark matter). But for perfect spherical galaxies there will not be much reflection of gravitons back and they will appear to be galaxies without dark matter. Ellipsoid galaxies are galaxies in between, that might show some signs of dark matter. This is also what recent observations tell us (see next section). The structure of the universe looks like a fabric of filaments with galaxy clusters as nodes. The filaments can, seen from a distance, be viewed as long poles. GET offers a model where graviton self-interaction will make these bonds much stronger.

The hypotheses in GET: *Dark matter (or part of the dark matter claim) might be an illusion. The real explanation is that we have to rethink gravitation. Self-interaction of gravitons may be the answer to the unexpected gravitation.* However, this is still a *hypothesis* and much more research have to be done to verify that this is the case.

Below a list of observations and computer simulations that support the hypothesis.

5.2.1 Observations that support the hypotheses in GET

Below are observations that support the hypotheses above.

- “In conclusion, elliptical galaxies could have dark matter halos similar in mass and extent to those in spiral galaxies (Danziger, 1997) but the evidence is not so clear, and it cannot even be completely rejected that they possess no dark halo at all”.[77] [78]
- "showing that there is no sign of large amounts of dark matter surrounding these galaxies!"[79]

- “However, the 'lack of dark matter' in these galaxies can be explained by another view of the 'missing mass problem'”[80]
- “The evidence of dark matter in ellipticals is less than in the case of spirals. Even the complete absence of dark matter cannot be easily ruled out.“[81]
- “Last week, astronomers announced the discovery of NGC 1052-DF2: a galaxy without dark matter. “[82]
- 19 Galaxies Are Apparently Missing Dark Matter. No One Knows Why.[83]
- Hubble Reveals New Evidence for Controversial Galaxies Without Dark Matter [84]
- “The differences in early galaxies’ rotations demonstrates that there is very little dark matter in towards their middle. Instead, they are almost entirely made up of the matter we can see in the form of stars and gas. The further away (and thus earlier in cosmic history) the galaxies were, the less dark matter they contained.”
  This is exactly what would be expected. In GET reflected gravitons will return and by time increase the acceleration of the outer regions of a galaxy. In a newly born galaxy would not show any sign of dark matter but eventually the acceleration of the outer part will slowly increase. [85]
- A theory of “sticky galaxies” is proposed in [86]. "Instead, other theories of dark matter predict that a force can exist between particles of dark matter, and this may very well be the first measurement of that force.". The interesting part relevant for GET is the proposal of *a force* (!).

5.2.2 Computer simulation of the Milky Way

Note! These computer simulations (we also did simulation of the solar system) were done some years ago when our assumption about graviton-graviton field interaction was a little bit different than today. Previously we assumed that when two gravitons interact, they deflect in an opposite direction to the meeting graviton (one interaction was sufficient to cause a big change of the angle). This assumption has been refined to the current proposal where a graviton field still deflects, when it interacts with another graviton field, but with a much smaller deviation. It takes a number of interactions to reach the opposite direction of a flux of meeting gravitons fields. The result from the computer simulations below however should be more or less the same. But with the refined model the deviation would be smoother. Another change of the previous assumption is that for an interaction to occur the angle between the gravitons must be sufficiently large.

The Milky Way was chosen to be the test object. Its spiral galaxy has around 250 billion stars. The shape of the galaxy is like a disc with a diameter of about 100 000-180 000 light years and a thickness of about 2000 light years. It has a bulge in the center with a radius of about 10^4 light years where 20% of the visible mass resides. Our first idea was to simulate the gravitation pattern inside of the galactic plane, but since it is reasonable to believe that GET conforms quite well with both NG and GR in this case the value of such a simulation would be of limited interest. Instead, the new focus was on a simulation of the vertical axis relative to the disc plane (only one side was simulated since the opposite side is just a symmetric view). The assumption of graviton-graviton field interaction, stated earlier in the document, is of crucial importance for the galaxy simulation.

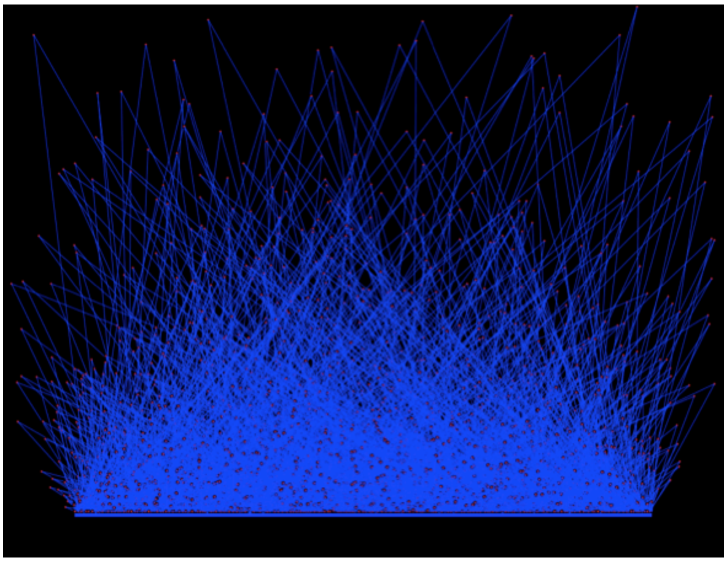

Figure 8. (from the computer simulation). Interaction pattern for gravitons emitted from a spiral galaxy (view from the side of the galaxy).

In the setup for the galaxy simulation gravitons were sent out in random directions from the plane (the blue horizontal line in figure 1) at simulated time steps. In the center of the galaxy a semi-sphere (the bulge) was added, and the gravitons were sent out randomly in radial directions from the sphere. 100 000 gravitons were created, and the red dots show the interaction points between two gravitons[38]. The simulation was previously based on a single interaction for the total deflection. But a new model defines a multi-interaction model instead. The result should probably though not differ in a significant way. It will only change from a single interaction event to a series of smaller deflection events.

For each time step it was checked if two gravitons were close enough to interact. The impact of the gravitons that deflected back to the disc plane was summed using the coordinates and force vector in a number of rings around the center. The accumulated energy vectors (which is the velocity vectors with the carried energy by the gravitons) where transformed to a list of orbital speeds from the center and outwards. Each graviton carried the same energy in this model.

The calculated density of dark matter shapes a halo perpendicular to the disc plane of a galaxy[87]. In figure 1 the blue lines and the red dots shows paths and the interaction pattern for gravitons emitted from a spiral galaxy. The view is from the side of the galaxy, where the pattern of graviton-graviton interaction is shaping a similar halo.

Previously a particle model where isolated gravitons interacted was used. This should be replaced with a dynamic vector field model, where a single interaction is replaced by a series of interactions between wave representations of two graviton vector fields. We anticipate that the overall result with such a refined model, should be smoother but still give approximately the same qualitive result.

The list orbital speeds where matched to the list of unexplained increased orbital speeds for the galaxy. The match was done by adjusting the curve by a constant (i.e. no derivation of absolute values was done). The white staples give a good match to the blue curve. The blue curve is the additional speed explained by the hypothesis of dark matter. The result is very interesting since the extra orbital speed of the outer part of the galaxy matches the observed speed. For the inner parts there is an acceleration turned inwards (not shown in figure 9). The physical interpretation of that is that the inner part will slow down due to the vertical effect of graviton interactions.

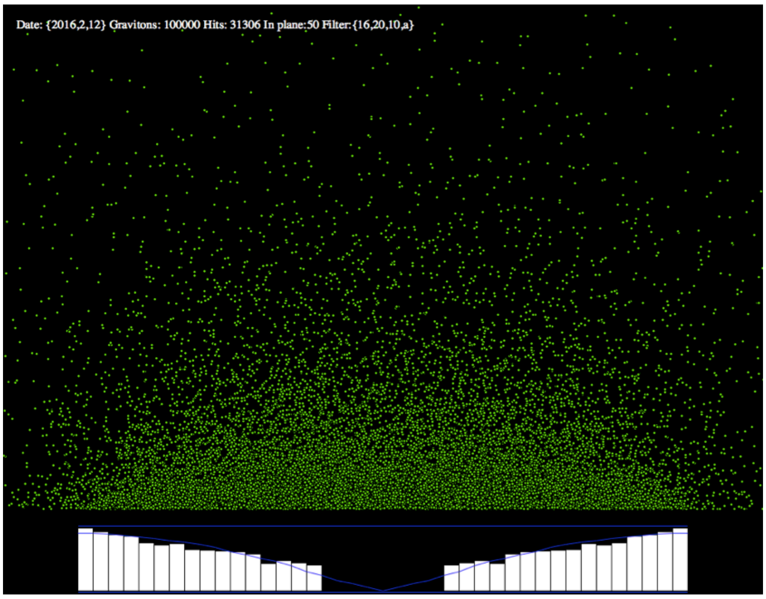

Figure 9. A cloud of interacting gravitons (green dots) above the galactic plane (blue line) and the resulting speed staples (white). The thin blue line is the expected added speed values. The center part has negative staples (not shown).

The interactions are summarized from the graviton vectors for 20 circles from the center. The energy is used to calculate the corresponding orbital speed as a function of the radius. The curve for the additional orbital speed, explained by the hypothesis of dark matter, is fit into the diagram (blue line). In the middle of the galaxy the energy vectors are inward bound which gives an inward acceleration that will slow down the orbit speed of the center. The speed values were taken from a graph of the M33 galaxy[88] because it was the best curve that was found. The essential part is that assuming that the shape of the curve is the same as for the Milky Way. The values were adjusted by a constant (i.e. the shape of the curve was not affected) to match the Milky Way.

The z energy vectors result in a force that increases toward the center and pull the galaxy center. This may explain the bulge that is observed. In the outer region of the galactic plane the observed velocity curve has a similar shape as the velocity from dark matter would have. In the center the forces are pulling outward (see the negative values in the footnote) which may slow down the rotational speed near the center.

The interesting part is that gravitons in the z plane shape a spherical cloud (halo) that results in extra acceleration inwards at the outer parts of the galaxy. The *shape* of the orbital speed curve matches the extra speed that is supposed to be caused by dark matter. Much more observations and analytics are needed though to be able to claim that this is the missing link to “dark matter”.

The assumption of graviton-graviton field interaction cause structures that are not spherical to behave in an unexpected way concerning their gravitation. For spherical objects there are no deflected gravitons (i.e. galaxies without dark matter) but for disc-like structures there will be additional forces inwards the center of the galaxy (i.e. the sign of dark matter).

Computer simulations of spiral galaxies together with the assumption of graviton-graviton field interaction gives an alternative potential explanation to the hypotheses of dark matter. According to GET the graviton-graviton field interaction is dependent on the structure of interacting objects. One prediction is that a spherical or elliptical galaxy would show much less evidence of “dark matter” than a disc-like structure such as the Milky way (the reason is that gravitons moving in a strict radial radiation don’t interact).

6 Potential Problematic Parts

GET is not a complete theory of gravitation. It lacks a complete mathematical model and has some weak parts (like almost all new theories have in the beginning). The list below covers the most important feedback from external reviewers and areas we have found ourselves to be potentially problematic.

1. **Proton decay.** The most important observation not in favor of GET is that there is no evidence that protons decay. Accurate experiments such as Super-Kamiokande[89] [90] show no signs of decay of protons and the minimum half lifetime is expected to be approximately 10^{34} years. However, the setup for the experiments relies on an implicit assumption that the decay will result in known particles (i.e. photons etc.). But if the decay is into gravitons the interpretation will change.

2. **Mass loss.** Observations of mass loss is crucial for GET. In section 2 a list of observations that support this picture is presented. Several of these observations are within the range $1 \times 10^{-12} \leq \lambda_d \leq 5 \times 10^{-12}\, y^{-1}$. But there are also a few pointing to a lower range $1 \times 10^{-14} \leq \lambda_d \leq 1 \times 10^{-13}\, y^{-1}$. The acceptable range for a GET model, dependent on a few initial conditions, might be $1 \times 10^{-14} \leq \lambda_d \leq 5 \times 10^{-12}\, y^{-1}$. Below are the current main known factors that determine the range presented.

   It's not unusual that different observations point at different results, but still are stated with a small margin of error. Such examples are different estimates of the Hubble constant and the struggle of measuring G with high precision[91]. These examples work as reminders that the intrinsic properties of gravitation might not yet be fully understood. The estimate of λ_d is crucial, but for the time being there are contradicting results and the precision is low. Below a list of anticipated ranges due to various conditions are presented.

   - $1 \times 10^{-12} \leq \lambda_d \leq 5 \times 10^{-12}\, y^{-1}$
     The summary of the major observations in section 2

   - $1 \times 10^{-14} \leq \lambda_d \leq 9 \times 10^{-14}\, y^{-1}$
     From the sources [81] and [82]

   - $\lambda_d > 5.5 \times 10^{-13}\, y^{-1}$
     To satisfy the NG symmetry for a planet in the Solar system, it should radiate the same energy that it receives. $\lambda_d > \frac{2P}{mc^2}$. Value above is with data for Mercury

   - $\lambda_d \leq 5.2 \times 10^{-14}\, y^{-1}$
     The capture radius should be greater than the real radius for all planets. The required maximum value of $\lambda_d = \frac{4R^2 P_M m}{r_{cp}^2 M c^2}$. The value above is calculated with data from Neptune.

   - $\lambda_d = 3 \times 10^{-14}\, y^{-1}$
     Using the equation of G from 6.3 where $G = k_1 k_2 k_3 \frac{\lambda_d^2 c^3}{16\,\pi}$, $\lambda_d = \sqrt{\frac{16\pi G}{k_1 k_2 k_3 c^3}}$ and we set $k_1 = 0.5$, $k_2 = 0.9$ and $k_3 = 3 \times 10^8$ gives $\lambda_d = 3 \times 10^{-14}\, y^{-1}$

   - Shadow effects. The flux from the Sun will change from a parallel to a radial flux on the back side of the planets but keep its magnitude. The surrounding flux will though partly compensate for the change in direction since it will deflect slightly inwards on the back side. A low λ_d gives larger capture spheres but compared to the distance from the Sun they are still *very small (typically a fraction of a few parts per 1000)* and will probably not give rise to major shadow affects.)

3. **Quantum interaction.** The next issues consider the quantum level of a gravitation model. A full quantum theory of gravitation is not within the current scope of this document, but some processes are discussed briefly anyway due to its importance. If the macroscopic description in GET is true, then gravitons must give rise to an attractive force and transfer sufficient energy between two objects to explain the orbits in

space etc. The transferred energy to the receiving object must be focused through an invisible "lens". Otherwise, the energy would not be sufficient. When two graviton fields interact, they bend each other inward. Gravitons that hit matter must be able to transfer (almost) all their energy to the receiving object.

The relation between momentum and energy for massless particles is normally given by $P = E/c$. If this formula is applied, then the energy generated by the graviton flux in GET would not be sufficient to explain the magnitude of the forces in NG. However, the Compton scattering process for interactions of photons with atoms gives much higher momentum compared to the standard formula. Perhaps a similar process exists for graviton-atom interaction where all energy for the graviton is transformed into kinetic energy for the atom. The standard relativistic formula for the relation between p and E:
$p = \frac{1}{c}\sqrt{E^2 + 2Emc^2}$ [kgms^{-1}]. Another example is photons as force carriers for the electromagnetic force where they transfer a large momentum.

Another part, related to the interaction between a graviton and matter, is the sign of the force, where gravitons have to transfer an attractive force. The theoretical reasoning behind that is that a force carrier (graviton) between two mass objects) always give rise to an attractive force if the spin is even (the graviton has spin 2). That is also true for the graviton-graviton interaction, "As a mathematical consequence, fermions exhibit strong repulsion when their wave functions overlap, but bosons exhibit attraction" (see [92], [93], [94] and [95]).

7 Conclusions

GR is the current theory of gravitation that best fits observations. Its predictions have been verified and many independent tests confirm the theory. However, the theory is not yet compatible with quantum physics and new observations in cosmology might be difficult to explain without at least a refinement of the theory.

The main assumption in GET is that mass *decay slowly over time* into particles that mediate the force of gravitation. If it turns out that no gravitational decay exists, then GET is simply wrong. But if the assumption is true, then GET probably gives a reasonable description on how gravitation works. The results will probably be very close to GR for non-extreme cases, but the underlying model of explanation is different. However, at the moment there is no complete mathematical model of GET where all relevant parts of gravitation are included.

GET relies on two assumptions. However, based on the energy principles in GET these assumptions can be seen as requirements or predictions instead. Thus, the assumptions are turned into consequences instead by the fundamental principle that gravitation must be explained by local energy interaction. The result can be summarized as follows:

i. **Mass decay slowly into gravitons.** In GET all gravitational accelerations of objects need energy which requires radiation of energy from mass. In GR space is distorted by mass, but in GET the explanation is a dynamic energy landscape of graviton fields generated by mass decay. For non-extreme cases and spherical objects, the effect on mass and light will probably be almost the same in GR and GET.

ii. **A graviton field that interacts with particles or another graviton field will cause an attractive force.** The mechanism is crucial in order to get sufficient energy for circular motion, for the property in NG that mass can be reduced to its mass center, the independence of the density of the objects and finally the graviton as an attractive force carrier particle.

From the basic principles in GET a number of interesting predictions can be deduced:

i. The baryonic mass will decrease in the Universe (affecting the Hubble constant, mass of white dwarfs, rotating orbits for objects such as planets and binary pulsars etc.). The radiation of gravitons creates a dynamic landscape of energy where energy interaction creates a number of effects. A black hole must communicate its mass to the external world in some way and in GET the mechanism is through emission of gravitons.

ii. The movement of big scale structures depends on the interactions of gravitons (which may remove the need for dark matter). "Normal gravitation", tidal forces and gravitational waves can all be explained by a vector field of gravitons.

iii. Time is a local scalar property of mass particles only and it's not connected to space as such but to their energy level in the space. Mass may be hidden in black holes due to less radiation of gravitons due to slower time.

Energy interaction is used as the common denominator to explain gravitation in GET and the idea includes parts from NG, SR and extensions of the Standard Model. The graviton is assumed to be the force carrier particle and gravitation is described in a similar way as the other three fundamental forces. Therefore, GET gives a bridge to quantum physics. Similar to John A. Wheeler's description of GR, the core of GET can be summarized as:

Matter decay and continuously radiates gravitational particles in all directions that create a landscape of energy. That landscape determines how matter and light will move but is also the cause of gravitational time dilation for elementary particles with rest mass.

Table 2. The differences between NG, GR and GET can be summarized in the table.

Key Properties	NG	GR	GET
Cause of gravitation	Force	Geometry (and force)	Force
Origin of force	Attractive force between matter	Curved space-time (by matter and energy) in steady state, energy radiation when gravitational waves and tidal forces arises	Radiated energy from matter mediated by gravitons. Matter only (not energy) generates gravitation.
Time dilation	N/A	Space-time curved by matter	Energy level of fermions
First level characteristics	NG (by definition)	NG	NG
Mathematics	NG (gravitation formula)	Space-time with field equations described as tensors	Probably close to GR for circular objects
Relation to quantum physics	N/A	Not compatible?	Opens for a merge of both
Bending of light and gravitational lensing	50% of the observed value	Predicted accurately	Explained as an optical medium (calculations indirectly)
Frequency shift of light	N/A	Predicted accurately	Explained as a change of energy levels
Deviation of Mercury	N/A	Predicted accurately	Probably the same as in GR
Gravitational mass loss	N/A	N/A	Predicted range: $1 \times 10^{-14} - 5 \times 10^{-12}$ y^{-1}
Compatible with SR	N/A	Yes	Yes
Speed of gravitation	Instantly	c or less	c
Dark matter	N/A	N/A (indirect)	Interacting graviton fields?

Appendices

8 Energy for circular motion

A crucial question in GET is to determine the minimum amount of *energy exchange* needed per time unit to perform a circular motion. The reason why this question is so important is that if a circular motion requires an exchange of energy, then the energy must come from somewhere. If the motions are caused by gravitation, then the energy must come from the central object. Since the distances are macroscopic mass therefore must leak energy which is the fundamental cornerstone in GET.

Question

> *How much power P [W] is ideally required to force an object to move in a perfect circular orbit with radius r [m] if the mass of the object is m [kg] and its tangential speed v_t [m/s] is constant?*

Important conditions

- No (external) gravitation or any electric charge affect the object
- No string is attached to the object and the center of the path
- The object is not moving inside a cylinder, along a trace or inside any other equivalent external construction (i.e. external mass is negligible)
- The motion is assumed to act under ideal conditions, i.e. there is no energy loss due to friction whatsoever
- No net energy is transferred to the object during the motion and its mass is assumed to remain constant during the motion
- An external energy source is assumed to be the cause of the motion
- Relativistic effects are negligible, i.e. $v_t \ll c$

Variables used

Note! See figures on next page for an explanation of some of the variables.

- P – the ideal power required for the circular motion [W]
- m – the mass of the object [kg]
- r – the radius of the circle [m]
- v_t – the tangential speed [m/s] (where $v_t = |\mathbf{v}_{t(i)}|$ and $|\mathbf{v}_{t(i)}| = |\mathbf{v}_{t(i+1)}|$ for all i)
- a_r – the radial acceleration [m/s^2]
- v_r – the radial speed [m/s] (where $v_r = |\mathbf{v}_{r(i)}|$ for all i)
- F – the centripetal force [N]
- T – the period time [s]

Diagrams of the motion

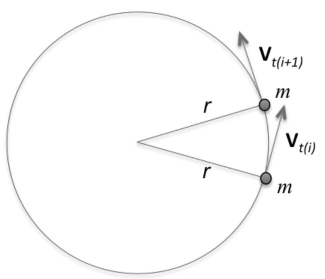

Fig a) The object moving in a circle.

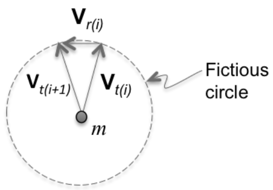

Fig b) Translated velocity vectors,
where $\mathbf{v}_{t(i)} + \mathbf{v}_{r(i)} = \mathbf{v}_{t(i+1)}$

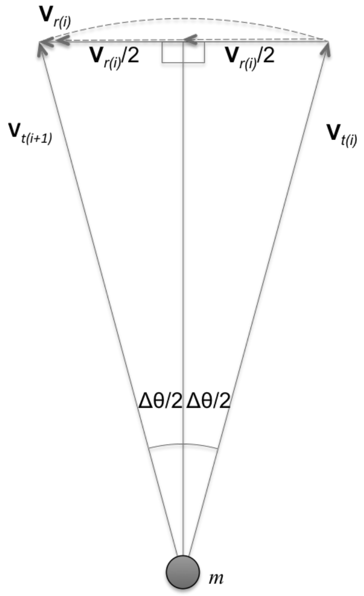

Fig c) Zoomed velocity vectors.

The question above has been addressed to *many* professionals in classical mechanics. *All* of them have instinctively responded that $P = 0$. They have motivated their answer arguing that since the dot product between the centripetal force and the tangential velocity vector is always zero, no mechanical work is performed on the object (i.e. $\mathbf{F} \bullet \mathbf{v_t} = 0$ at any arbitrary time during the motion). Further, they have also argued that since the speed is constant no (net) energy is transferred to the object, thus the power is zero. We are *very well* aware of these arguments. However, given the specified conditions it's clear that the power cannot be zero (even though the net mechanical work on the object will be zero). It has to be a specific value that is greater than zero and not infinitely high. The professionals that have understood the *real question* (given the specified conditions) have after a while also agreed with this view. However, none of them have presented a realistic solution of the problem.

In order to get a more intuitive picture of the problem discuss a few tangible examples will be discussed before presenting our solution. (The conditions specified above do also apply here.) One example can be a puck on ice without any friction. The puck has the velocity $\mathbf{v_t}$ and would move on among a straight line (forever) in the absence of any forces. But in order to bend the path into a circle a force (caused by energy) needs to be applied towards the center of the circle, according to Newton's second law. According to classical mechanics the strength of the (centripetal) force is $F = \frac{mv_t^2}{r}$. But what is the power to make this happen? Since the speed does not change, the kinetic energy for the puck stays constant and the net mechanical work is zero. But an *exchange of energy and a change in momentum* has to take place in order to change the direction of the velocity vector. Another example would be a rocket in free space, far from any external forces including gravitation. How much power would it take to force the rocket to move in a circle? It's obvious in the examples with the puck and the rocket that they will not move in a circular orbit without any external power.

In order to better understand the line of reasoning in our solution we will present another tangible example of how the mean value for speed can be calculated:

Example 1. Different speeds for a car.

Let's say a car drives a certain distance for 8 hours. During the first 4 hours the car drives at speed 100 km/h and the next 4 hours at the speed 50 km/h. What is the mean speed per hour?

The sum of the speeds is $v_{\text{sum}} = (100 + 100 + 100 + 100 + 50 + 50 + 50 + 50) = 600.$ The unit is no longer [km/h] but instead [km/8h]. To get the mean value and the desired unit, the sum must be divided by the number of values. Thus, the mean speed is $v_{\text{mean}} = v_{\text{sum}}/8 = 75$ [km/h].

From figure b) we can see that the radius of the circle is v_t. The sum of all v_r along the circumference is $v_{\text{sum}} = \sum_{n=1}^{\infty} \mathrm{v}_{rn}$. The quantity v_{sum} will have the unit [distance/time] but it will *not be in SI units*. The unit will be [m/(N_T s)] which is speed/orbital time T, and N_T is the *number* of seconds to make one orbit (N_T has the dimension 1). Thus, *N_T is just a pure number without any unit* according to the example above. The speed may of course be expressed in an arbitrary time unit (such as milliseconds) but the second is usually the preferred unit for scientific applications.

Derivation of the required power

The required power can be derived in two ways. The first method is short and straightforward but is not mathematically solid in every step. The second method is more extensive and complicated but more mathematically stringent.

Method 1 (straightforward approach)

The sum of the value of the radial velocity vectors v_r must equal the circumference of a circle with radius v_t during one orbit. This relation gives:

$$\sum v_r = 2\pi v_t \text{ [m/(N}_T\text{s)]} \tag{8.1}$$

The mean value $\overline{v_r}$ of the sum of the velocity vectors' values is:

$$\overline{v_r} = \frac{\sum v_r}{N_T} = /\text{ substitute (8.1) }/ = \frac{2\pi v_t}{N_T} \text{ [m/s]} \tag{8.2}$$

The power P for the circular motion becomes:

$$P = F\overline{v_r} = /\ F = \frac{mv_t^2}{r} \text{ and substitute (8.2) }/ = \frac{mv_t^2}{r}\frac{2\pi v_t}{N_T} = \frac{2\pi m v_t^3}{rN_T} \text{ [W]} \tag{8.3}$$

Method 2 (mathematically more stringent approach)

In order to present a more proper solution we introduce the definition below:

Define the function: $scale(x) = x/1$ [unit/unit] thus $[scale(x)] = 1$ with no unit, just a pure number. The scale function is similar to the absolute value function that is used when a unit vector[96] is created. For example let $\mathbf{u}$ denote a velocity vector with a certain unit, e.g. [m/s]. Then the unit vector is $\hat{\mathbf{u}} = \frac{\mathbf{u}}{\|\mathbf{u}\|}$. The unit in this case will be $\left[\frac{\text{m/s}}{1}\right] = $ [m/s]. The reason is that $\|\mathbf{u}\|$ just denotes the value of the length of $\mathbf{u}$ and does not include the unit of $\mathbf{u}$. The scale function works exactly in the same way (even though the quantity is a scalar and not a vector in that case). The purpose of the scale function is to transform a physical quantity into a uniform unit system (preferably the SI system).

Newton's second law of motion combined with the centripetal force F:

$$F = ma_r = \frac{mv_t^2}{r} \tag{8.4}$$

The radial component $v_{r\,(\text{not adj.})}$ of the velocity (not adjusted to be expressed in a uniform unit system):

$$v_{r\,(\text{not adj.})} = 2v_t \sin\left(\frac{\Delta\theta}{2}\right) \tag{8.5}$$

Since $\frac{\Delta\theta}{2\pi} = \frac{\Delta t}{T} \Leftrightarrow \Delta\theta = \frac{2\pi\Delta t}{T}$ equation (8.5) can be rewritten:

$$v_{r\,(\text{not adj.})} = 2v_t \sin\left(\frac{\frac{2\pi\Delta t}{T}}{2}\right) = 2v_t \sin\left(\frac{\pi\Delta t}{T}\right) \tag{8.6}$$

The radial component v_r of the velocity should be expressed using a uniform unit system (preferably the SI system). Therefore formula (8.6) has to be adjusted (normalized) multiplying it by a scaling factor k:

$$v_r = k \times 2v_t \sin\left(\frac{\pi\Delta t}{T}\right) \tag{8.7}$$

Note that Δt cannot be treated as an independent quantity since the sum of all v_r (if $\Delta t \to 0$) has to equal the circumference of a circle with radius v_t (see Fig b). Thus, Δt must be scaled k times in order normalize the product quantity into a time unit (preferably one second). The product $\Delta t \times k$, i.e. a time unit, must be multiplied by $scale(T)$ in order to complete one orbit during the period time T. The last two conditions are captured in the equation:

$$k \times \Delta t \times scale(T) = T \tag{8.8}$$

Solve equation (8.8) for k:

$$k = \frac{T}{\Delta t \times scale(T)} = \frac{1}{scale(\Delta t)} \tag{8.9}$$

Substitute equation (8.9) in (8.7):

$$v_r = \frac{1}{scale(\Delta t)} 2v_t \sin\left(\frac{\pi\Delta t}{T}\right) \tag{8.10}$$

The instantaneous power $P_{\text{instantaneous}}$ for the circular motion is:

$$P_{\text{instantaneous}} = Fv_r = \text{/ substitute (8.4) and (8.10) /}$$

$$= \frac{mv_t^2}{r} \frac{1}{scale(\Delta t)} 2v_t \sin\left(\frac{\pi\Delta t}{T}\right)$$

$$= \frac{2mv_t^3}{r} \sin\left(\frac{\pi\Delta t}{T}\right) \frac{1}{scale(\Delta t)} \tag{8.11}$$

The motion has to describe a perfect circular orbit and therefore $\Delta t \to 0$. Hence equation (8.11) becomes:

$$P_{\text{instantaneous}} = \lim_{\Delta t \to 0} \left[\frac{2mv_t^3}{r} \sin\left(\frac{\pi \Delta t}{T}\right) \frac{1}{scale(\Delta t)} \right]$$

$$= \lim_{\Delta t \to 0} \left[\frac{2mv_t^3}{r} \frac{\sin\left(\frac{\pi \Delta t}{T}\right)}{\frac{\pi \Delta t}{T}} \frac{\pi \Delta t}{T} \frac{1}{scale(\Delta t)} \right]$$

$$= \frac{2\pi mv_t^3}{r} \lim_{\Delta t \to 0} \left[\frac{\sin\left(\frac{\pi \Delta t}{T}\right)}{\frac{\pi \Delta t}{T}} \frac{\Delta t}{T \times scale(\Delta t)} \right]$$

$$= \frac{2\pi mv_t^3}{r} \times 1 \times \frac{1}{scale(T)}$$

$$= \frac{2\pi mv_t^3}{r \times scale(T)} \qquad (8.12)$$

Note that $P_{\text{instantaneous}}$ will be expressed in watt [W] if all other quantities are expressed in SI units. However, the formula is general and applicable to any uniform unit system.

Additional result

The mean power per orbit P_{mean} can be calculated as follows:

$$P_{\text{mean}} = \frac{\sum P_{\text{instantaneous},\, i} \Delta t}{T} = \frac{1}{T} \int_0^T \frac{2\pi mv_t^3}{r \times scale(T)} \, \mathrm{d}t =$$

$$= \frac{2\pi mv_t^3}{r \times scale(T)} \frac{1}{T} \int_0^T \mathrm{d}t = \frac{2\pi mv_t^3}{r \times scale(T)} = P_{\text{instantaneous}} \qquad (8.13)$$

Thus, $P_{\text{mean}} = P_{\text{instantaneous}}$ which is the expected result. (Integrating over another arbitrary positive time interval gives the same result.)

Conclusion

From the circular motion part, the formula for the exchange of power is:

$$P = \frac{2\pi mv_t^3}{r \times scale(T)} \ \text{[W]} \qquad (8.14)$$

Let's discuss the result. Since the speed is constant during the motion, the net energy transfer to the object must be zero. This implies that all energy that is received must also be emitted. If electromagnetic forces are the cause of the motion, the force carrier particles are photons. In GET the force carrier particles are gravitons. A graviton interacts with an atom within the object and *pull* the object towards the center of the circle. When the graviton leaves the atom, it *pushes* the object towards the center instead. No gravitons will be consumed by the object and they will continue their radial path outwards from the central object. The absolute value of the velocity vector (the speed) will remain constant for the object, but its direction will change.

The conclusion is that the formula above describes the total *exchange* of energy for the object. However, the interesting part of the calculation is how much power that is needed from an external source in order to perform the motion. Since the same energy will constitute both a pull and a push, the value actually needed is *half of the calculated value*. In order to obtain the correct value of the momentum (se next section) the value also has to be half of the value. Thus $P_{\text{injected}} = P_{\text{emitted}}$, and we get:

$$P_{\text{injected}} = \frac{\pi m v_t^3}{r \times scale(T)} \text{ [W]} \tag{8.15}$$

Where P = power, m = mass, v_t = tangential velocity, r = orbiting radius, $scale(T)$ = a scale factor that converts the speed per orbital time into meters per second.

The power origins from the flux of gravitons from a central object. If the object is not in circular motion the injected power (and the force) will be the same but cause an increase or decrease of the speed for the object (depending on its initial direction of motion). If the object is accelerating, the gravitons are consumed and transformed into kinetic energy (i.e. no energy balance in that case and no emitted gravitons).

Reality check

In order to judge if the power seems to be reasonable, the formula (8.15) will be applied on two everyday examples.

Example 2. Puck on ice.

Data: $v_t = 2$ [m/s], $m = 0.1$ [kg], $r = 1$ [m]

$$P = \frac{\pi m v_t^3}{r \times scale(T)} = / \ T = \frac{2\pi r}{v_t} / = 0.8 \text{ [W]}$$

Example 3. Car on ice.

Data: $v_t = 20$ [m/s], $m = 1000$ [kg], $r = 50$ [m]

$$P = \frac{\pi m v_t^3}{r \times scale(T)} = / \ T = \frac{\mathbf{2\pi r}}{v_t} /= 32000 \text{ [W]} = 43 \text{ [hp]}$$

Both results seem to be reasonable.

Summary

Energy is needed to move free objects in circular orbits. If the object is a planet or a moon where should the energy come from? The most probable answer is of course from the central object in each case. The required energy values in this section are identical to earlier values computed by a different approach and strengthen the case that energy is a hidden factor and the reason of gravitation.

9 The interaction of two graviton fluxes

9.1 Statistical model for graviton-graviton interaction

Let's study two fluxes of gravitons N_1 and N_2, coming from opposite directions, that will meet and interact on a surface A. For simplicity reasons it is assumed that no gravitons *in each flow* will overlap each other. This condition can be mathematically expressed as: $\frac{N_1\sigma}{A} \leq 1$ and $\frac{N_2\sigma}{A} \leq 1$ where σ denotes the cross-section area for a graviton. The number of interactions N_{product} between the fluxes will be.

$$\frac{N_{\text{product}}}{A} = \frac{N_1}{A}\frac{N_2}{A} \Leftrightarrow N_{\text{product}} = \frac{N_1 N_2}{A} \tag{9.1}$$

Equation (9.1) will be used in the next two sections. In section 9.2 a simplified example will illustrate the principle of a statistical model for graviton-graviton interaction. In section 9.3 the framework will be extended in order to make step 5) probable in section 3.7.3.

9.2 Simplified example

Consider the following simplified example: $N_1 = 8$, $N_2 = 5$ and that $A = 5 \times 5 = 25$ [no unit] (assume the area is modeled as a discretized matrix with 5×5 elements). Further it is assumed that $\sigma = 1 \times 1 = 1$ [no unit] (assume the area is a square of 1×1 distances). Let "x" denote an assumed distribution of the gravitons in each matrix. Let "o" denote the interactions if the matrices are overlapped (which will be the consequence if the graviton flows are opposite and hit the same area). If a computer simulation would be performed the result may have been according to the figures below:

Matrix 1

	x			x
				x
x				x
		x	x	
	x			

Matrix 2

	x			
x		x		x
				x

Overlapped matrix

	o			
		o		

The third "Overlapped matrix" shows how many of the gravitons that would interact if Matrix 1 and Matrix 2 are overlapped.

According to the (theoretical) simulation the probability and number of interactions would be:

$$\frac{N_{\text{product}}}{25} = \frac{2}{25} = 8\% \Leftrightarrow N_{\text{product}} = 2 \tag{9.2}$$

Using equation (9.1) the result would theoretically be:

$$\frac{N_{\text{product}}}{25} = \frac{8}{25} \times \frac{5}{25} = 6.4\% \Leftrightarrow N_{\text{product}} = \frac{8 \times 5}{25} = 1.6 \tag{9.3}$$

If many simulations would be performed, then the mean value for equation (9.2) would be equal to the theoretical value in equation (9.3). This result would of course also hold using other numbers for N_1, N_2 and A.

9.3 General extension

In order to explain the interactions of the graviton flow between M and m the following extensions are made: The surface is split into two surfaces: $A_M = 4\pi R^2$ and $A_m = 4\pi r_c^2$. The overlapping surface is $A_c = \pi r_c^2$. Further, set $N_1 = N_M$ and $N_2 = N_m$. Then equation (9.1) becomes:

$$\frac{N_{\text{product}}}{\pi r_c^2} = \frac{N_M}{4\pi R^2}\frac{N_m}{\pi r_c^2} \Leftrightarrow N_{\text{product}} = \frac{N_M N_m}{4\pi R^2} \tag{9.4}$$

The energy transfer[39] $P_{\text{ineraction}}$ between two fluxes of gravitons (P_1 and P_2) distributed over an area A will be:

$$P_{\text{interaction}} = \frac{P_1 P_2}{A} \tag{9.5}$$

If $P = P_{\text{graviton}} N$ and if (9.4) is used, then (9.5) becomes:

$$P_{\text{interaction}} = \frac{P_{\text{graviton}} N_M \times P_{\text{graviton}} N_m}{4\pi R^2} = \frac{P_M P_m}{4\pi R^2} \tag{9.6}$$

10 Various cases in the GET model

In this appendix we consider how GET, in a qualitative way, describes several typical scenarios.

Active mass. The active mass does not show any shadow effects on its own mass. The obvious reason is that a sole mass does not move by its own gravitation. The sum of the forces (i.e. the graviton flux) in different directions is zero. The object cannot change its speed vector due to symmetry of the forces and it will not consume any gravitons. Since its mass will decrease, all gravitons that is the result of the decay, must radiate away from the body.

All masses experience self-gravitation since they build up an instantaneous pressure inwards when gravitons try to pull atoms within the mass towards the mass center. But since electromagnetic forces build up a pressure in the opposite direction there will be an instant (i.e. rapid) equilibrium, and consequently after that the flux of the outgoing gravitons will be constant.

Passive mass. For the passive mass several cases can occur. In order to judge which case that will occur it is crucial to ask the question: is it possible for an atom to move or increase its pressure towards other atoms when a graviton arrives (or more exactly change its energy state)? If the answer is yes, an interaction takes place, otherwise a saturation state is reached, and the graviton will just pass by to the next atom on its way.

Circular motion. A passive mass is in a circular orbit around a central mass. The passive mass is in energy balance and has a constant speed. It must emit the same amount of energy that it receives in every moment. That leads to a balance and there will be no shadowing effects regarding the total field of gravitons. The angles of the emitting field will however be affected.

Acceleration. An object accelerates towards an active mass and change its speed. It must then consume energy and the change in speed is given by the Lorentz equation. The shadow effects, which are the net difference in

[39] It can be argued that this quantity is not an effect according to structure of the formula. However, according to the physical situation it is reasonable to interpret it as an effect.

consumption and emission of energy in every moment, can be calculated by the Lorentz equation when the speed is known (and compensate for the continuous loss due to the radiation from decay).

Deceleration. An object decelerates from an active mass and reduces its speed. It must then emit energy to decrease its speed and the change in speed is given by the Lorentz equation. This happens when gravitons hit the object in the same direction to its velocity. The object the will emit gravitons in the same direction as it moves and therefore decrease its speed.

Elliptical motion.[40] During the acceleration phase the object consumes energy and in the deceleration phase it must emit the same amount of energy. During one revolution the net energy balance is zero.

Some shadow effects will occur when the object accelerates and gain energy. When it decelerates it emit gravitons in the same direction to slow down and it will lose energy. Due to the deceleration the object will emit gravitons in the same direction as it moves. It's not related to the normal decay process that radiates gravitons in all directions. It's the same process as when electrons emit photons when they change direction in a particle accelerator (see [97]). The Lorentz equation[98], combined with $E = mc^2$, determines the relation between energy and speed:

$$E = E_0 / \sqrt{1 - \left(\frac{v}{c}\right)^2} \quad (10.1)$$

This is the relation between the total energy of an object and its speed. If the speed does not change, the energy of the object must stay constant. In all these cases it's understood that E is the rest mass energy plus the consumption or minus the emission of energy originated from the external flux, not the result of the continuously decay of energy in all directions.

Locked objects. A "locked" object is an object that cannot move towards the flux because there are matter pushing back (a stone on the ground for example). Since it does not change its speed it cannot consume gravitons. A stone on earth will try to accelerate towards the ground but the earth is pushing back. The result is a lock-in situation where all gravitons are passing through the stone and there are no shadowing effects. The object reaches a state of saturation. Another way to put it – the stone is part of the Earth.

Small object. If the passive object is too small to have a radiating cloud of gravitons, a molecule or microscopic objects, then the model with a capture area and graviton deflection is not applicable. In this case (almost) no graviton-graviton field interactions will take place. Instead, only direct hits from external graviton fluxes will affect the object.

Large objects. An object[41] in a flux must capture the energy from the gravitons to accelerate. Assume the following process for a large object. A graviton does a "handshake" process with the atom. It "asks" – can you accelerate towards my direction or increase the pressure towards other atoms? If yes, then the graviton is absorbed. If no, the graviton travels to the next atom in line and ask the same question. This must be a very fast process. If every atom is locked in, then the graviton will pass the body with a speed close to c. The process ensure that the body is in balance with the surrounding graviton flux. And if a substantial part of the object has absorbed gravitons in a certain direction it will accelerate.

When the body is saturated then the gravitons is just passing by (no shadow effects). When it can accelerate it will absorb gravitons and increase its energy (shadow effects). If the graviton flux comes from the same direction as the velocity of the object it must emit previous captured gravitons to decrease its energy and speed (reversed shadow effects where the object will emit gravitons in the same direction as it moves).

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[40] This case is actually a combination of the previous three cases, but since the planetary orbits are elliptical and therefore crucial to explain gravitation it is described as an own case.

[41] The body is assumed to be kept together by self-gravitation and/or electrostatic forces.

The first assumption of mass decay in GET is crucial. In the next section we present a list of observations that indicate unexpected[42] mass loss.

11 GET and Micro Cosmos

Background

The purpose of this section is not to present an overall quantum mechanical description of gravitation, since that's beyond the current scope of GET. However, since the main assumption in GET requires that matter decay into gravitons, we will outline some brief ideas that can work as starting points on how this process may work at the quantum level. Even though a speculative potential decay processes is presented, the actual mechanism probably works in a totally different way not accounted for in this document.

In addition to ordinary stars and planets, hydrogen gas clouds and neutron stars also gravitate and therefore both protons and neutrons must decay into gravitons. It's uncertain if electrons actually decay. Protons cannot decay into gravitons directly, since that would break the conservation law of electric charge. Therefore, our tentative guess is that protons first decay into neutrons and that neutrons decay into gravitons in the next step. These decay chains will be discussed in the next section.

Possible decay processes

Proton decay

The most important observation not in favor of GET is that there is no evidence so far of isolated protons (or hydrogen nucleus) decay. Accurate experiments such as Super-Kamiokande[99] [100] show no signs of decay of protons and the minimum half lifetime is expected to be approximately 10^{34} years. However, the setup for the experiments relies on an implicit assumption that the decay will result in known particles (i.e. photons etc.). But if the proton decays into particles, not detectable by the experiment, this picture may change. If the proton decays into gravitons in a series of steps it will of course be of particular interest for GET.

The necessity for proton decay is not unique for GET. Most attempts to find a "Grand Unified Theory" (GUT) involves this property. In order to explain why we live in a Universe filled with matter decay of protons must have occurred (at least initially). For more information about the properties of the Universe related to decay of matter, see the sources [101] [102].

A proton (inside the atom nucleus) may decay according to β^+ decay[103]:

$p \Rightarrow n + e^+ + v_e$ where e^+ is a positron and v_e is an electron neutrino.

New experiments, performed at Duke University in Durham, show that an inverse beta decay can occur when a neutrino reacts with an entire atom nucleus. When a neutrino hits a proton a neutron and an electron can be created according to the process[104]:

$p + v_e \Rightarrow n + e^-$ where v_e is a neutrino

[42] With *unexpected* we refer to unknown processes (except from fusion, cooling, loss of atmosphere etc.).

Another possible solution would be a similar process called electron capture[105]:

$p + e^- \Rightarrow n + v_e$ where v_e is a neutrino

Neutron decay

The normal decay process is that free neutrons decay into a proton and an electron according to β^- decay[106]:

$n \Rightarrow p + e^- + \overline{v}_e$ where $\overline{v}_e$ is an electron antineutrino

There is a theoretical speculative possibility that two neutron may decay into two gravitons according to the process[107]:

$n + n \Rightarrow g + g$ where g is a graviton

The total decay chains

The goal is to find a process where protons and neutrons decay into gravitons. If the processes described above are combined the following process may be possible theoretically:

$$p + p + (\text{other particles}) \Rightarrow n + n + (\text{other particles}) \Rightarrow g + g + (\text{other particles})$$

The process above requires that the other particles that might be a part of the first two steps exist naturally within matter. The process also requires that the other particles that might be produced in the last step doesn't lead to any logical or practical inconsistencies. For more details about possible interactions see for example [108].

Even though protons may decay into gravitons via neutrons theoretically according to the process above, we believe that this is probably not the way gravitons are generated. The reason is that each neutron probably decays into a huge number of gravitons where the energy level for each graviton is quite low. If two neutrons would decay into two gravitons, then the energy for each graviton would be very high. Consequently, the discretized character of gravitation would be very prominent which should have been detected.

As said previously it's unknown how gravitons are created from matter and therefore the ideas presented above should only be seen as a speculative sketch on how this process may work. Thus, the actual decay process may be explained in another way.

Observational indications of creation of unknown particles from neutrons

A recent experiment has opened up for the possibility that neutrons may decay into unknown particles. The decay rate for neutrons from a "bottle" and "beam" experiments differ. The bottle experiment gives shorter decay time (14 min 39 sec) compared to the beam experiment (14 min 48 sec). It may be interpreted as a fraction of the neutrons (about 1%) have decayed into unknown particles that so far cannot be traced! If the potential unknown particles would be *gravitons* it would of course be a breakthrough for GET. For more details about this experiment, see the sources [109], [110], [111] and [112].

Possible experiments to detect mass loss at the micro scale

Here are some potential experiments that might detect mass loss at the micro scale:

- Examine if perfect crystals (such as diamonds, graphene, cooled neutrons etc.) will change structure in some way over time due to "missing atoms".
- Compare very old crystals (> 3×10^9 years) with newly created crystals and see if the old ones have lower density.

- Weight a massive number of iron atoms with high precision, a nanometer pipe, and look for changes.

Other interesting observations

- It has been shown that neutrons jump in quantum steps within a gravitational field, which is an indication that gravitation, at least at the receiving process in this case, is quantized.[113]

- It has still not been possible to get a value of G with a high precision[114]. The experiments have been designed very carefully but still they differ in the value of G according to each other. The current approach is to be even more rigorous when designing the experiments. But is there a hidden systematic problem? Does gravitation work in a slightly different way than anticipated?

- Is the decay rate of neutron stars higher, due to an increased decay rate, compared to ordinary matter? If so is the mass over estimated?

How can gravitons create attractive momentum and forces?

Don Lincoln, particle physics researcher, says: "*...gravitons have a basic attraction to other gravitons*" and "*Gravitons are emitted essentially just as photons are. Further they don't push anything, they cause a pull. (Yes, that is a bit tricky to see, but it's really no different than how photons cause attractive forces.)"*[115]

From the formal definitions of real photons and virtual photons are[116]:

"Real photon particles: $E^2 - (pc)^2 = 0$
Virtual particles: $E^2 - (pc)^2 \neq (mc^2)^2$*, can be >0 =0 or <0"*

We believe that this is the case for gravitons as well. The former explanation addressed by the scientific community was to explain this by introducing a negative time. The modern interpretation seems to be that during a short moment in time a (virtual) photon may be seen to arrive from the opposite direction without braking the Heisenberg's uncertainty principle. Perhaps a similar model with virtual gravitons can be used in order to explain why gravitation is always attractive. However, such a model must still follow the energy transfer principles in GET.

Subjects already discussed

There are also a few more subjects where the solution must be in the domain of quantum physics. These have already been discussed:

- Transmission of momentum from a graviton field to an atom
- Graviton-graviton field interaction
- Graviton-photon field interaction

12 Summary of GET Predictions

	Prediction
1	The baryonic mass will decrease in the Universe.
2	Mass decrease will affect the measurements of the Hubble constant.
3	Objects will shrink.
4	Very old crystals will lack some of its protons or neutrons.
5	Orbiting objects will increase their orbits and decrease their speed.
6	Interval for rate of mass decrease: $\lambda_d = 1 \times 10^{-14}$ - 5×10^{-12} y^{-1}
7	For a small test mass on the backside of an object in circular motion caused by gravitation from a central mass, the gravitation from the central mass on the test mass will appear to be almost radially emitted from the object in the circular motion.
8	If an object accelerates towards a heavier mass, then a small test mass passing on the backside of that object will experience less gravitation from the heavier mass. The reason is that the object that accelerates towards the heavier mass will consume gravitons during that process. Reversely, the gravitation on a test mass will be stronger if the same object is moving outwards from the heavier mass and therefore experience deceleration and emits gravitons towards the test mass.
9	The movement of big scale structures depends on the interactions of graviton vector fields.
10	The landscape of gravitons around an object is dependent on the shape of the object. An object with a strict spherical surface will emit gravitons that do not interact. All other shapes will be surrounded by a cloud of gravitons that will interact with each other.
11	The structure of small objects in a weak graviton fields effects the gravitational force.
12	Light will slow down passing between two massive objects.
13	Two spacecrafts passing by an object with a certain velocity, on the same distance but on different sides of the velocity direction, will experience a difference in the gravitation from the object due to gravitational red/blueshift effects.
14	The problems to determine an accurate value of G is due to that NG is an approximative model.
15	Black holes appear to have a smaller mass than their real value, due to slower decay rate of matter.
16	Black holes must communicate its mass through gravitons and emit gravitons outside the sphere of the event horizon
17	The deflection and frequency shift of light is due to photon-graviton interactions?
18	All gravitation (static field, tidal forces and gravitational waves) can all be explained by fields of gravitons.
19	Time dilation is a local scalar property of objects with rest mass and is determined by their local energy level
20	In GET there are also predictions/speculations about the evolution of the Universe (not included here)

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