The quest for new physics. An experimentalist approach.

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Abstract.

In this book the outline of the few ideas are given. Those ideas may lead to the breakthrough in fundamental physics but may merely confirm the existing paradigm. Whether they be successful is difficult to predict without try. However, they are not the only way the physics will go forward and solve todays problems, rather one of the many possible pathways. Many other authors today are doing a similar quest, trying to develop the theory of everything like general field theory or predict something just out of the reach of modern science. The major difference is that this book is written by experimentalist, who tried to use his experience with modern devices and experimental techniques already available to shape the most probably future of physics.

Introduction.

The idea of modern physics being in crisis is a very popular approach now and it is somewhat correct. Indeed, the number of discoveries per decade is dwindling and no major breakthrough achievements happened for many years. The analysis of such saturation behavior is necessary to start from the historic perspective and relative strength of fundamental forces: gravitational, electromagnetic, weak and strong. The most strong ones are already being carefully investigated and all the related phenomena are discovered and that was the origin of the numerous discoveries around 100 years ago, when physics was developing at the accelerated speed. Electromagnetic force is strong on "household" level (between galaxy and nucleus) thus allowing to see many quantum phenomena relatively easy. Here is the proof.

The quantum of electric charge is big enough to hold macroscopic mass in relatively low electric field, like the field generated during triboelectrization (dielectric strength of air). From mg=eE, where m is the mass of the particle, g is 9.83 m/c^2 for Earth surface, e is quantum of charge and E is electric field strength and for usual triboelectric field in air of 3 kV/mm (dielectric strength of air) the mass is $5*10^{-14}$ kg, what corresponds to the water droplet with radius of $2*10^{-6}$ m, 2 um, quite a measurable value. For example, the weakest of the fundamental forces, gravitational force is so weak that in open space two electrostatically charged by one quantum of charge balls with mass of $2*10^{-9}$ kg each will be attracting each other with the same force as repelled by the just two electrons (one on each ball). Indeed:

$$G*m^2/R^2=[1/(4\pi\varepsilon_o)]*e^2/R^2 \text{ and } m=\{[1/(4\pi\varepsilon_o)]*e^2/G\}^{1/2}=1.86*10^{-9} \text{ kg}$$

Here G is the gravitational constant, e is charge of electron, ε_o is the dielectric permittivity of free space. But that amount of mass corresponds to ~ 10^{18} protons (to some extent "quanta" of mass). It means that the electric charge quantized into the entities somewhat 10^{18} times larger compare to gravitational “quanta”, what makes discoveries in the electromagnetic realm much easier. This huge value of electric charge quantum has another implication – some of the inherently quantum phenomena like Landau-Zeener probability of system energy levels crossing may reveal itself directly on macroscopic level in ordinary life, thus making even macroscopic world inevitably stochastic. It is actually the huge value of electric charge quantum that allows relatively small numbers of electrons during triboelectization process to govern the mechanics of macroscopic bodies, and since the fluctuations of that number is unpredictable even assuming the initial conditions are known (because of Landau-Zeener phenomena) the final outcome is completely stochastic on guaranteed quantum mechanics level.

Thus around 100 years ago an avalanche of discoveries in the field embraced by electromagnetism happened, creating quantum mechanics and generating feeling that the one per year discovery in physics is a norm. Later arrived time for the strong and weak fundamental forces, which (strong) are even stronger compare to electromagnetic and despite the cost of discoveries is enormous (accelerator is necessary!) the discoveries were still easy and in 50^{th} and 60^{th} the avalanche of discoveries in nuclear physics supported the feeling of fast and steady progress in fundamental physics.

However the progress in technology being driven by the fundamental discoveries (lasers, computers, atomic clocks etc) was based onto the electromagnetic forces mainly and come to inevitable saturation, too. What means that the “easy” discoveries in a strong and electromagnetic governed realm are already made (and implemented into the corresponding devices and methods) and now it is time for some “difficult” discoveries in old realms like electromagnetism, strong and weak forces. And time for new discoveries (and phenomena to explain) in the realm of gravitational force (which are not “feeble” in general perception like dark matter problem), they need an extraordinary sensitivity of the devices because of the weakness of the gravitational force itself.

Therefore, from the measurements point of view the new phenomena and discoveries are now on the “very outskirts” of achievable area and experimentalist point of view what is possible “in principle” with the available methodology and not at cosmic price becomes more and more valuable. This approach “the cost of device first” may even predominate the old approach: theoretician predicts, experimentalist discovers.

It is necessary to emphasize that experimentalist is not a technician working on textbook principles only, he or she is capable of evaluations of the phenomena too, like theoretician, but he or she merely stops before say numerical integration or numerical solution of differential equations, integro-differential equations, never bothering with Bessel functions and reducing all the mathematics to exponents, trigonometric functions and rational functions expressions. On the other side experimentalist must have a feeling what type of experiment is achieavable and where science fiction starts (it is not uncommon to see nice theories which asks for the experimental apparatus for verification so enormous that it is clearly out of reach – for example detection of graviton needs a detector of a size of a planet).

In this book few of the several approaches to the experimenting in the fundamental physics is discussed with the hope to demonstrates the experimentalist approach to the question: where the new physics hides?

Chapter 1. Unification of matter and wave.

The idea of the matter-wave dualism is very old. Actually De Broglie himself was strong supporter of non-zero mass of photon, what means that from his point of view, not only all the mass particles have a wave associated with them (De Broglie wave), but all the waves (photons) have something with mass associated with them (see, for example [1]). I am trying to infer some new ideas from the following hypothesis: any matter is simultaneously particle and wave. How to describe it mathematically is a difficult problem and probably such mathematical formalism does not exist yet. However, some interesting ideas may be inferred from the mere fact of such duality. The most obvious is the mass of photon - it should have a mass, despite it is clear that it is very, enormously small. However, this fact will instantly explain the quantization of the light absorption - the light is quantized because it is countable very much like any other particle.

The conclusion from such a summation rule:

Any matter is PARTICLE + WAVE simultaneously

Would be the **reciprocity principle** – any phenomenon known for waves should have the reciprocal phenomena for what is considered so far particles. Some of such phenomena are already known and others to be discovered. More examples are in the Table:

Phenomenon or property	Particle (say electron)	Wave (say light)
Classical mass	Obvious	Should be, but possibly very small
Diffraction, interference	De-Broglie wave	Obvious
Einstein first coefficient (spontaneous emission)	Decay of radioactive nucleus	Fluorescence
Einstein second coefficient (induced emission)	Ramsauer formula in nuclear physics, Neutron Enigma (hypothesis)	Lasers
Quantization of energy	Quantization of de-Broglie waves proposed	Planks idea, Einstein formula

Any more rows in this Table may be inserted with much more phenomena existing already and reciprocal ones predicted. Some new physics are to be found through such analysis.

<u>A.The phenomenon of extremely low energy resonance cathodoluminescence and extremely low energy resonance secondary electron emission is predicted.</u>

The easiest phenomenon which would be possible to predict has already an analog in nuclear

physics. This is Ramsauer Model for cross-sections of different events (like nuclear fission) [2]. According to this result, the smaller the energy of neutron, the better his chances to start fission, what is consistent with the quantum mechanics idea of De Broglie wave around the neutron. A similar contrary to usual sense behavior is observed in Ramsauer-Townsend effect - at certain low energy of electron the gas in the chamber becomes transparent (the De Broglie wavelength is around the mean free path for electrons). For future use the ultracold neutrons with De Broglie wavelength of 10 A are supposed to be generated in new sources [3]. So the idea of finding a phenomena, reciprocal to phenomena well known for light but being applied to matter wave considered as the main part of the wave-matter particle is appealing.
Some research groups are already observing for matter waves the phenomena, exactly like those previously described for light. For example, the rotation of particle beams in space without external fields was described in [4]. Authors correctly described the behavior as impossible from classical point of view for electrons (particles), easily observed for photons (wave) and now observed for electrons but created by the De Broglie part of electrons (wave part of the matter). This phenomena confirms the reciprocity idea: the phenomenon exists for pure waves (photons), thus it must exist for matter waves (in the case the wave part of the particle is essential, as for the case of ultra slow electrons [4])
The unusual example of the appearance of the wave properties of the particles (electron) would be observation of the cathodoluminescence in some compounds for extremely low energies of electrons (1-3 eV). Usually the cathodoluminescence is easily observed and important phenomenon for energies of few kV. At this region the electron is working essentially as a particle only and simply creating excitation through hit of particle. But for usual light the luminescence is easily observed for energies of few eV - because they are waves, and it is resonant – very strongly depends upon the energy. Even despite charge interactions, if the electron is working as a wave (reciprocity principle), the resonances may be predicted for very low energy electrons in the range 1-3 eV. The idea is that electron in this region has the essential wave admixture. Despite the De Broglie wavelength is still much smaller compare to light with this energy, it may be enough to be absorbed as a wave, not interact as a particle. In this situation the sharp in energy resonance is expected for the electron created luminescence due to the interaction of electron as wave, not as a particle.

Another phenomenon to be predicted is the secondary emission of electron by the primary electron (ionization generated by the electron, not by light). In this case the formula similar to Einstein formula for photoionization may be predicted:

$m*v^2/2=E-I$

here m is the mass of the electron, v is the velocity of it, E is the total energy of the electron (would be hν for photons), I is the ionization potential. Quantization rule for De-Broglie waves is different from photons, it would be E=hν/2 for slow non-relativistic electron and E=hν for ultra-relativistic electron, discussion of De-Broglie waves quantization is in another chapter. The idea is the same – at the moment of the photoionization the electron works as a pure wave, thus creating a resonant phenomena (ionization potential will be slightly different from photon case because of electron-electron repulsion).

B.Neutron enigma and Einstein's second coefficient: may the smaller lifetime of ultra-cold neutrons be explained by the induced decay (similar to fission process and lasers)?

Modern physics is quickly developing the unified theory of wave-particle mathematical formalism. While the exact equations, which would describe in one limit the particle (pure mass, Newton-Einstein mechanic) and in another limit the pure wave (Maxwell equation) are far from completion, the preliminary use of such concept may allow to explain some modern phenomena and predict new.

The idea is: any matter is neither particle nor wave but both. It means that it has two intrinsic parts: matter and wave, considered for some approximation as a sum. The closest modern approach would be consider De-Broglie wave as material and consider any particle as consisted of two parts: usual particle (inertial mass) and De-Broglie wave. In this case the photon must have a finite (despite enormously small) mass and any moving particle has the added energy associated with dragging De-Broglie wave. Photon is almost pure De-Broglie wave and stopped classical particle (neutron) is almost pure particle. However, even the highest energy gamma-quantum has some finite mass inside and even ultra-cold neutron has some energy associated with De-Broglie wave - the matter and wave are inseparable in principle.

In this case the idea of reciprocity of physical phenomena may appear: each phenomena for particles has the similar phenomena for waves and vice versa. Photon - almost pure wave - has Einstein's first and second coefficients associated with him. Any particle like neutron must have reciprocal coefficients associated with De-Broglie part of particle. First coefficient A is responsible for spontaneous decay of excited atom and the corresponding coefficient is simply spontaneous decay of neutron. Einstein's second coefficient is responsible for induced decay of excited atom (lasers) and the corresponding second coefficient for neutron would be the induced decay of excited nucleus (another neutron).

It is interesting that such idea is already applied to fission process, where the energy dependence of the cross-section of fission induced by neutron has in excellent agreement with squared De-Broglie wavelength (at least at lower energies and without consideration of resonances). From the wave-particle unification point of view the fission process is laser like process but for nuclei. It may be even possible that in fission the created neutrons have exactly the same De-Broglie wave as the initial neutron, but since in neutrons contrary to photons the De-Broglie part of matter is small, the neutrons as a whole are not looking exactly coherent as created photons in laser. The matter part of neutrons is obviously not synchronized and de-coherent. And the cross-section of both processes is governed by the similar equations:

Ramsauer model for fission: $\sigma(E) \sim \pi(R+\lambda)^2 \sim \lambda^2$ for small energies

Einstein's second coefficient:

$\sigma_{21}=A_{21}*g(\lambda)*(\lambda^2)/(8\pi*n^2)$

In both cases the cross-section is proportional to λ^2

For the case of neutron enigma it means that the effect of deviation of lifetime for neutrons would be even more pronounced in the case of ultra-ultra cold neutrons and it will also strongly depend upon the concentration of neutrons (very much like for efficient nuclear explosion the critical mass is necessary or critical density).

Hopefully the future experiments concerning the neutron enigma will involve more and more slow neutrons and this predicted effect will be observed.

Einstein's second coefficient was derived using perturbation theory by Dirak

Most probably exactly the same formalism may lead to the derivation of the cross-section in the case of fission process and for neutron enigma, assuming the De-Broglie wave is considered instead of photons as in the article.

That does not mean that the De-Broglie wave may be treated separately as a similar to photons (see the beginning of the blog). The idea is that particle is a sum of De-Broglie wave and particle is a very rough approximation. The real mathematical description of such matter-wave object is absent now. However, even the simplistic treatment of the particle as a sum of matter and wave may help to establish the reciprocal phenomena for both particles and waves (like the idea of existence of Einstein's second coefficient for the particles).

From the modern science perspective the dual behavior may be considered as tunneling between two states: the particle is tunneling into and out of wave all the time, so it is possible to see interference of matter waves, but the particle has a mass and behave like particle in many situation. Possibly in very old time immediately after Big Bang all the particles were pure waves, than the Higgs mechanism created mass, but the particle does not “forget” completely the initial state – it tunnels in and out of it all the time.

<u>C. Non-zero rest mass for photon – the known direction of search for new physics.</u>

On the other side of the reciprocity principle the typical wave like photon not only absorbed as particle (Einstein) but should have non-zero rest mass. This is of course not new idea and the search for new physics in this direction is underway. The most known approach is Proca equations for massive spin 1 particle (massive photon) [6]. The most famous experiment for the evaluation of the rest mass of photon is the experiment on checking the presence of the electric field inside the metal sphere (must be exactly zero according to Maxwell **first** equation and non-zero from massive photon modification of Maxwell first equation).

The problem with the most sensitive to the rest mass of photon experiment is here: it is actually testing the modification of only one equation of the Maxwell equation. Proca equations implement the mass of photon into every equation, and thus check for the validity of first equation means that the whole set of Proca equations is rejected. But the dynamic properties of light (photon, not static distribution of the electric field) actually are derived from **third and fourth** Maxwell equations only (no need for first or second equation). Thus the most sensitive experiment is not checking actually the rest mass of photon (dynamic structure), but rather it is checking the static structure for electric field (and actually checking the exactness of the three dimensionality of the local world). It is possible to speculate that other set of equations, not Proca equations would be exactly like Maxwell equations for first equation (thus confirming the static behavior of field) but implementing rest mass for photon in third and fourth equations (thus creating the solution for the wave with non-zero rest mass).

The direct check for the rest mass of photon (dynamic entity) comes from the known and continuing experiments in the observation of the delay time difference for the arrival of the photons with different energies, originated at the same event [7]. In this case the photon is considered as ultrarelativistic particle with some extremely small rest mass m_o. From the Einstein equation for energy for such particle:

$E=m_oc^2/[1-(v/c)^2]^{1/2}$

It is possible to see, that for more energetic photon the velocity should be a little bit closer to c, not reaching it, thus for the very long intergalactic travel for two photons with different frequencies the time delay may become measurable. It also means that c is not actually speed of light, rather Lorentz speed, impossible to reach by any entity, **including** photon.

The dispersion of the signal originated at radio frequencies has some limitations in this case: the radio wave may be delayed by non-zero refraction coefficient on this frequencies due to limited amount of free electrons in the space, effectively dispersing radio waves. More convenient is observation of gamma quanta with different energies but originated at the same event using Earth orbiting space telescopes. Recent observation [8] of such gamma-quanta arrival time shift may help to evaluate the rest mass of photon. Assuming the observed time difference was 1 second between the gamma quantum with energy of 8 MeV and gamma quantum with energy of 0.2 MeV, the rest mass of photon may be evaluated as follows:

$E_1=m_oc^2/[1-(v_1/c)^2]^{1/2}$ $\qquad$ $E_2=m_oc^2/[1-(v_2/c)^2]^{1/2}$

Here v_1 is the velocity of gamma quantum with higher energy, v_2 is the velocity of the gamma quantum with lower energy, $E_1=40*E_2$

Therefore:

$m_oc^2/[1-(v_1/c)^2]^{1/2}=40*m_oc^2/[1-(v_2/c)^2]^{1/2}$

$[1-(v_1/c)^2]^{1/2}=(1/40)*[1-(v_2/c)^2]^{1/2}$

$1-(v_1/c)^2=(1/1600)*(1-(v_2/c)^2)$

$(c^2-v_1^2)/c^2=(1/1600)*(c^2-v_2^2)/c^2$

$(c^2-v_1^2)*1600=(c^2-v_2^2)$

$(c-v_1)*(c+v_1)*1600=(c-v_2)*(c+v_2)$

Because both v_1 and v_2 are very close to c, both $c+v_1$ and $c+v_2$ are actually equals to 2c. Therefore:

$(c-v_1)*1600=(c-v_2)$

Defying $\Delta v_1=c-v_1$ and $\Delta v_2=c-v_2$ we got: $\Delta v_2=1600*\Delta v_1$

Time delay for the massive photon compare to Lorentz speed c for the distance of travel L:

$\Delta t=L/c-L/(c-\Delta v)=[L*(c-\Delta v)-L*c]/[(c-\Delta v)*c]=-L*\Delta v/c^2$

(because Δv is so small compare to c, $(c-\Delta v)*c=c^2$)

The time difference between arrival of the fast photon and slow photon is:

$\delta t=\Delta t_1-\Delta t_2=-L*\Delta v_1/c^2 +L*\Delta v_2/c^2=(\Delta v_2-\Delta v_1)*L/c^2=1599*\Delta v_1*L/c^2$

From data of [8]: $\delta t=1$ sec, L=7.3 billions of light years ($6.9*10^{25}$ meters) and $\Delta v_1=8.2*10^{-13}$ m/c

For the gamma quantum with energy of 8 MeV=$1.28*10^{-12}$ Joules

$E_1=1.28*10^{-12}\ J=m_oc^2/[1-(v_1/c)^2]^{1/2}=m_oc^2/[c^2-v_1^2)/c^2]^{1/2}=m_oc^3/[(c-v_1)*(c+v_1)]^{1/2}$

Because v_1 is so close to c: $c+v_1=2c$

$m_o=[E_1/c^3]*[\Delta v_1*2c]^{1/2}=10^{-39}$ kg (10^{-9} of mass of electron)

This way of evaluation of the rest mass of the photon (constraining the mass of the photon), using the observed gamma-ray bursts is discussed in many papers [9] and yields the rest mass of photon around 10^{-48} kg – many orders below what is shown above. However, it is clear that the more accurate specifically designed experiments are necessary for final determination of rest mass of the photon (or final rejection of the whole idea of the photon being an ordinary particle with non-zero rest mass, like neutrino, merely always observed in ultra-relativistic conditions).

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Chapter 2. Dark matter new ideas. Weak equivalence principle check for non-barionic matter. Gravity enhancing field hypothesis.

Weak equivalence principle and slow light.

In the foundation of many fundamental grativational problems (both Newton and Einstein) the weak equivalence principle is situated: the inertial mass is exactly equal to the gravitational mass. It was confirmed many times with enormous precision for the usual, barionic matter (all the matter that has non-zero rest mass). But the other type of matter, the usual non-barionic matter is also well known: this is light. Photons do deviate in the gravitational field (one of the proofs of the Einstein general theory of relativity) and they do have gravitational mass. They do not have rest mass, but they have an effective mass determined from $E=mc^2$ rule, which is considered to be equal to gravitational mass (thus extending the weak equivalence principle onto the usual non-barionic matter).

While deviation of light by gravitation in vacuum seems to confirm this weak equivalence principle for light in vacuum, it was never checked in highly refracting medium (slow light). Why it may be important? The usual most common barionic matter in the Universe is hydrogen, helium and cold planets, where the amount of light inside is negligible. But what about stars? They are generating light (phonons in all energy bands) and inevitably have a lot of light trapped inside. This light is generated but not yet left the star, so the star is essentially the mixture of barionic (hydrogen, helium) and non-barionic (temporarily trapped inside light). What is even more important, in the plasma of the sun interior the effective refraction coefficient should be enormous (at least for light in visible and UV and soft X-ray regions, below the plasma frequency), the light should be very slow light. What are the gravitational properties of such slow light? Some scientists are sure it will be gravitating much stronger compare to the usual light propagating in vacuum [1,2]. What if the amount of this slow light inside the star is huge? In such system (barionic matter plus non-barionic) matter the total gravitation may start deviate perceptibly from the allowed by inertial mass (because the inertial mass of the photon will stay intact due to energy conservation law). How to check the weak equivalence principle for the system consisting of both barionic and non-barionic matter? May be the effect of this added gravity is so strong that it may explain the dark matter?

A. Derivation of the formula for gravitation of slow light

Light is bended by the gravity - this is very old phenomenon, once confirmed the general theory of relativity. The Einstein formula for the light bending is:
$\Upsilon=4*G*M/(r*c^2)$
where ϒ is the angle of the deviation of the light near the star, M is the mass of star, G is gravitational constant, c is speed of light and r is the shortest distance between the light and star.
From this formula it follows that the light, being traveled near the star, influences the star, too, transferring part of its pulse to star. While for passing light this is truly negligible, what about the light trapped inside the star itself? It is well known fact, that the gamma quantum

generated during the fusion in the Suns core, will spend millions of years till it is emitted by the Sun. During all this time the quantum of the light will be subject of the gravitational pull of other stars (Galaxy in general to explain the additional force added to the usual gravity which may help to explain dark matter partially). This force means that some kind of gravitational mass equivalent is added to the star. According to the energy conservation law the amount of inertial mass of the star does not change at such process: part of the rest mass is transferred into the radiation during fusion, but the total energy should be preserved, so the trapped photons will have the inertial mass according to mc^2 rule.
The evaluation of the importance of such additional force from the photons back onto the barionic matter may be done as follows:
For the formal consideration (just to have the formula) the photon is treated as having mass m. Then deviation of the light near the star would be:
$V_p=a*t$, $a=F/m$, $F=G*m*M_s/(r^2) \rightarrow a=G*M_s/(r^2)$
here V_p is the perpendicular component of the velocity of the photon of formal mass m, t is time of flight near the star, a is the formal acceleration of the photon of formal mass m, M_s is the mass of the star, G is gravitational constant, r is the effective distance between the star and the photon, t is the effective time of flight of the photon near the star. Knowing the values of the acceleration and time it would be possible to evaluate the perpendicular component of velocity:

$V_p=G*M_s*t/(r^2)$

Evaluation of the time of flight will lead to "classical" formula for the deviation angle:
$t=2r/c$ and
$\Upsilon=V_p/c=G*M_s*2r/(r^2*c^2)=2G*M_s/(r*c^2)$

which is exactly 2 times smaller than the Einstein results (Einstein results confirmed the general theory of relativity).

The same formal approach may be used to evaluate the influence of the galactic pull onto the all the photons inside the star (multiplying later the result by 2 to account to general theory of relativity).
The photons generated inside the star during the fusion are not leaving it immediately but essentially trapped inside for millions of years. During all this time all the numerous trapped photons are generating the pull toward the center of galaxy, which may be estimated as follows:
Using the same formal approach the formal "force" onto the photon is:

$F=G*m*M/(r^2)$

Here G is gravitational constant, M is the effective mass of the Galaxy, r is the distance between the photon and the Galaxy center, m is the formal "mass" of the photon (the idea of such approach is that since it allows to obtain Einstein formula with accuracy of factor 2, it will allow to evaluate this pull with the same accuracy - later final formula to be multiplied by 2).
The force on the photon toward the center of Galaxy:

$F=ma$, $a=G*M/(r^2)$, $V_p=at=G*M*\Delta t/(r^2)$

Here F is the force onto the photon toward the center of Galaxy, a is the acceleration created by such force, Vp is the perpendicular component of the velocity the photon obtained during the time Δt of its stay inside the star.

What would be the change of pulse of the photon during such stay? It may be evaluated assuming the velocity of the photon equals to c/(n), where n is the effective refraction coefficient for the light in the star medium (since the interior of star is enormously dense and hot plasma, this value is not 1)

The change of pulse of photon is:

$\Delta p=V_p*n*P/c$

here Δp is the change of pulse of photon, P is the total pulse of photon, Vp is the obtained perpendicular component of the velocity, c/n is the velocity of light inside the star. The obtained velocity Vp is considered very small compare to the initial velocity - despite million of years, the photon inside the star is moving as a photon only for small time periods - it is absorbed and re-emit almost instantly. Using the formula for Vp it is possible to obtain:

$\Delta p=G*M*\Delta t*n*P/(r^2*c)$

where Δp is the full change of pulse during time period Δt, G is the gravitational constant, M is the mass of Galaxy, n is the effective refraction coefficient, P is the full pulse of the photon, r is the distance from the star to the Galaxy center, c is speed of light.

But Δp/Δt is the effective force (toward the center of the Galaxy) expressed through change of pulse of photon during time Δt. For one photon:

$F=\Delta p/\Delta t=G*M*P*n/(r^2*c)$ Here F is the pull onto the photon toward the center of the Galaxy, M is the effective mass of the Galaxy P is the pulse of the photon, n is the effective refraction coefficient, c is speed of light, G is the gravitational constant, r is the distance from the star to the center of Galaxy.

The pulse of photon is P=n*E/c for the refracted light (Minkowski formula [3]) and:

$F=\Delta p/\Delta t=G*M*e*(n)^2/(r^2*c^2)$

Where e is the energy of one photon. For the total force exhibited by all the photons this force would be:

$F=\Delta p/\Delta t=G*M*E*(n)^2/(r^2*c^2)$

Where E is the total energy of the photons inside the star. Now it is possible to calculate the ratio of this force to the gravitational force exhibited by the star (as derived from weak equivalence principle E=mc*c). The gravitational force

$F_g=G*M_s*M/(r^2)$ where G is gravitational constant, Ms is the mass of star, M is the mass of Galaxy, r is the distance between the star and Galaxy. The ratio of those forces

is:

$F/F_g=E*(n)^2/(M_s*c^2)$

Adding multiple 2 from Einstein's formula:

$$\mathbf{F/F_g=2*E*(n)^2/(M_s*c^2)} \qquad \text{(A)}$$

Here F is the force created by the light trapped inside the star (light is generated but not yet left the star, so it is feeling the force from other stars as a non-barionic matter), F_g is classical gravitational force (weak gravity approximation), E is the total energy of the light inside the star, M_s is the total inertial mass for barionic matter, n is the effective refraction coefficient for the light inside the star. It is necessary to note that even for n=1 (vacuum) light is gravitating twice stronger compare to barionic matter per energy (this conclusion is already noticed by many researchers and is a direct consequence of the general theory of relativity). So strictly speaking from Einstein equations directly follows that the equivalence principle for stars is not valid (the problem is that the amount of light trapped inside is so small, that this deviation from weak equivalence principle is not possible to notice at modern accuracy of measurements).

That was the derivation of the gravitation of the light for the photons which are travelled in the directions perpendicular to the direction star – center of galaxy or star to another star. But what about the photons which are traveled exactly in the direction toward the center of galaxy or another star. As it follows from the Einstein's general relativity, in this situation the photon should pick up energy (blue shift), assuming the energy pick up or energy loss from the gravitation toward the center of the star itself is compensated each other for the photons on different sides of the star. Indeed, the attraction of the photon toward the core of the star itself would be much-much larger compare to the gravitational force of the very distance star or galaxy center, but it is always possible to imagine two photons on the opposite sides of the star, for one of them this energy is gained and for the second is lost. Of course the possible implication of the stronger gravitation of the slow light would have the largest influence on the star itself, effectively compressing it in addition to usual gravitation, but this is not to be discussed here (and as it will be shown below, the already available astronomical data demonstrated that the accelerated gravity of the slow light, if present, is small enough not to be seen with present accuracy, for example, definetly well below the necessary for dark matter values).

For the photon traveling in the direction exactly along the gravitational attraction line the logic is as follows. One of the achievements of Einstein was introduction of the metric for finite maximum speed. If the Euclidean metric tensor is Kroneker tensor:

$$\begin{matrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{matrix}$$

In Minkowski metric the space-time interval is preserved during the change of the observer frame:

$x^2+y^2+z^2+(ict)^2=Const$

Here c is the maximum achievable speed, speed of light **in vacuum**. The metric would be for this space-time:

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

and for Schwarzchild metric:

$ds^2=-[1-2GM/(rc^2)]c^2dt^2 + [1-2GM/(rc^2)]^{-1}dr^2 + r^2d\Omega^2$

If somebody considers the maximum speed of v instead of c (v<c), the metric would be:

$ds^2=-[1-2GM/(rc^2)]c^2dt^2 + [1-2GM/(rc^2)]^{-1}dr^2 + r^2d\Omega^2$

But light **inside the strongly refractive medium** has speed v=c/n and then the energy shift for this particular light in the gravitating medium would be:

$Z=GM/(v^2R)$

(this is because for the refracting light not for particles the metric now is different. Particles may travel faster than v, generating Cherenkov radiation, and for high energy photons which travel with velocity close to c this metric is not applicable too, but it is suitable for the photons of lower energy which travel **in the medium** with speed v possibly well below c)

The corresponding Pound-Rebka formula[10] would be:

$$f_r=f_e\sqrt{[1-\frac{2GM}{(R+h)v*v}]/[1-\frac{2GM}{Rv*v}]}$$

Here f_e is the frequency of the emitted slow photon somewhere inside the star f_r is the frequency of the photon after gravitating over the distance h toward the body of mass M (galaxy center or another star) placed at the distance R away from the star the photon appeared (obviously R>>h, because h is at most diameter of star and R is the distance between stars), v is the maximum velocity in this metric (coincides with the velocity of this photon, it is frequency dependent and for gamma-quanta is c). Because the distance R is so large the formula may be simplified:

$f_r-f_e=f_e*GMh/(R^2v^2)$

The change of the energy for the slow photon moving distance h toward galaxy center or another star due to the gravity of this galaxy or another star :

$\Delta E=h(_{plank})f_r-h(_{plank})f_e=h(_{plank})f_e*GMh/(R^2v^2)$

Here ΔE is the change of energy of the photon, $h(_{plank})$ is Plank's constant.

The distance traveled is h=v*Δt, Δt is time of existence of the photon between the emission and adsorbtion, change of pulse of photon is Δp=ΔE/v (compare to usual formula E=pc, in this situation the velocity of the photon is v not c). Then for change of pulse during existing of photon:

$\Delta p=\Delta E/v=[h_{(plank)}*f_e/v]*[GM*v*\Delta t/(R^2*v^2)]$

But the definition of the force is $F=\Delta p/\Delta t$ – change of pulse during the time Δt, and the gravitating photon created the gravitational force at absorbtion after being traveled distance h inside the star with the speed v instead of c:

$F=\Delta p/\Delta t=[h_{(plank)}*f_e]*GM/(R^2v^2)$

But for effective refraction coefficient n the velocity of photon v=c/n and:

$F=[h_{(plank)}*f_e]*GM*n^2/(R^2c^2)$

When the photon is generated inside the refractive medium it is energy is the same as in the vacuum (blue photon is blue photon whether it is inside glass or in the vacuum). The effective inertial mass of the photon would be determined by the same formula as it follows from energy conservation law: $E=mc^2$ (during the thermonuclear synthesis part of the inertial mass of the particles is converted into photons, and at re-adsorption the same energy is converted back into the usual barionic **inertial** (not gravitational) mass). Thus the photon inside the star has the effective inertial mass m determined from the formula: $m=[h_{(plank)}*f_e]/c^2$ and formula for gravitation of the slow light in the direction of the center of galaxy or another star compare to the gravitation of the equivalent inertial mass m:

$F/F_g=\{[h_{(plank)}*f_e]*GM*n^2/(R^2c^2)\} /[GMm/R^2]= [h_{(plank)}*f_e]*n^2/(mc^2)=\mathbf{E*n^2/(mc^2)}$ (B)

Because for photon has the energy $E=[h_{(plank)}*f_e]$, the formula (B) is essentially identical to (A) except for coefficient 2. From author perspective it should be added in the same way as it was added in formula (A) but author is not sure. Anyway the value n^2 for slow light should be much higher compare to 2.

The value of additional slow light created gravitational force may be somehow estimated using the data for Sun. Mass of the Sun is $2*10^{30}$ kg, energy release is $3.9*10^{26}$ Watt and assuming photons are trapped inside for 10 millions years ($3.15*10^{14}$ s) the ratio would be:

$F/F_g=(n)^2*1.4*10^{-6}$

which is very small if n=1. However, the star matter is relative not investigated and the effective refraction coefficient may be very high (in metals, for example it is supposed to be infinity). Essentially the light inside the Sun may be traveling very slow. If in the highly conductive full ionized plasma value of n is 100, the added force may jump to 1.4 % and become noticable Still there is no additional gravitational pull for the Sun, which lives for billion of years. The dark matter however usually associated with the presence of young stars in the sleeves of Galaxy. For the star with the big initial mass the life time may be just 10 millions of years. It means that such star will emit the equivalent of 10^{-7} of its mass per year as radiation and if the photons are still trapped inside for one million of years, 10% of the total energy of star is in the light form now. That means that the ratio of forces now is $0.1*2*n^2$ (what for effective value of n=10 corresponds to additional force 20 times larger compare to classical gravitational force!). That means that for the star of larger mass the pull toward the center of Galaxy, associated with the light matter may be many times larger than the gravitational pull from the ordinary matter. But this trapped light still makes contribution to inertial mass E=m*c*c (according to weak equivalence principle), which would mean that it will be rotating faster compare to pure barionic mass body like planet. This may explain the dark matter, at least partially.

Another implication of the idea of difference of gravitation of particle versus gravitation of the wave is for the tunneled particle. In a broad sense this idea is in today track of unification of matter and wave behavior. In addition to being full with trapped for long time quanta (pure wave), inside the star the process of tunneling of baryonic particles takes place (during the fusion). However, during the tunneling the baryonic particle is pure wave (the energy is negative, what is inconsistent with particle). Thus inside the star more energy is in wave form and waves are attracted gravitationally differently, so the overall star may have larger than possible orbital speed without presence of dark matter. More experimentation with plasma in fusion reactors may be necessary to understand the behavior of stars.

B. <u>Binary stars of different types may be used for the verification of the equivalence principle for non-barionic matter</u>

But how can we check the weak equivalence principle for non-barionic matter in the case of slow light? Should we perform experiments proposed in [1,2]? Possibly and this would be the fastest way to find something in new physics (authors in [1,2] are proposing this way). However, if the gravity of slow light is so enhanced, and there is so much of such light inside the stars, it should be already visible in the astronomic data. Especially interesting to check whether this phenomena may be responsible for dark matter. Author checked the idea using data on mass-luminosity curves for binary stars [4-6].

<u>B1. Visual binaries: the trajectory is fully resolved and the masses are determined from third Kepler Law.</u>

The way the stars in Galaxy are weighted relies heavily on the weak equivalence principle (Third Kepler Law). This law was verified in Solar System for baryonic matter – the planets and satellites rotating around the Sun. No deviations from this law was found (assuming the General Relativity corrections). However, the Sun has a lot of non-baryonic matter inside (the photons are trapped inside for millions of years, slowly progressing toward the surface). The gravitation properties of such non-baryonic matter were never carefully investigated: unfortunately the Sun is not a binary star and gravitational attraction of two stars in the solar system was never checked. Observations of visual binaries may help to check the validity of the third Kepler law for stars motion. Since stars are special objects in the sense of the possible gravitational deviations: they have both baryonic and non-baryonic matter (like trapped and slowly advancing to the surface light) inside, check of any violations of the third Kepler law for stars may help to check the weak equivalence principle for non-barionic matter.

There are many binary stars which are visible as double stars with resolved period and axis and ratio of inertial masses (through measurements of the velocities of stars). Many parameters of such stars are published in old article [7]

The usual formula applied to the stars from the third Kepler Law:

$T^2=4\pi^2*a^3/[G(m_1+m_2)]$ (1)

Here T is the period of rotation of one star around the second one, a is semi-axis, m_1 and m_2 are masses of the stars (assuming gravitational mass is equal to inertial mass) and G is gravitational constant.

However, the light theoretically may have much higher gravitational pull compare to the inertial mass from E=mc*c relation (it is assumed that the inertial mass of light being emitted and reabsorbed inside star is still according to E=mc*c, as it was proved by Einstein himself). The presence of slow light may modify the gravitational pull, making it much stronger for the star which has more trapped light (and other non-baryonic matter). While the exact amount of trapped light is difficult to calculate (not much is known about the light content of the interior of fully ionized plasma), it is obvious that this amount is correlated with luminosity of the star - the higher the luminosity, the higher the amount of trapped light and the higher the additional gravitational pull on the star (the higher the deviation between the gravitational and inertial mass).

In the derivation of the formula (1) the gravitational masses are always comes as a product [9]:

$F=G*M_1*M_2/r^2$

Here M_1 and M_2 are gravitational masses. Assuming the added due to light inside the stars pull is proportional to luminosity which is proportional to mass (whether gravitational or inertial) [1], it is possible to assume:

$F=G*K_1*K_2*m_1*m_2/r^2$

Here K_1 and K_2 are multiplicity coefficients, the value of K may be especially high to ultra-bright star. It is important that both coefficients for binaries are always a product.

The modified third Kepler Law:

$T^2=4\pi^2*a^3/[G*K_1*K_2*(m_1+m_2)]$

Here m_1 and m_2 are inertial masses. When $K_1=K_2=1$, the third Kepler Law for baryonic matter is obtained.

To determine the masses from the observation of binaries we need: T, a (semi-axis), and ratio of masses $m_1/m_2=n$. Since the ratio of masses is determined through the Doppler shift of spectra of stars, it is a ratio of inertial masses (the inertial mass determines the acceleration in the Newton equations, the gravitational mass determines the attraction between stars). We have two equations for masses m_1, m_2:

$G*K_1*K_2*(m_1+m_2)=4\pi^2*a^3/T^2$

$m_1/m_2=n$

Then:

$m_2=4\pi^2*a^3/[G*T^2*K_1*K_2*(n+1)]$

$m_1=4\pi^2*a^3*n/[G*T^2*K_1*K_2*(n+1)]$

Suppose we decided to determine the inertial masses from the visual binaries with two distinct masses $m_1>>m_2$. How it would influence the mass-luminosity correlation (like in [1])?

It is possible to show, that contrary to the case of valid third Kepler Law the slope of the dependence will be depended upon the ratio of inertial masses!

Lets consider three cases (assuming $m_1>>m_2$):

1.Binary m_1 and m_1

2.Binary m_2 and m_2

3.Binary m_1 and m_2

In the first case the value of m1 is (because n=1)

$m_1=m_1(old)/[K_1*K_1]$, here $m_1(old)=4\pi^2*a^3/[G*T^2*2]$

Here $m_1(old)$ is real inertial mass. K_1 is large and the value of m_1 is shifted strongly toward **smaller mass** compare to real inertial mass (now due to the hypothetical presence of the slow light the gravitational "mass" is not equal to inertial mass).

In the second case the value of m_2 (n is equal to 1)

$m_2=m_2(old)/[K_2*K_2]$

If K_2 is smaller than 1 (supposedly Sun has the value of K exactly one) the mass of smaller star will shifted strongly toward **larger mass**

In the third case the value of m_1 is

$m_1=m_1(\text{old})/[K_1*K_2]$, $m_1(\text{old})=m_1(\text{old})=4\pi^2*a^3*n/[G*T^2*(n+1)]$

Since both coefficients K_1 and K_2 are here, one is small and one is big, the shift compare to the real inertial mass is smaller compare to the case of the equal masses (and if one star is larger than Sun and another is smaller it may be exactly absent, on average the slope does not change)

$m_2=m_2(\text{old})/[K_1*K_2]$

This idea may be immediately checked. If the mass-luminosity curve is plotted using first only stars with close masses, it will be compressed toward y-axis because of K_1*K_1 and K_2*K_2 coefficients along the x-axis (the slope will be larger). If the same curve is plotted using the stars with different masses (preferably with large difference, but I used what we have in [7]) the slope will be smaller. I manually chose approximately half of visual binaries (17 binaries or 34 stars) from Table 1A from [7] with close masses and obtained the relation between the luminosity and mass:

Absolute luminosity= -3.2119*ln(m)+5.1264

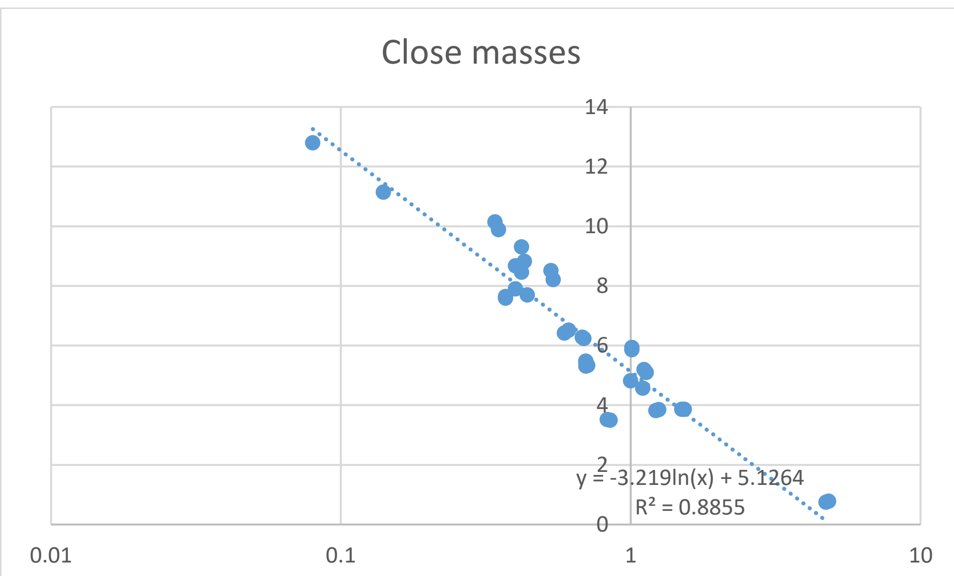


Fig 1. The mass-luminosity relation for close in mass stars (from visual binaries data, Table 1A from [7])

And for the rest of the binaries (21 binaries, 42 stars) - masses are different:

Absolute luminosity = -2.495*ln(m)+5.4042

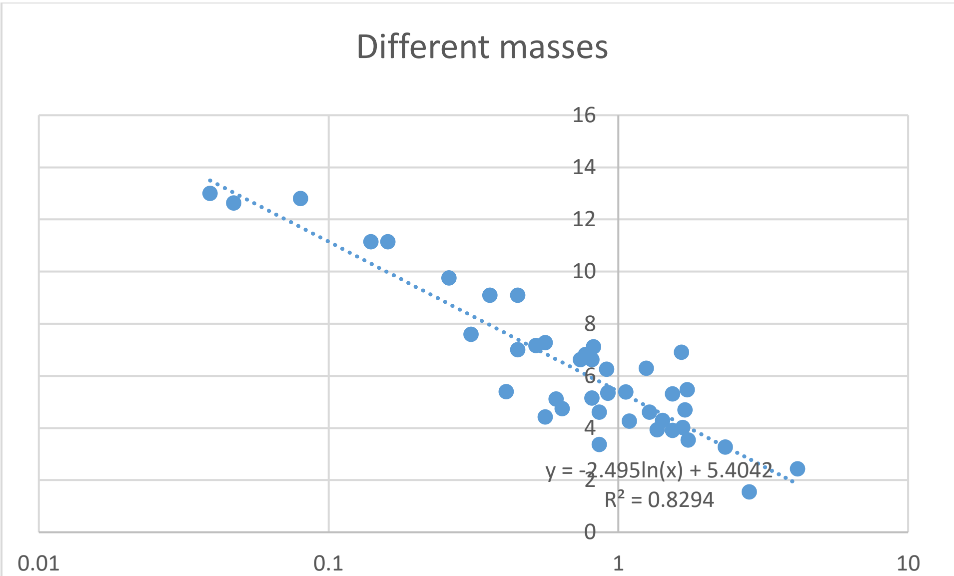


Fig 2. The mass-luminosity relation for different in mass stars (from visual binaries data, Table 1A from [7])

The white dwarfs were excluded, like in [7].

The scattering in the second case is much larger (as expected, because the product of coefficients K_1 and K_2 is highly unpredictable). Much less scattering should be if the coefficients are the same - the shift is larger, but it is more predictable - obviously it is some smooth function of luminosity and can not jump from star to star).

Indeed as predicted the slope is larger beyond any error for the subset of close in masses stars compare to the far in masses stars. Unfortunately the used dataset of visual binaries is rather limited and the publication is old (1972). So the newer data should be used.

<u>B2. Eclipsing spectroscopic binaries allows verification of the weak equivalence principle for non-barionic matter inside stars with accuracy of around 6% - enough to rule out this explanation of dark matter.</u>

If the observation of the difference in slopes would be true it would be especially strong for the ultra-bright stars (they live only few millions of years, but the amount of light trapped inside is also enormous compare to say Sun). In this case the mass-luminosity curve which has the big scattering for the small masses would have especially high scattering for the larger masses. But on the contrary for the large masses it is becoming very smooth. For the case of spectroscopic binaries the angle of the inclination of the orbit is unknown from the observation, but for the eclipsing spectroscopic binaries it is close to 90 degrees and all the parameters of the orbit may be found.

In this case the sum of masses is expressed through the velocities, measured as the Doppler shifts for the spectra of two stars observed as one. According to [9] the sum of masses is determined by the formula:

$m_1+m_2=[P/(2*\pi*G)]*[(V_1+V_2)^3/Sin^3(i)]$ (2)

here P is the period, V1, V2 are maximum velocities of the stars, and angle i is the inclination of the orbit with respect to the observers line of site. Ratio of masses is determined through the ratio of velocities: $m_1/m_2=V_2/V_1$

In the derivation of the formula (1) and (2) the gravitational masses are always comes as a product [9]:

$F=G*M_1*M_2/r^2$

Here M_1 and M_2 are gravitational masses. Now I am repeating the steps of showing how the brightness of the stars would influence the mass-luminosity curve. Assuming the added pull is proportional to luminosity which is proportional to mass (whether gravitational or inertial), it is possible to assume:

$F=G*K_1*K_2*m_1*m_2/r^2$

Here K_1 and K_2 are multiplicity coefficients, the value of K may be especially high to ultra-bright star (because due to very short life time the ultra- bright star should emit more light per second and as a consequence has more light "on hold", ready to be emitted but so far trapped inside). If weak equivalence principle hold, K=1. It is important that both coefficients for binaries are always a product.

The modified third Kepler Law:

$m_1+m_2=[P/(2*\pi*G*K_1*K_2)]*[(V_1+V_2)^3/Sin^3(i)]$

Here m_1 and m_2 are inertial masses. When $K_1=K_2=1$, the third Kepler Law for baryonic matter is obtained.

To determine the masses from the observation of visual binaries we need: period P, maximum velocities V_1, V_2, angle i, and ratio of masses $m_1/m_2=n$. Since the ratio of masses is determined through the Doppler shift of spectra of stars, it is a ratio of inertial masses. We have two equations for masses m_1, m_2

$m_1+m_2=[P/(2*\pi*G*K_1*K_2)]*[(V_1+V_2)^3/Sin^3(i)]$

$m_1/m_2=n$

Then:

$m_2=[P/(2*\pi*G*K_1*K_2)]*[(V_1+V_2)^3/Sin^3(i)]*[1/(n+1)]$

$m_1==[P*n/(2*\pi*G*K_1*K_2)]*[(V_1+V_2)^3/Sin^3(i)]*[n/(n+1)]$

Suppose we decided to determine the inertial masses from the visual binaries with two distinct masses $m_1>>m_2$ taken in different combinations. How it would influence the mass-luminosity correlation?

It is possible to show that for very strong effect (K is large) the slope of mass-luminosity curve will depend upon the choice of stars in pair (Kepler third law is not valid any more).

Lets consider three cases:

1.Binary m_1 and m_1

2.Binary m_2 and m_2

3.Binary m_1 and m_2

In the first case the value of m_1 is (because n=1)

$m_1=m_1(old)/[K_1*K_1]$, here $m_1(old)=[P/(2*\pi*G)]*[(V_1+V_2)^3/Sin^3(i)]*1/2$

Here m_1(old) is real inertial mass. K_1 is large and the value of m_1 is shifted strongly toward smaller mass compare to real inertial mass.

In the second case the value of m_2 (n is equal to 1)

$m_2=m_2(old)/[K_2*K_2]$

If K_2 is smaller (closer to 1) the mass of smaller star will be actually equal to inertial mass

In the third case the value of m_1 is

$m_1=m_1(old)/[K_1*K_2]$, $m_1(old)=[P/(2*\pi*G)]*[(V_1+V_2)^3/Sin^3(i)]*[n/(n+1)]$

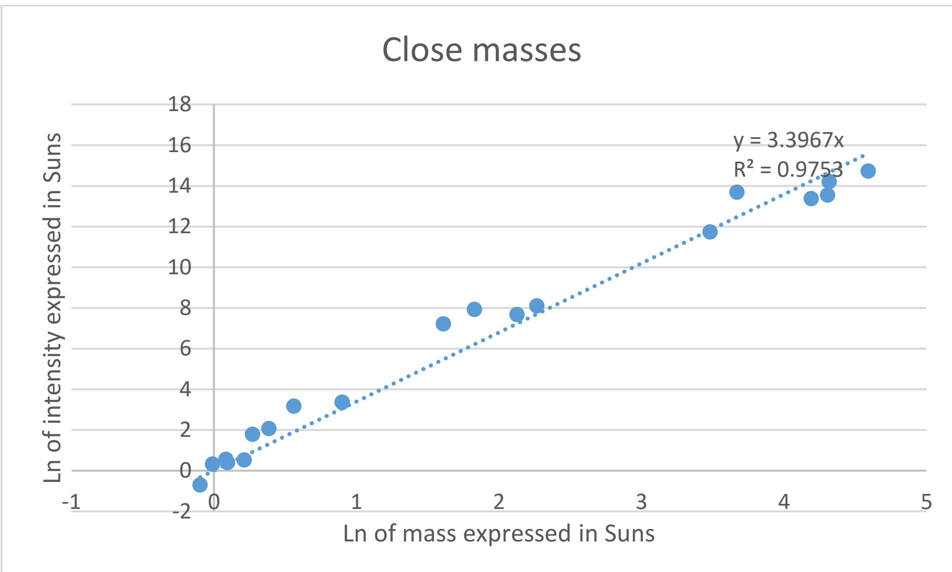
Since both coefficients K_1 and K_2 are here, one is small and one is big, the shift down compare to the real inertial mass is smaller compare to the case of the big equal masses.

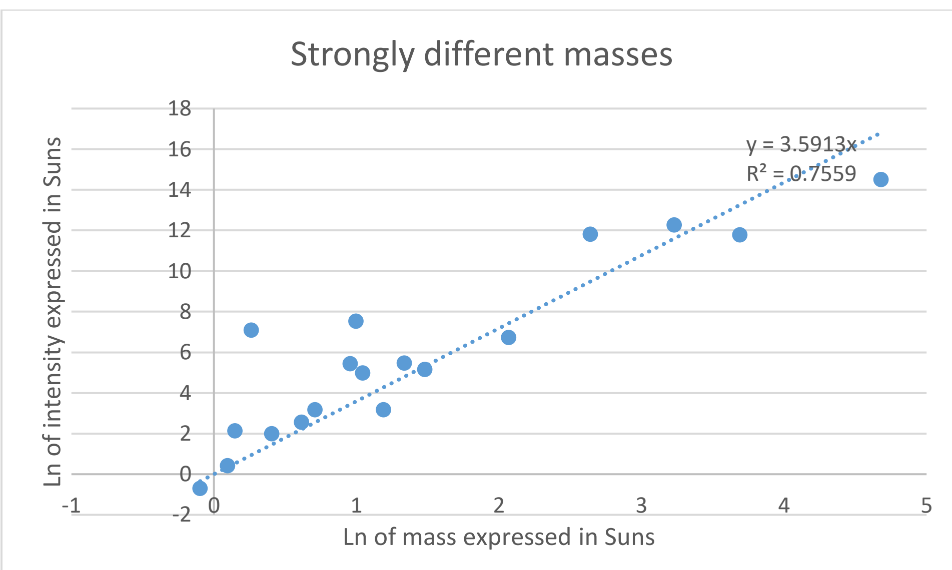
$m_2=m_2(old)/[K_1*K_2]$, $m_2(old)=[P/(2*\pi*G*K_1*K_2)]*[(V_1+V_2)^3/Sin^3(i)]*[1/(n+1)]$

This idea may be immediately checked. If the mass-luminosity curve is plotted using first only stars with close masses, it will be compressed toward y-axis because of K_1*K_1 and K_2*K_2 coefficients along the x-axis (the slope will be larger). If the same curve is plotted using the stars with different masses the slope will be smaller. In addition since the same stars now would be in pairs with different masses the scattering will be much larger (the same star like Sun in pair with another Sun-like star would give almost the inertial mass, but in pair with blue giant a much smaller mass, thus creating additional to the experimental error scattering). In [4] this idea was checked for visual binaries from publication, which is 70 years old. The results showed that indeed the slope for the mass-luminosity curve was higher for close masses.

The results were checked with the help of visual binaries using the modern data from Wikipedia. The slope for the close masses was higher again. However, the most prominent effect is expected for the ultra bright stars with masses 30-100 of Sun mass. For them the percentage of trapped light should be tens of thousands times more compare to Sun and smaller stars (because the total amount of light trapped inside is inversely correlated with life time of star and ultra bright stars are very short lived).

In this case the only way to verify the idea it to use data on spectroscopic binaries. For very important subset of spectroscopic binaries called eclipsing spectroscopic binaries both stars are eclipsing each other thus guarantee that the angle i is close to 90 degrees and that allowed determination of masses of such stars using the known astronometric data. I used binaries: 1 Persei, Theta 1 Orioni 3, Prismis 24-1, NGC 3603-A1, CD Crucis for the brightest stars with close masses and WR22, LY Aurigae, AO Cassiopei for the largest stars with different masses. For the smaller masses the stars from the visual binaries were used (except for stars smaller than Sun). The results are below:





With accuracy of 6% the slopes are the same. Intercept on both curves put on zero

The expected from the preliminary results [4] higher slope for the close masses is not confirmed for the ultra bright stars (where the effect should be the largest). While the weak equivalence principle still may be violated due to stronger gravitation of slow light (the observation error is rather large), the effect on rotation of Galaxy is negligible and by no means may be responsible for the explanation of large scale phenomena like dark matter.

One of the important consequence of this verification of the absence of sensitivity of the slope of mass-luminosity curve to the choice of stars: it also excludes all strong hypothetical effects on gravitation in any way associated with the processes inside the stars. For example, if gravitons are to be responsible for the dark matter, they would be generated mainly inside the stars (enormous turbulent flows gravitationally bend inside the star). Again, the brighter the star, the higher amount of gravitons being emitted would created deviation of the mass-luminosity curve for stars. Any other process of generating of the gravitating particles of unknown nature inside the stars may be excluded as explanation of dark matter (because it would be obviously dependent upon the intensity of the thermonuclear synthesis and on brightness of the star). The generation of photons is kind of marker of the generation of any particles inside the hot thermonuclear plasma both known like neutrinos and undiscovered yet like gravitons and something else. The more other particles is generated, the more photons are generated and thus any gravitational effect depended upon the intensity of the thermonuclear process would be instantly seen.

The accuracy of the results is low (say 6%), enough for exclusion of dark matter, but not enough for elimination of the process of the gravitation of slow light (it may be merely too small to be observed using present day accuracy). Because, as it follows from formulas (A), (B), the weak equivalence principle must be violated for the combination of barionic and non-barionic matter, merely the effect is so far beyond the grasp of experiment. Possibly the future more accurate results on binaries will allow to discover it (or completely reject the whole hypothesis). That seems where the new physics may appear.

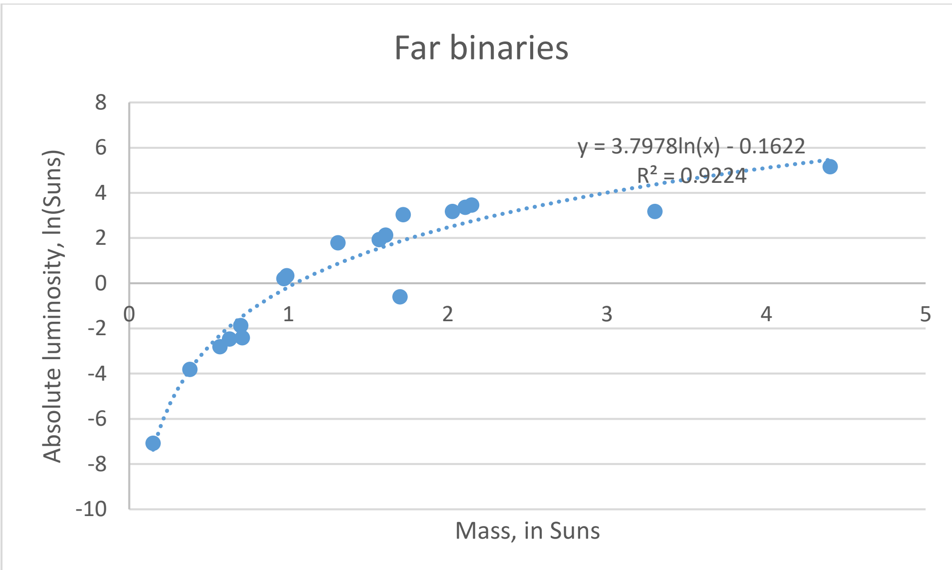
C. Further analysis of mass-luminosity curves: gravity enhancing field instead of dark matter or MOND. Search for new physics in this direction.

One of the unsolved problem of modern science is the observed deviations of the galaxy rotation curves from the predicted ones. The phenomenon is observed only on large scales and that is why it is so difficult to understand. At the same time such phenomenon is expected to reveal itself on all scales and all objects, including the simplest ones, where the gravity may be probed – binary star. Indeed, the simplest atom – hydrogen atom allowed to create quantum mechanics (including quantum electrodynamics due to Lamb shift) and from history of science perspective it is expected that the investigation of the simplest objects may lead to the most efficient theories. Hydrogen atom was especially simple binary system because both masses were quantized with high accuracy. Binary stars, of course, may have all the possible variations of masses of both stars, but still it is a simplest model object for applications of law of mechanics. Any deviation from simple Newton laws (Einstein modifications for close stars would be necessary) which is visible on galactic scale (dark matter problem) must reveal itself despite possibly in miniscule amounts on this simple objects.

The long and unsuccessful search for dark matter started to reveal different ideas. One of them is MOND, and at modified Newton gravity the binaries with high deviation between stars would start feel this deviation from Newton law and attract each other stronger [11].

In order to test the idea of the change of gravity law for the binaries as a function of separation between them I decided to go the same way as for the testing of the additional gravity created by photons [4,5]. That is, the mass-luminosity curve will have a different slope for the different subsets for binaries (subset of binaries with close luminosities versus subset binaries with different luminosities would reveal any additional force connected to the photons trapped inside the stars, for example). The comparison of subset of binaries with relatively far separation between star versus subset of binaries with small separation would reveal any deviation from Newton law as a function of distance.

I manually chose several visual binaries which are close to the Sun (the close the star, the better accuracy of all measurements) and plotted separately relatively close binaries versus relatively far binaries. (two eclipsing spectroscopic binaries were added to close binaries to have points with masses between 3 and 4 Suns)



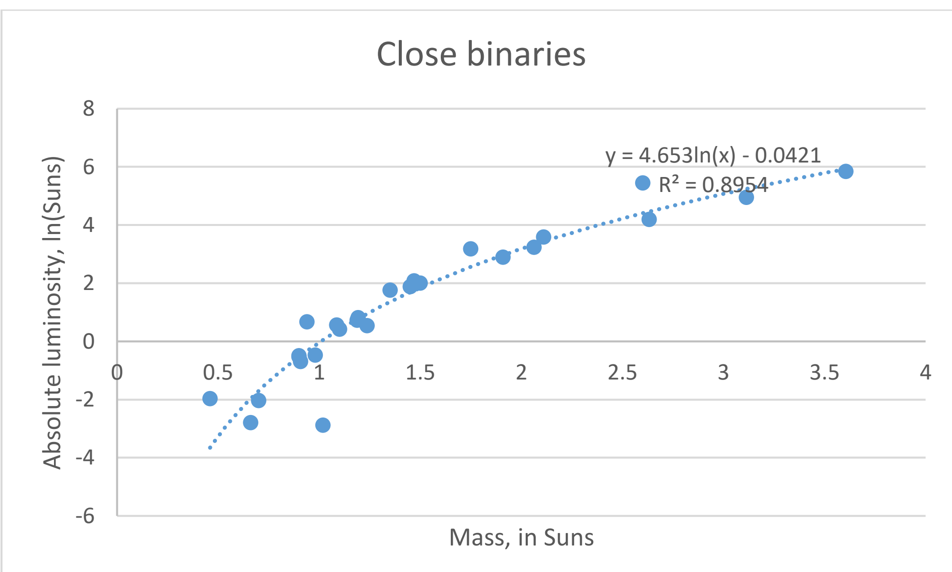


Fig 1. Mass-luminosity relation for binaries with relatively far semi-major axis (average~ $5.6*10^{-3}$ ly) and relatively small semi-major axis (average ~ $3.6*10^{-4}$ ly).

Table 1 Distant binaries.

Name of binary	Mass in Suns	Ln(Luminosity), Luminosity is in Suns
Andromeda Groombridge 34	0.38	-3.816
	0.15	-7.07
Eta Cassiopea	0.972	0.208
	0.57	-2.81
24 Comae Berenices	4.4	5.155
	3.3	3.173
61 Cygnus	0.7	-1.877
	0.63	-2.465
Mu Cignus	1.31	1.79
	0.99	0.34
Gamma Delphinus	1.57	1.93
	1.72	3.034
Epsilon Lirae 1	2.03	3.18
	1.61	2.13
Epsilon Lirae 2	2.11	3.367
	2.15	3.466
36 Ophiuchus	1.7	-0.6
	0.71	-2.41

Table 2 Close binaries.

Name of binary	Mass in Suns	Ln(Luminosity), Luminosity is in Suns
Xi Bootes	0.9	-0.5
	0.66	-2.8
Sirius	2.063	3.23
	1.018	-2.88
Alfa Centarous	1.1	0.418
	0.907	-0.69
Alfa Comae Berenices	1.237	0.542
	1.087	0.56
Beta Delphinus	1.75	3.18
	1.47	2.08
Delta Equaleus	1.192	0.81
	1.187	0.728
Zeta Herculesis	1.45	1.879
	0.98	-0.48
99 Herculesis	0.94	0.673
	0.46	-1.966
Sigma Herculesis	2.6	5.44
	1.5	2.0
Beta Leonis minor	2.11	3.58

	1.35	1.76
Psi Centari*	3.114	4.95
	1.909	2.89
Chi 2 Hidrae*	3.605	5.84
	2.632	4.19
70 Ophiuchus	0.9	-0.53
	0.7	-2.04

- * - eclipsing spectroscopic binaries (obviously close binaries)

Slopes of the curves are different! It means that for close binaries the effective gravitational constant would be larger. Indeed, the visual binaries gives the masses as:

$M_1+M_2=4*\pi^2R^3/(G*T^2)$

M_1, M_2 – masses of the stars, R- semi-major axis, G – gravitational constant, T is the period of the binary.

And similar formula for the eclipsing spectroscopic binaries:

$M_1+M_2=T^2*(V_1+V_2)^3/(2*\pi*G)$

Here V_1, V_2 – maximum velocities of the stars

Assuming that the absolute luminosity determines the inertial mass of the star (indeed, any deviation from gravitation law is small and should not influence the evolution of the star), it is possible to see, that higher slope corresponds to smaller deduced gravitational mass for close binary compare to far binary (if the gravitational constant is the same). Assuming the equivalence principle holds, it means that the gravitational constant for close binaries is different from the gravitational constant for far binaries (larger for close binaries). This observation is exactly opposite to what is expected for MOND – in this case the far binaries would be attracted stronger. It looks like some additional mass is present in addition to the star masses which forces them to go closer (almost like the dark matter is present).

However, why would the dark matter be present only for close binaries and not for all of them (in this case on average the slopes should be the same)? More plausible idea is that gravity constant depends upon the mass of the star itself – **the gravity enhancing field** is created by ordinary matter, which is stronger for higher concentration of the matter in the space.

What is the problem with dark matter being considered as some kind of exotic particles being able to gravitate but not react in any other way with usual barionic and non-barionic (light, for example) matter? In principle such matter is possible, but all the previous experimental evidence tells that the less particle interact with barionic matter the less it contributes to gravity. Indeed, any ions and molecules are easy to catch and they contribute to gravitation tremendously so far. Electrons are less interacting with matter and also less heavy. Neutrinos are kind of particles that are almost not interacting with barionic matter but they are also do not have significant contribution to the gravity. It plausible to assume that other types of particle exist which would interact with matter even less, but they also would contribute to the gravity even less. The idea of any type of particle which would be not interacting with ordinary matter but contribute to the gravity even more than barionic matter is out of this sequence and seems not obvious.

In addition the recent discovery of ultra-diffuse galaxies with diluted stars concentration and completely devoid of dark matter [12] poses even more questions: how the dark matter may be separated from the ordinary matter [13] if they interact gravitationally? Why would not dark matter be attracted back for billions of years and completed the usual setup: dark matter halo around the visible galaxy?

At the same time the dark matter is absent in ultra-diffuse galaxies only – may be the concentration of ordinary matter plays some role? The ordinary matter changes the gravity constant through some kind of gravity enhancing field?

From the slope of the curves it is possible to roughly evaluate how gravitational constant G changes with distance.

We have two equations:

Y=3.7978*ln(x)-0.1622 – far binaries (distance ~$56.29*10^{-4}$ light years, l.y.)

Y=4.653ln(x)-0.0421 – for close binaries (distance ~$3.63*10^{-4}$ l.y.)

For mass m=2 from the first equation y=2.4702. This value is assumed to be correlated with inertial mass which determined by star evolution and it is assumed that small change in gravity law can not influence the luminosity (the luminosity dependence upon the heavy metal composition is neglected). Substituting into second equation we got m=1.716 (instead of two). The equivalence principle should not be violated for close binaries compare to far binaries, so it means that the mass of the star is not enough for such luminosity.

It may be simpler explanation, of course for such deviation – both stars were formed from the same cloud, which was much denser for close binaries (that is why they are closer) compare to very diluted cloud for far binaries. In addition to the stars, huge amount of planets and asteroids are hanging around each star (because the initial cloud was dense), effectively creating invisible but quite real barionic matter ("dark matter" in the very original sense). Assuming the observations of the brightness variation exclude such explanation (constant dimming of the star due to interstellar objects), the other explanation is that the gravity constant is different. From equations (1) and (2) it follows that G would be larger for close binaries (and G=K/m law holds). For close binaries G is 2/1.716=1.166 times larger.

Influence of the mass to the gravity may be written in a formula similar to Coulomb law:

$$F=(1/[4\pi\varepsilon\varepsilon_o])*q_1*q_2/r^2 \quad (3)$$

Where q_1, q_2 are electrostatic charges, r is the distance between charges, ε is the permittivity of space (due to dipole nature of the medium the force is weakened), ε_o is the permittivity of free space.

For gravity it would be:

$$F=(\varepsilon_g/[4\pi\varepsilon_{go}])*m_1*m_2/r^2 \quad (4)$$

Where m_1,m_2 are masses, r is the distance between masses, ε_g is the gravitoelectric permittivity of space (due to the absence of antigravitation it always enhances the force) and ε_{go} is the gravitoelectric permittivity of free space (the notations would be suitable for gravitoelectromagnetism [14,15]).

In this equation ε_g moved up to numerator compare to formula (3) because the gravity is enhanced, not weakened as in the case of electricity.

With loose similarity to Debye length [16] the dependence of such field may be written in a way like this:

$$\varepsilon_g=1+\delta*\{\Sigma M_i*\exp(-r_i/\xi)\}/\{\Sigma M_i\} \quad (5)$$

Here M_i are masses around the point (actually all masses in Universe, but due to exponential decay only closest masses are necessary), r_i are distances to the point of interest, ξ is the decay length, δ is some empirical constant (how strongly gravitational constant is enhanced). Formula (5) would drop to 1 in infinity (no influence of mass) and to some enhanced value near the star.

Simplifying even further to evaluate the value of the effect in the Solar system:

$$G=G_o*\exp(-r/\xi) \quad (6)$$

And $1.166=[\exp(-3.6*10^{-4}/\xi)]/[\exp(-5.6*10^{-3}/\xi)]$

The decay length would be 0.034 l.y. ($3.2*10^{14}$ m) and for the Pluto orbit ($5.9*10^{12}$ meters) change of gravitational constant of 2% is expected ($G=0.98G_o$).

This is quite large a change and should be easily noticeable if the Cavendish experiment is performed on Pluto orbit or on the Pluto surface (because the planets are small compare to Sun, the only real player in Solar system is Sun). For example, the Cavendish experiment performed on Moon surface would lead to only around $4*10^{-8}$ relative change – not enough with modern accuracy of Cavendish experiment. The previously published idea of Cavendish experiment near the surface of the Sun would be helpful in the case the accuracy will be good enough [17].

It is interesting to note, that the idea of quantum vacuum being influenced by different fields with corresponding change of gravity constant or electric field constants is not new and was already discussed [17,18]. In [17] the weakness of gravity is hypothesized to be due to the existence of Higgs boson “gravitational antiparticle” (second quantization is predicted), so that virtual pairs particle-gravitational antiparticle would weaken the field in exactly the same way as virtual electron-positron pairs are weakening the electric field in quantum vacuum explanation of speed of light value. If there is no gravitational antiparticle in nature, the presence of the mass is expected to polarize the quantum vacuum in such a way, that popping out of quantum vacuum particles are all bosons with the same positive sign of mass (all attracting each other). In this case if the boson condensation of all of them is avoided (collapsing the mass into the black hole as described in [17]), the virtual particles would be increasing the strength of the gravitational filed, not weakening it as in the case of electromagnetism. This would be exactly what is observed in this article. The enhancement length seems to be enormous – but this is in the range what is expected for dark matter (actually the real length may be higher, because more accurate experiments are necessary).

D. <u>Generalizing the search for dark matter. Einstein formula for light bending revisited.</u>

The most information about dark matter comes from deviation of light observation in astronomy – light bending by galaxies, clusters of galaxies, etc. The most general expression for the gravity influence on light goes from Schwarzchild metric expression (see above discussion about slow light gravitation in the direction of the galaxy center):

$Z=GM/(c^2R)$

This Z value as observed is too large for the measured distance, visible mass and known gravitational constant. So the hypothesis are:

1.Missing matter – dark matter approach – value M should be higher to account for Z

2.Gravitity law is changed at high distance – combination of G and R should be reconsidered (MOND)

3.G value is wrong when away from Earth – gravity enhancing field hypothesis, fifth force hypothesis

4.Speed of light is not constant and if it is **smaller** between galaxies the value of Z may be higher to account for the measured light bending. The speed of light theoretically may be smaller away from gravitating mass if the gravitation influences quantum vacuum much stronger than expected now – in this case not only the G constant is smaller away from galaxy (the hypothesis discussed above), but the vacuum permeability, responsible for speed of light is **larger**, for example, due to enhancement of positron-electron virtual pairs generation in the absence of gravitational field

5.The geometry is not correct – the value of R is wrong. For example, the Einstein's idea that space is created by the mass is even more important and between galaxies there is virtually less space than inside galaxy – in this case the simple geometrical rules are not applicable.

While present day efforts are mainly concentrated around M value in this formula: search for missing matter, some attention may be given already to other ideas. My idea is about G value not being constant.

Conclusion to chapter 2.

Dark matter is a big, old and possibly very complex problem. Weak equivalence principle violation idea may be tested easily using existing data and not responsible for dark matter (may still have some effect on gravitation – for future research in binaries databases). Gravity enhancing field is essentially fifth force hypothesis and has a hint from binaries analysis. Altogether those ideas may help to find new physics.

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Chapter 3. Quantization rule revisited. Back to Plank idea.

Quantization rule initiated by Plank more than one hundred years ago was successfully applied to energy (Plank, Einstein), moment (Niels Bohr) and to wavelength (De-Broglie). But what if it is universal and applicable to any physical value which has the dimension Joule*second?

<u>A.Quantization of the gravitational dipole.</u>

At the present time gravity is considered by many scientists as the under-investigated force of nature due to its weakness. It is interesting to investigate the hypothetical possibility of the associated with the mass of the elementary particle gravitational dipole. That would be analogous to electric dipole for the electric field and it would reflect the non-uniform distribution of the mass inside the elementary particle.

Since all the physical values which have the dimensions of energy*time (J*s) are quantized (the Plank constant), it would be interesting to see, what physical values may be quantized, too. For example, production m*v*r (mass*velocity*radius is quantized and this is orbital moment). Investigation of quantization of this moment lead to all modern quantum mechanics, started by Niels Bohr. However, the same production may be considered as production of m*r (gravitational dipole, similar to electric dipole q*r - charge times distance) and velocity v of the particle.

Following Niels Bohr steps, it is possible to suppose that such value is quantized too:

(m*r)*v=n*h

here h is Plank's constant.

It may be rewritten as follows:

m*r=n*h/v,

Since h/(m*v) is the de Broglie wavelength λ

m*r=n*m*(h/m*v)=n*m*λ

It means that the mass of the particle is "spread" in the space as de Broglie wavelength. Here n is the number 1,2,3,4...

The most important consequence of the hypothesis - the gravitational dipole moment is not equal to zero! This is a conclusion similar to de Broglie wavelength - it must exist, due to quantum mechanics the particle can not be represented as a point, therefore the dipole moment can not be zero under any circumstances.

Lets estimate the additional gravitational force due to the gravitational dipole moment of the particle. Lets consider the ball with mass M as the second body (the first body has mass m). The gravitational dipole force between the dipole and spherical mass M is:

F_d=m*r*grad(E_g)

here F_d is the force acting onto the dipole m*r, grad(E_g) is the gradient of the gravitational field, what is equal for the spherical mass to:

grad(E_g)=d/dr(M*G/(R*R))=2*M*G/(R*R*R)

Here G is the gravitational constant, M is the mass of the second body, R is the distance between the centers of the attracting masses. Then the gravitational dipole force may be written as:

$F_d=n*m*\lambda*(2GM/R^3)=2n*(\lambda/R)*(GmM/R^2)=2n*(\lambda/R)*F_g$

Here F_g is the classical gravitational force between two spherical masses separated by distance R between centers. For the multiple harmonics of the gravitational dipole force (n>1) and for very slow electron (de Broglie wavelength is high) it may be comparable with gravitational force and measurable relatively easily - the electrons will be split into several beams. The gravitational force is not quantizied and the same for all electrons, but the dipole gravitational forced is different depending upon n.

Here comes the different problem discussed in another blog [1,2] - de Broglie wavelength is unique and not quantizied according to Bohr rule. It may happened that there is no "excited" states for gravitational dipole, only the lowest state exist (n=1).

For the ultraslow electron with the temperature of 1 micro-Kelvin (reachable now in some experiments) the velocity of electron would be 6.7 m/s and de Broglie wavelength is 0.1 mm. For the second body with radius of 0.1 m the ratio of dipole gravitational force to gravitational force is 2*0.0001/0.1=0.002.

The accuracy of the direct measurements of gravitational force today (Kavendish experiment) is much higher than 0.2%, thus making such measurements quite possible.

Additional alleviation may be from the shape of the second mass - the gradient of the gravitational force, similar to the gradient of the electric field, will be much stronger near the sharp edges, so the manipulation with different shapes of the second body with mass M will allow to amplify the gravitational dipole force while keeping the classical gravitational force the same.

B.Quantization rule and harmonics of matter waves.

When modern scientist is recalling the quantization rule for photons, usually the famous $E=h*\nu$ is recalled. However, in the original Planck's derivation the more general rule of quantization was assumed: $E=n*h*\nu$ [3]. A similar rule of quantization was assumed by Nield Bohr concerning the orbital moment. The values n=2,3,4 .. are responsible for the excited states of the quantum system.

In quantum electrodynamics the quantization rule for electromagnetic field is similar to oscillator:

$E=n*h*\nu +0.5*h*\nu$

At the same time the wavelength of the de Broglie wave has only one value: $\lambda=h/p=h/(m*v)$ not $\lambda=n*h/p$, where n is a number 1,2,3..., p is the pulse of the particle (applicable for any particle), m - rest mass and v - velocity of the particle (applicable only for non-relativistic case).

Since the matter waves are not really easy to investigate, it may happened that the de Broglie wavelength also follows the most general rule with the presence of the harmonics:

$\lambda=n*h/p$,

But they were simply overlooked and careful experiment would be necessary to discover them.

For de Broglie wave it is would not be easy to find presence of such harmonics, because during the interference experiment they would generate the maxima and minima, which coincide with maxima and minima of the main matter wave. If harmonic is present in the miniscule amount it will lead to some hardly observable effect.

Let's consider for example the case of only one added harmonic. Let the first harmonic has maximum of 1 and decays as exp(-0.1*m), where m is the interference band number, m=0,1,2,3,4... In this case the amplitudes of the interference bands would be: Io=1, exp(-0.1), exp(-0.2), exp(-0.3), exp(-0.4)=1, 0.905, 0.819, 0.741, 0.670...

Second harmonic of de Broglie wave would have the amplitude of 0.01 and decays with distance away from the center according to the same law exp(-0.1*m), here m is the interference band for the second harmonic, which would coincide with a certain band for first harmonic (because wavelength is exactly 2 times larger). The amplitude would be I=0.01, 0.01*exp(-0.1), 0.01*exp(-0.2)… =0.01, 0.00905, 0.00819 ...

The sum of the amplitudes would be:

1.01; exp(-0.1); exp(-0.2)+0.01*exp(-0.1); exp(-0.3); exp(-0.4)+0.01*exp(-0.2); …..=

1.01; 0.905; 0.828; 0.741; 0.679; …..

In order to distinguish the case of the one and multiple harmonics the ratio of the amplitudes of the consecutive bands may be calculated: bamd1/band0; band2/band1, band3/band2.....

For exactly one de Broglie wavelength that would be monotonic function:

0.905, 0.905, 0.905 …. (constant in this example, because the chosen decay function was exponential)

For the sum of harmonics it would be: ratios are:

0.896; 0.915; 0.895; 0.916 …. - non-monotonic function, the superposition of monotonic function and a_o*Cos(π*m), where m is the interference band number.

The third and higher harmonics will add more "waviness" to the smooth function.

How to estimate the amplitude of the harmonics in matter wave? The idea of evaluation is inferred from the reciprocity principle: the particle is both matter and wave [4]. Assuming the matter wave is something real (similar to a photon, but permanently "attached" to the particle), the probability of the excitation of the second energy level would be similar to the idea proposed by Plank [3]:

population of each next level would follow Boltzmann rule [5]:

$-\log(N_i/N) \sim E_i/kT$

But what is the expected energy of the initial de Broglie wave? Hypothesizing that the particle is both matter and wave it is possible to speculate about this value.

Since de Broglie wave is "attached" to the particle, the only velocity it may have is equals to the velocity of particle v. From the general rule connecting velocity, wavelength and frequency of the wave it follows:

v=λ*f or λ=v/f (here f is used of more common ν (Nu) to distinquish it from v (velocity))

here v is the velocity of the particle, λ is the wavelength, f is the frequency of the wave.

Substituting λ into the formula for non-relativistic de Broglie wave:

λ=h/(m*v) and v/f=h/(m*v)

which may be transformed as follows:
$mv^2=hf$ or $mv^2/2=hf/2$
For non-relativistic particle the energy of de Broglie wave can not be larger than the full kinetic energy of the particles and de Broglie wave quantized as oscillator (quite reasonable idea, because the zero energy of electromagnetic field has the same value). Assuming the next harmonic will have the energy according to the Planks rule (or quantum electrodynamic rule, similar to oscillator), the difference in energy between two levels for de Broglie wave would be double the kinetic energy of the non-relativistic particle (for relativistic particle the quantization rule for De-Broglie wave is simpler and coincides with the quantization rule for photons).
Than the ratio of the amplitude of the second harmonic of de Broglie wave to the initial amplitude would be equal (from Boltzmann rule):
$I/I_o=exp(-2E_k/kT)$
where E_k is the kinetic energy of the non-relativistic particle. For example for electron with possible to reach energy of 0.1 eV, observed at the room temperature (300 K, at this temperature de Broglie wave is still well resolved since 0.1 eV > kT), the ratio would be:

$I/I_o=exp(-2E_k/kT)=4.4*10exp(-4)$
Which is small, but at numerous averaging is possible to reach and to discover. The presence of the second harmonic of the De-Broglie wavelength would also reveal itself in a very rare event, when the particle suddenly accelerated to exactly triple energy (velocity jumped by a factor $\sqrt{3}$) because the particle's De-Broglie wave absorbed, for example quantum of energy (resonant phenomenon) from a photon being present nearby or from some oscillator of interacting molecule. The excitation of energy of particle being considered as particle is of course also possible, but it is not quantized – velocity merely increases by some value and moves to higher values in Maxwell distribution. But not with resonant event – the velocity can not jump into any value, it must be changed by quanta only. Such resonant jump in velocity would be very similar to another quantum effect predicted in [4].

It would be very interesting question about the De-Broglie wavelength quantization in the intermediate energy range between the ultra-slow particle (E=hf/2) and ultra-relativistic case (E=hf). The answer is unknown so far: the exact formula may be guessed but enormous theoretical efforts are to be applied to explain it. Again, this book not about theoretical approach to new physics, it is about experimental approach and many experiments may be planned without exact understanding of all the underlying issues.

C. Plank versus Einstein: are multiple energy photons possible? May they be seen by two photon absorption spectroscopy?

Two photon absorption spectroscopy is well known non-linear optic phenomena [6]. In this phenomena the virtual level is present which allows to absorb the second photon and thus excite the state with energy equal to two times the energy of the original quantum. The

corresponding two-photon excited fluorescence is well known (and now three-photon excited fluorescence is known well). The most important observation connected with multiple quanta absorption is the non-linear dependence on power: this allows easily distinguish it from other phenomena.
The fundamental hypothesis outlined in the previous post [2] concerning the harmonics of de Broglie waves may be also stated for the photon itself. Indeed, the initial hypothesis of Plank concerning the photons [3] was the energy of photons itself is: E=n*h*ν [3]. From observation of photoelectric effect Einstein deduced the more commonly known rule: E=h*ν, which eventually lead to the development of the quantum electrodynamics and numerous discoveries.
However, any mathematical expression is only the approximation to the natural law, and the idea of the photons having energy of only E=h*ν may be very successful but not finally correct. Indeed, the double energy photon (with E=2*h*ν) may be so rare that virtually non-observable and thus making the Einstein idea so exceptionally great fit to the natural law that it looks absolute. The double energy photons may easily decay into two ordinary photons or mutate into the photon with double frequency.
The probability of the existence of such photons would be governed by the usual Boltzman rule (from [2]):
the population of double energy photons would be exp[-hν/(kT)] less compare to the usual photon. That value for relatively small energy infrared photons (1064 nm wavelength, 1.17 eV ordinary photon energy) would be at room temperature only 2.35*10exp(-20). This means that even such photons exist, they are so rare that virtually non-observable.
However, the two photon excited fluorescence is a convenient way to check theirs presence. Indeed, in addition to the quadratic in power term of such fluorescence (due to virtual levels creation [1]) an extremely small linear in power fluorescence is predicted. This fluorescence is so weak that it is necessary to consider the background created by usual thermal excitation (with some non-zero probability the same excited level may be reached by the usual thermal excitation according to the Boltzman formula P/P_o=exp[-E/(kT)].
The trick to subtract background is that the two photon fluorescence is a resonant phenomena. It means that for the deviation of the wavelength from the resonant value it will quickly disappear. Since for the linear phenomena search the laser should not be powerful (to prevent observation of the more common quadratic in power two photon fluorescence [6]) it may be with tuned frequency and thus allowing to observe the linear in power resonant phenomenon. When the frequency of the laser deviates from the frequency necessary for two quanta fluorescence (this frequency may be obtained from the quadratic term of the induced fluorescence) the observed linear term should quickly disappear (and the thermal background stay the same).
In summary: the observation of the linear term in the two photon fluorescence is predicted due to hypothetical existence of double energy photons (from Planks rule E=n*h*ν [3]), the phenomenon would be really weak (20 orders of magnitude weaker compare to one-photon fluorescence at least for infrared photons) but resonant in photon frequency.

D.Another approach to finite rest mass of photon – the finiteness of the coherent length direct check for particles and photons.

The idea is as follows – if the photon is an extremely small particle with finite rest mass, what would be the coherent length limitation for the associated wave? If photon is a pure wave, there is no limit on the coherence length of the wave – the longer the base for the laser, the higher coherent length may be reached.

On the contrary, De-Broglie wave has an inherent limitation of the coherence length because the size of the object is finite [7]. Despite the electron is very small, it has a finite size. Any deviation of the velocity from left and right side of the electron (whether it is ball or something else) will lead to a slight deviation of the De-Broglie wavelength and to inherent limitation on the diffraction pattern (it would not be visible after certain maximum even despite the velocity of the electrons is made more and more precise). That is one of the reasons why the diffraction pattern of the electrons has something like 10 maximums visible and the rest of the picture is blurred, while even the simple He-Ne laser may demonstrate hundreds of maxima visible easily in diffraction pattern, not even mentioning the record-breaking modern lasers.

Being observed in the experiment, the finite coherence of photons (no change as the wavelength becomes more and more precise – say the separation between laser mirrors is larger and larger) would mean the presence of the finite size of the particle beyond the photon and thus confirming the similarity between the De-Broglie wave and electromagnetic wave. While not establishing directly the finite mass of the particle the establishment of the finite size of the particle would mean the new physics beyond the modern understanding of matter-wave dualism.

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Chapter 4. Action at a distance, quantum "entanglement" and quantum superposition.

The idea of the quantum mechanics not complete is not new and essentially correct. Indeed, physics is not mathematics and just an approximation to the reality with some limitations [1]. Interpretation of quantum mechanics is so big problem because it is touching one of the limitations of quantum mechanics – how to observe. Here comes the idea of quantum "entanglement" which creates the new direction of the theory research – the matter somehow interacts with each other allowing superluminal information exchange [2]. This information transfer contradicts to the most basic idea of the field intermediary for each interaction and most probably means that in this question the limit of the applicability of quantum mechanics is reached contrary to the physical existence of such phenomena.

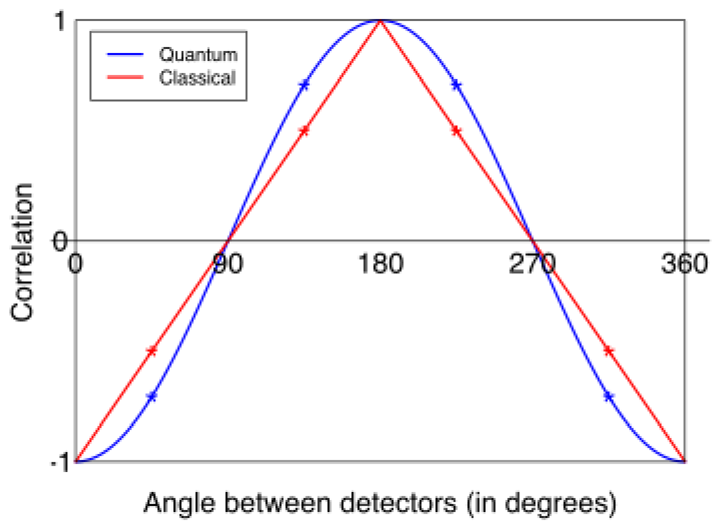
The most serious contradiction to the violation of the Bells theorem (which is by itself is correct as any mathematical proof) is the observed correlation between the polarization vectors.

A. About the correlation function between two vectors and quantum superposition of photons.

For many years, starting 1982 numerous researchers are investigating the so-called quantum entanglement - quantum superposition of polarized photons. The work started by Alain Aspect, who found that the correlation function between the two simultaneously generated photons in a radiative cascade of calcium [3] is not linear, but follows the law Cos(F), where F is the angle between the polarizers. For intensity that would mean $Cos^2(F)$ law. This is exactly the law expected for two completely independent by equally polarized photons (Malus Law).
The deviation from Bell's inequality was thought to occur because of the idea (wrong idea) that for classical case the correlation function between the polarization vectors would be linear (that is directly proportional to angle between polarizers). This is not possible because of the mathematical definitions of vectors: according to [4] the correlation function between any vectors (quantum or classical) must be expressed as a function of Cos and Sin and by no means may be simply proportional to angle. In [4] the correlation function between any vectors is to be proved to be Cos(F) (because it is actually simply normalized dot product of two vectors):

$$Correlation=Cos(a \cdot b)=(a \cdot b)/(|a| \cdot |b|)$$

In this case either classical or quantum correlation will follow the Cos(F) law (simple Malus law) and no deviation from Bell's inequality is observed. In reality in [3] a simple generation of two equally polarized photons was observed without any quantum superposition between them. Linear function of an angle is not possible for correlation function because it will have two special points (at 0 and at 90 degrees), where the derivative is discontinuous, which is not possible for correlation function which must be smooth function.



Thus the zig-zag correlation function for classical vectors is equally impossible as for quantum vectors, and the presence of Cos(F) is not proof of quantum behavior of the two independent photons in [3].

This does not exclude the possibility of quantum superposition of photons (and action at the distance), simply the present papers are not proof of it (and the correct discovery of such phenomenon would indeed be “new physics”)

B.Quantum tunneling faster than speed of light.

Contrary to the “entanglement” the quantum superposition of states is a well documented phenomenon and reveals itself in numerous experiments. The coherent quantum tunneling leads to the preservation of phase and Rabi oscillations between the connected quantum states. The non-coherent quantum tunneling leads to the energy splitting between the levels in the non-rigid molecules. Contrary to “entanglement” where the measurement act supposedly break the connection without any possibility to check its presence, in quantum tunneling the interaction is perfectly seen through oscillations or energy splitting.

The velocity of the tunneling is supposed to be **superluminal** in some situations [5] and this is not contradiction to Einstein view: the limitation of speed of light is valid for the space as we perceive it. What is going on under the barrier, where the energy of the system is negative (and according to $E=mc^2$ formula either mass is negative or velocity is imaginary) is out of the reach of modern space-time concepts (the limitation reached, physics is not mathematics). Several research groups are already trying to measure directly tunneling time [6]. The phenomenon of the tunneling and how fast it is indeed the question which may generate the way to investigate the under-barrier “space” (or what is there where the energy is negative) and help to expand physics. This particular idea for search for “new physics” is not actually new and in some publications [6] it is emphasized that it is more interesting than research of “entanglement”, which, being based on the wrongly interpreted experiment, most possibly does not exist at all.

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Chapter 5. The weakest force future research – gravito-electromagnetic national laboratory.

From the perspective of new discoveries in the field of gravitation in addition to the astronomical observations (see chapter 2) another approach would be to try to create the necessary source for research here on Earth. Today the experiments on the measuring of the gravitational constant (Cavendish experiment) are done using stationary masses. In this case only the gravitation field is measured (assuming the analogy to Maxwell equations, that would be gravito-electric field [1] and the first gravitoelectromagnetic equation (GEM equation, [1]) is tested). The first ever attempt to detect gravitomagnetic field was done using space probe (Probe B [2]) and it does not lead to really conclusive results (the problem is that the Earth is not ideal ball, thus disturbing the measurements). Possibly the best way to create the necessary conditions to perform experiments with gravitoelectromagnetic fields is to build the source here on Earth. Obviously such a source is very expensive and may be only done as a national laboratory (no university may allow such money spent). The idea is to build the source of gravity as big as possible using rotating heavy element (like cross or ball with asperities to create oscillating at medium frequency 10-100 kHz gravitational field and gravitational field gradient). In this case the oscillating gravitomagnetic field will be created and the enhancement of it may be reached because of higher **frequency** of generation compare to slow rotating Earth. It is well known for electromagnetism, that the radiated by oscillating source electromagnetic energy increases proportional to the forth power of the frequency [3]. Correspondingly for gravitoelectromagnetism the effect would be the same and switching to higher frequencies will allow to increase the generated fields (especially gravitomagnetic) many orders of magnitude to be detectable at the present sensitivity of the **phase sensitive detectors** (since the frequency of the effects is expected in the range of up hundreds of kHz, the principle of lock-in may be used to enhance the sensitivity on the detector side). In this frequency range the modern electronics works perfectly (at those frequencies all the low-frequency noises are already completely suppressed, the phase lock signal may be easily provided assuming the source is Earth based – the rotation of the ball on the Earth may be easily monitored with enormous accuracy). Thus the use of higher frequency has two advantages – higher generated signals and higher sensitivity of detectors. Hopefully combination of those factors will allow to reach level of detectability of gravitational effects and to investigate the weakest force thoroughly (hopefully this will also finally allow to meet unexpected phenomena and find new physics).

A.Gravitational Stark effect for Ridberg atom in centrifuge

The possible way for direct observation of the quantum gravitational effects on Earth would be use of principle of equivalence and use of fast rotating centrifuges already available to create the equivalent of strong enough gravitational field.
Back in 1950 Popular mechanics magazine mentioned two commercially available record-setting centrifuges: The Sharples Corporation of Philadelphia manufactured centrifuge with 1.2 millions rotations per minute and Dr Jesse Wakefield Beams, University of Virginia reported

about 166000 rotations per second.
The easiest way to observe gravitational Stark effect is to rely upon the gravitational field gradient instead of the gravitational field itself (because due to the equivalence principle both electron and nucleus will be attracted with the same force). The field gradient, however, will create the energy difference for the atom to be observed as line shift. The gradient of the gravitational field in the centrifuge is:

$F=mw^2r$

$dF/dr=mw^2$

Here r is the distance from the center of the rotation, m is the mass of the object, w is the rotational angular frequency.
From the simple formula for energy in the gradient of the gravitational field:

$\Delta E=\Delta F*a_o$

Here ΔE is the energy difference due to the different gravity for the electron as it rotates around the nucleus - gravitational force is different throughout the atom, a_o is the radius of the atom (the radius of Bohr orbit)

$\Delta F=(dF/dr)*a_o$

and

$\Delta E=m_e*w^2*a_o^2=m_e*(2\pi v)^2*a_o^2$

here m_e is the mass of electron, v is the rotational frequency expressed in Hz , a_o is the radius of the Ridberg atom (around 1 micrometer possible now). Substituting 166000 Hz as the record rotational frequency we have:
ΔE=2*10exp(-30) Joule or 1.24*10exp(-11) eV or in frequency domain the splitting would be 3021 Hz.

Such splitting between lines is possible to record. Assuming the centrifuges improved in the last 70 years the overall experiment seems feasible.

B.Use of modern centrifuges for discovery of gravitational phenomena on quantum level

Modern centrifuges are improved a lot from the last time their record values were published. Magazine "Popular mechanics) back in 1950 (70 years ago) was already mentioning centrifuges with 166000 rotations per second [4]. Assuming the scientific progress continued today they are even faster. Since from equivalence principle of Einstein the accelerated motion of the object (including atom or molecule) is the same as the motion in gravitational field, such ultracentrifuge may be helpful in discovering and verifications of the new quantum phenomena connected with the gravity.
Most theories talking about the gravity on atomic level are mentioning the vicinity of black hole or neutron star, but modern centrifuges may offer the same accelerations on Earth. For example, even biological centrifuges may easily reach 1 millions g (which is enough for separation of any proteins), but they are not intended for physical experiments and probably the specially made centrifuge may go much further. Such centrifuges would be part of the future gravito-electromagnetic national laboratory.
There are several possible phenomena relevant for such gravitational force.

1.Deviation of slow light.

The hypothesis that the slow light deviates much stronger inside the stars and may thus generate the gravity force in addition to the usual gravity of baryonic matter is expressed in [5]. However, the deviation of the light in the usual gravity is too weak to be measured directly for light in refracting matter (in the vacuum it was measured during Einstein times and is the confirmation of general theory of relativity). Using the same approach as in [5], for the deviation of light in any weak (compare to the inside of the black hole) it is twice as strong as Newton deviation. For example, for the deviation of the light which travels with the velocity of 0.7c (for example, inside the glass) the formula would be as follows.

For the distance of L=1 meter (reasonably long centrifuge) the time of travel would be:

t=L/(0.7*c)

here t is the time of travel, c is speed of light in vacuum.

Deviation in the perpendicular direction (assuming the light is traveling almost along the axis of the rotation, in uniform gravitational field):

S=a*t*t (this would be twice the Newtonian value of a*t*t/2)

The angle would be:

a=S/L=a*L/(0.49*c*c)=2.3*10exp(-10)

for a equal to 1 million g. The shift for light S is only 2.3 A - too small to be measured easily. For easy to notice deviation of say 1 mm the velocity of light should be 100000 m/c (or 0.00033*c).

Today the experiments exists for light as slow as 90 m/c [6], so the experiment of observation of slow light will not even need the record centrifuge. Seems to be possible soon, thus checking also the ideas of slow light gravitation inside the stars and violations of weak equivalence principle (see chapter 2 above).

2.Ionization induced by the gravitational field.

In strong enough electric field the tunneling of the electron out of the molecule happened. This called field ionization and usually needs rather high electric field. The observation of the phenomena close to field ionization using the gravitational field may be only possible for the molecules or atoms which are already close to being ionized - excited atoms or molecules, where the electron is in Rydberg state for atoms in vacuum or in Rydberg like state in semiconductors.

Rydberg atoms are capable of detection of the microwaves with frequencies in MHz range already [7](pre-excited by laser atom enters the Rydberg state and gets the final energy from RF quanta). For 100 MHz the energy of quanta is only 4.1*10exp(-7) eV

The idea is that such Rydberg atom being placed in a strong gravitational field (say 10 millions g) will create the potential bending for electron shallow enough to observe the tunneling of electron out of such an atom.

The largest problem to obtain even more excited states Rydberg states is temperature (electron should be on the Rydberg level at least around kT from ionization barrier. For record temperatures achieved on the level of 50 nK [8] that means that the lowest energy detection possible for Rydberg atom hold at this temperature is kT, 6.9*10exp(-31) Joule or 4.3*10exp(-12) eV (assumed it is hold near the thermal bath big enough to absorb the heat created at laser excitation to the Rydberg level)

For the gravitational field of 10 millions g the energy of E=6.9*10exp(-31) J is reached at the

distance of:
L=E/F=E/(m*10exp(7)*g)=7.7*10exp(-9) m
So electron should tunnel only 7 nm under barrier to reach the space where it may escape Rydberg atom. This value is a reasonable distance for tunneling of electron (up to 100 Angstroms).
Therefore, such experiment is already at the reach of the modern physics.
The largest problem of the observation of such phenomenon would be the ionization of the material induced by stress (mechanochemistry). Indeed, the gravitational field of 10 millions g is smashing any material very perceptibly. As the huge stress is build inside, the electrons will be emitted merely because near the defects they will be excited enough to leave the material even without help of gravitational pull on the electron itself [9]
Careful choice of materials, long waiting time (conditioning) and modulation of laser beam creating the Rydberg atoms may allow to overcome this problem. That would be another experiment to be performed at the gravito-electromagnetic national laboratory.

C.Accurate measurements of the gravitational constant in the pulsating gravitoelectric field.

All the previous experiments were using the equivalence principle for barionic matter to create the substitute of gravitational field by the centripetal force. Of course the real task of the gravito-electromagnetic national laboratory would be creation of the sources of the gravitational field. One such source would be creation of the fast moving huge masses with asperities – in this case the gravitational force would have a high local gradient (necessary for shorter pulses) as well as oscillating nature (in this case even the simple Cavendish-type experiment may be performed in dynamic mode). Today the only existing method uses the static arrangement of test masses [10] and that seems to limit the accuracy (because the surrounding should be taken into account, too. For the case of, for example, huge rotating ball with big asperities, rotating as fast as possible (the tensile strength of the material allowed) the only masses which are oscillating are the masses of the ball and asperities and the rest is stationary not generating any signal on the lock-in frequency. That would be radically new approach to the determination of the gravitational constant (still using the same first GEM equation, however).

D.Dark matter induced frequency dependent shift in gravitational field. Gravitational Impedance Spectroscopy.

Very much like the phase of the registered electric field and intensity depends upon the frequency of the oscillating electric field in Impedance Spectroscopy depends upon the frequency of the electric field, the phase between the driving gravitational field and the response of the test bodies will depend upon the frequency of the oscillation of the nearby masses. But even in vacuum the elusive "classical dark matter" would be felt as the medium, which delays the propagation of the gravitoelectric pulse due to the inevitable interaction between the dark matter hypothetical particles and test bodies. The author does not like this hypothesis at all (see Chapter 2), but it is still possible explanation of the accelerated rotation of galaxies and may be felt in such experiment (despite the effect should be very small).

E.One more quantum number associated with gravity? Gravitomagnetic field is necessary to answer.

All the previously described experiments are more or less obvious: they are not contradicting to the modern understanding of nature – nothing new is proposed. But the strong gravitomagnetic field may help to find the really new physics – something not yet considered possible.

E1.Quantum vacuum and the possibility of second spin.

Recent discovery of Higgs boson which has a relation to gravity but should be the boson particle with respect to the statistic poses some problems with gravitational constant origin and strength. Since boson is the antiparticle to itself, it may be created from the vacuum without any pair and since it may condense into the lowest state, the increased fluctuations of quantum vacuum near any particle will grow the final mass to infinity (see also chapter 2 for the possibility of gravity enhancing field due to polarization of quantum vacuum).
Fluctuations of quantum vacuum long ago were used to explain the origin of speed of light [11]. For the attenuation of the electric field near the charge the use of virtual dipoles from vacuum is relatively straightforward: the particle-antiparticle pair composed of fermions, which can not occupy the same state and thus can not accumulate near the charge up to infinite amounts, completely eliminating the electric field. Unfortunately, application of the same idea to the gravity fails simply because any particle has a mass and they all attract to the initial mass. While the usual particles like protons, neutrons, electrons etc will be attracted to the particle but being fermions can not accumulate infinitely, the Higgs boson can. It means that the virtual Higgs bosons will be clumping to any mass to infinity, creating infinitely heavy condensate, thus making the gravity impossible.

In [12] the idea of antiparticles being also antigravitational particles is proposed, thus explaining the weakness of the gravity in exactly the same way as the speed of light through the properties of quantum vacuum [11]. However, despite the direct experiment to determine the sign of mass for antimatter is in progress in CERN right now the most expected answer is that antiparticles have the same sign of mass as usual matter.
Another explanation is: similar to the particle-antiparticle dualism, there are virtual gravitational dipoles formed by pairs matter- antigravitational matter (the mass being considered as **independent quantum number**, the whole set of antigravity particles should exist for both particles and antiparticles, effectively doubling the number of existing particles). Because gravity is so weak, this second spin is not discovered yet because the level splitting for it are so small that with very high accuracy not reveal itself and the particles looks like bosons with respect to gravity. Just to remind, that first spin was discovered due to the beams splitting in strong magnetic field gradient and similarly strong gravitatomagnetic field gradient is not possible in the near future.
Those gravitational dipoles are formed by the particles, which may be bosons with respect to usual matter-antimatter relations but not with respect to gravity (**second spin**, another quantum number). Similar to the creation of the electron-positron pair in the intense electric field, those virtual dipoles will create pair particle - gravitational antiparticle in strong enough gravitational field (inside the dark hole, according to [12]).

Fortunately, antiparticles are formed not only in electric field, but also in any interactions of highly accelerated particles (that is how antiprotons are manufactured and separated by the electric and magnetic field). In a similar way the antigravitational particles should be formed (and may be already produced from time to time, but since the gravity is so much weaker compare to electric force, the usual separation methods in accelerators will render them unnoticed).

Using the formula derived for electric permittivity of vacuum from [11] it is even possible to estimate the mass of one component of such virtual dipole

$\varepsilon_o=[(K_w^2-1)^{3/2}/K_w]*2e^2/(3\pi*h*c)$

here ε_o - is the vacuum permittivity, e is the charge of electron, h is Planks constant, c is speed of light and K_w - is the coefficient received after the summation of all the possible fermion pairs in the vacuum near the charge.

The gravitational constant being considered similar to Coulomb constant for vacuum permittivity:

$k=1/(4*\pi*\varepsilon_o)$, that is $\varepsilon_o=1/(4\pi*k)$, where k=9*10exp(9) is Coulomb constant,

The equation would be (mass is instead of charge and gravitational constant instead of Coulomb constant):

$1/(4\pi*G)=[(K_w^2-1)^{3/2}/K_w]*2m^2/(3\pi*h*c)$

where G is gravitational constant and m is the mass of the particle- gravitational antiparticle pair.

Using value of 32 for K_w- the constant calculated in [1] the value of mass is 1.84*10exp(-9) kg or 166 GeV

Assuming the evaluations are very approximate, the only close in energy particle is Higgs boson (125 GeV).

Thus it is possible to predict that during the Higgs boson production at CERN, from time to time the antigravitational Higgs boson will be generated (like in the case with antiparticles, it will have the same mass, but of the opposite sign). It may be easily distinguished because the decay path of it will include antigravitational particles instead of normal particles and antiparticles, which would move differently at decay. The Higgs boson and antigravitational Higgs boson will be born in pairs, of course, so the total energy would be 250 GeV, but this is still well below the possible energy of BAC, which is 14 TeV.

Being discovered, such antigravitational particle would allow to justify the quantum vacuum virtual particles approach to the gravitational constant value calculations (combining approaches of [11] and [12]) thus effectively unifying electricity and gravity on the basis of quantum vacuum properties.

E2.Gravitomagnetic Stern-Gerlach experiment in space using Earth gravitomagnetic field. Importance for the direct measurement of quantum **mechanical** moment of elementary particles.

It is well accepted that gravitomagnetic field is extremely weak and just recently was measured using satellites. However, one of the problems of the physics - the weakness of the gravitational force - may have the answer connected with the presence of very heavy gravitational-antigravitational pairs of virtual particles in the quantum vacuum [13]. Very much like the

electrostatic force is limited by the presence of electron-positron virtual pairs in the quantum vacuum, the gravitational field is so weak because the very massive virtual pairs included antigravitational particle are polarized by the gravity of the tested particle and thus attenuates the force perceptibly [13].
But Higgs boson is not fermion from ordinary spin definition and seemingly should not have any antigravitational counterpart. The hypothesis is the presence of one more quantum number, close to spin but revealed by the mechanical moment decoupled from charge. Indeed, Einstein-De Haas experiment revealed that the reverse of the orbital magnetic moment forces the macroscopic object to rotate, thus connecting directly the mechanical moment and magnetic moment. For the orbital moment this experiment demonstrates full mechanical moment (because the orbital moment is essentially "rotation" of the electron around nucleus and for high orbital quantum number may be treated quasi-classically). But situation is not so obvious for spin of elementary particles. There is undoubtedly the mechanical moment coupled with electric charge (or electric current) and the flip of the spin will mean the flip of mechanical moment. However, the uncoupled mechanical moment may be still present. Imagine the fast rotating dielectric ball with superconducting strip on equator. The current in such a superconducting strip will be responsible for the magnetic moment of the object (magnetic spin) and cooper pairs would be responsible for the mechanical moment associated with such a magnetic spin. However, the main **mechanical** moment may be as large as possible and may have different direction. Flip of the current will reveal in this situation only the coupled part of the mechanical moment while the main moment will stay unnoticed. Only gravitomagnetic field will reveal the total mechanical moment of the elementary particle (for macroscopic object, of course, much simpler experiment will work).
The hope of this idea is that such experiment may reveal another quantum number, second spin, which would mean that the Higgs boson is not real boson, but only partial boson (with respect to magnetic spin) and still may have the gravitational antiparticle, thus explaining the weakness of the gravitational force.
How to measure such a spin? At first it would be necessary to evaluate, whether it is possible to measure the usual spin of say electron using any modern day equipment. In addition to future gravitoelectromagnetic Earth based source the only object generating strong enough gravitomagnetic field would be rotating Earth [1,2].
The easiest experiment to be done is gravitomagnetic Stern-Gerlach experiment: the spin will exert the force in the gradient of gravitomagnetic field. The gradient of the gravitomagnetic force would be (for Earth):

B_g=[G/(5*c*c)]*[M/r]*[2π/T]

dB_g/dr=-[G/(5*c*c)]*[M/(r*r)]*[2π/T]
Here B_g is gravitomagnetic field of the rotation ball (Earth), G is gravitational constant, c is speed of light, r is the distance from the center of the Earth, M is the mass of the Earth (5.97*10exp(24) kg), T is the period of the rotation (1 day or 86400 seconds).
The known mechanical moment of the elementary particle would be spin of electron, which is S=h/(4*pi). Here h is Planks constant and pi is 3.14159.
For the electron traveling in the gravitomagnetic field gradient the force between the spin up

and spin down particles would be F=2S*dBg/dr (electron will travel in space away from the Earth). Since the gradient is varying with the distance as 1/r^2 law, instead of integration of the force along the path for crude evaluation the distance r is taken to be 8 thousands kilometers (the experiment starts at 6.3 thousands kilometers and ends at 16.3 thousands kilometers). The force for the electron would be:

$F=2S*dB_g/dr=[h/(2\pi)]*[G/(5*c*c)]*[M/r*r]*[2\pi/T]$

F=1*10exp(-55) Newton

For the electron traveling with velocity of 0.1 m/s, the distance is 10000 km (1*10exp(7) meters), the time of travel is 1*10exp(8) seconds (~3 years). Using mass of electron 9.1*10exp(-31) kg and simple formula L=a*t*t/2 the expected separation of the electrons due to ordinary spin at the end of travel would be 5.5*10exp(-10) m (5.5 Angstrom - measurable at modern technology).

More accurate double integration will give the similar result:

$L=[1/v*v]*[h/(2*\pi)]*[G/(5*c*c)]*[M/m]*[2\pi/T]*\ln(R_1/R_o)$

Here v is the velocity of the electron, m is the mass of electron, R_o and R_1 are distance from the center of the Earth at the start and at the finish, correspondingly. L is 6.9 Angstrom.

The largest problem is here: the electron is subject to the magnetic field of the Earth and will travel in a circle around the Earth magnetic field line. The only way to compensate such rotation is to put the compensating electric field in the opposite direction during the whole travel of the electron from start to finish. Despite the keeping the whole satellite all the time around the traveling pulse of electrons is an expensive task, it may be done provided the electrons are moving very slow. The electrons and the satellites may, of course rotate around the Earth in the equatorial plane (otherwise such satellite would not work), slowly moving away from the Earth as the bunch of electrons travels away at a speed of 10 cm/s and the separation due to the gravitomagnetic field gradient accumulates.

Another problem would be the presence of the magnetic field gradient (so the classical Stern-Gerlach experiment would be performed in Earth magnetic field gradient). It is possible to carry the compensating magnetic field gradient on the same satellite as well. Actually while the full compensation of the classical Stern-Gerlach splitting would not be possible, the idea here to see the additional splittings in the final picture. The presence of such splittings would mean the presence of one more quantum number - second spin for elementary particles.

Second spin will allow to hypothesize the presence of heavy particle-gravitational antiparticle virtual pairs in the quantum vacuum (like Higgs - antigravitational Higgs pairs proposed in [13]) and explain the gravitational constant in a way similar to the electrostatic one.

E3.Gravitomagnetic and gravitoelectric field on the Earth. The design of the source.

As it was already mentioned many times the problem with gravitational field is that it is extremely weak. Correspondingly the price tag for any working source of such field here on Earth would be enormous due to necessity to deal with huge masses at motion – hundreds and thousands of tons of fast moving masses. While the detector may be made relatively small to utilize the high gradients of the fields near asperities (the formulas would be exactly the same as for electrostatic and magnetic fields), the source will inevitably be very big and heavy.

The largest problem with the source is the limited tensile strength of even the strongest possible materials. If the massive ball starts to rotate, the centripetal force necessary to maintain its integrity very soon will be equal to tensile strength and the ball will break apart well before the generated gravitomagnetic field will be of some useful value. For example, let's consider the strongest stainless steel with tensile strength of $2.617*10^9$ Pa. For example, the ball with radius of 10 meters made out of such ss steel with density of 8100 kg/m^3 would have the total weight of $3.4*10^7$ kg (34 thousands ton).

Yet the force tearing apart two halves of such ball at rotation (after integration) would be equal to

$F=1/4*\rho*\omega^2*S*R^2$

Here F – the force tearing apart two halves of the ball, ρ is the density of the material, ω is the angular velocity of the rotation, S is the cross-section at the center, R – radius of the ball. By definition of the tensile strength: σ=F/S and in this case the maximum ω for the 10 m radius ball made out of the strongest stainless steel would be only 113.7 sec^{-1}, what corresponds to only 18 rotations per second (period T=0.055 sec). Using formulas from [1] that would generate the gravitomagnetic field of only $5.8*10^{-20}$ Hz (5 orders of magnitude less than the gravitomagnetic field of Earth at equator. The only advantage here would be the exact control of the ball shape. However, the static field generated would be as difficult to detect as any other static field.

Suppose the equator of such ball is covered by asperities of triangle shape with base of around t=1 cm. In this case at rotation frequency of 18 rotations per second near the ball the alternating gravitoelectric field would be created with frequency of $\nu=18*2\pi R/t=1.13*10^5$ Hz – quite high to eliminate any low frequency noise and in the range of the highest possible sensitivity of lock-in detection. The amplitude of the oscillating gravitoelectric field would be:

$\Delta E_g=G*M/R^2-G*M/(R+t)^2=G*M*t/R^3$

Correspondingly $dE_g/dt=G*M*t*18*2\pi R/(t*R^2)=G*M*2\pi*18/R^2$

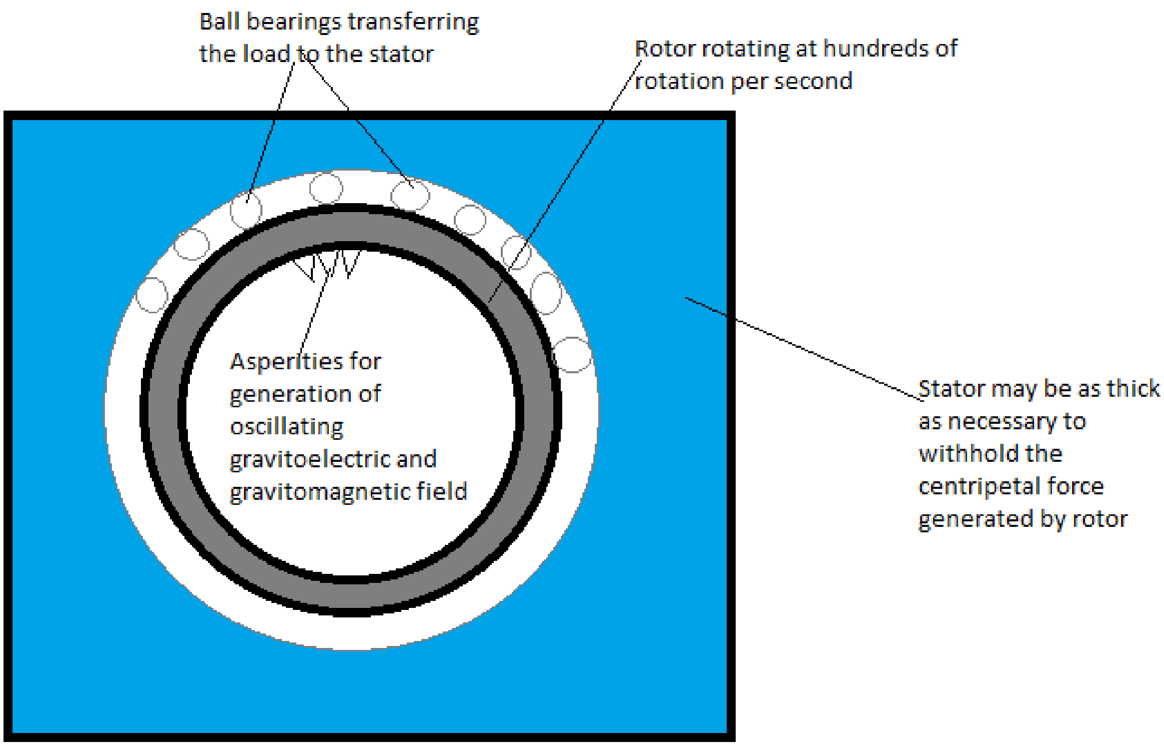
Now from the fourth gravitational GEM equation [1] assuming integration of the gravitomagnetic field along the circle with radius t (1 cm), and integration of the right side over the surface with radius t (exactly like it would be done for the case of Maxwell fourth equation) we would have:

$2\pi t*B_g=dE_g/dt*\pi t^2$

And $B_g=G*M*\pi*t*18/(c^2*R^2)=1.4*10^{-22}$ Hz (8 orders of magnitude less compare to Earth generated static field).

But advantage is here: it is generated at a frequency of hundred kilohertz and thus much easier to handle with. Contrary to static field where any noise will influence the result the powerful filter may separate the response in this case using principle of lock-in (or more advanced analysis in temporal-frequency domain).

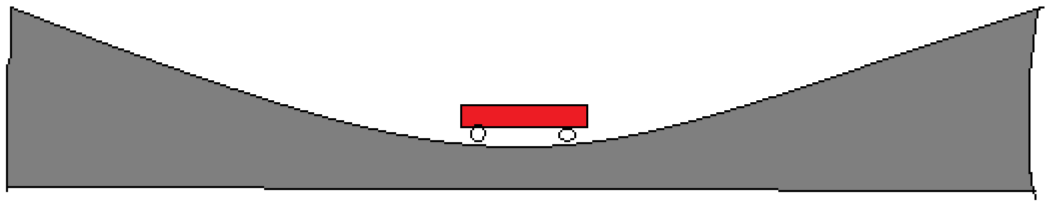
How to improve the source? The easiest idea would be to rotate the supported torus:



In this case it may be assumed that the rotor will be prevented from falling apart not by tensile strength of the rotor material itself, but rather by the strength of the stator, which may be made arbitrary thick. If balls bearings are to be crushed, the sliding bearings may be used. In this case the limiting factor would be the maximum pressure the material will withstand (if the rotation speed is too high, the pressure created by the rotating torus will start to shear the stator away. The maximum pressure stainless steel anvil may hold is 25 GPa ($2.5*10^{10}$ Pa).

Evaluations shows that the torus with median radius of 10 m and thickness of 2 meters square section (total mass of $2*10^6$ kg) may rotate up to frequency of 62.5 Hz before the created by the centripetal force pressure will shear the holding material. That would correspond to still very small static gravitomagnetic field of only $6*10^{-20}$ Hz (and correspondingly only ~10^{-21} Hz of oscillating gravitomagnetic field), but for asperities size of 1 cm the frequency would be 353 kHz – closer to what may be necessary for what may be necessary for combined experiment, where the precession of the elementary particle (electron or nucleus) is generated by the weak magnetic field, but the transition between the levels is generated by the gravitomagnetic oscillating field – magnetic-gravitomagnetic resonance. In this situation the high sensitivity of the magnetic resonance (say NMR) may be utilized to see the very weak gravitomagnetic field if the frequency of such field corresponds to what is necessary for the nuclear magnetic resonance transitions. For such resonances see below.

However, even this approach seems like science fiction for now. Because no material can withstand the rotation of the high masses fast enough for any appreciable effect, it is necessary to utilize the linear motion. For example the high mass cylinder placed on railway platform capable of holding say $2*10^5$ kg (200 tons) may be made even now.



With railway track build in mountains the overall carriage may be easily accelerated to say 100 m/s velocity in the middle of such travel (working like huge pendulum oscillating from one mountain top to another). Assuming the curvature in the middle is absent (almost straight line) this carriage will not create any strong additional pressure on the track thus making the overall idea really feasible (despite still extremely expensive).

The motion of such a cylinder may be theoretically predicted with high precision, so the generated gravitoelectric, gravitomagnetic, and corresponding oscillating fields (asperities are still present) are all known with extreme accuracy. In this situation the pulse generated may be used for numerous experiments and discoveries. For a ss steel with density of 8100 kg/m^3 the cylinder with radius of 1 meter would have the length of 8 meters to have the total mass of 200 tons. Assuming the asperities are still separated by the distance of 1 cm, the frequency of the generated gravitoelectric and gravitomagnetic fields would be 10 kHz with total number of pulses of 800 – enough for reliable lock-in in measurements. Unfortunately, mainly gravitoelectric experiments are feasible in this case – for them the field should be clearly within reach.

F.Combination of the classical charge, magnetic spin, mechanical spin (gravitomagnetic spin) and mass (gravitoelectic charge) may lead to near resonant techniques.

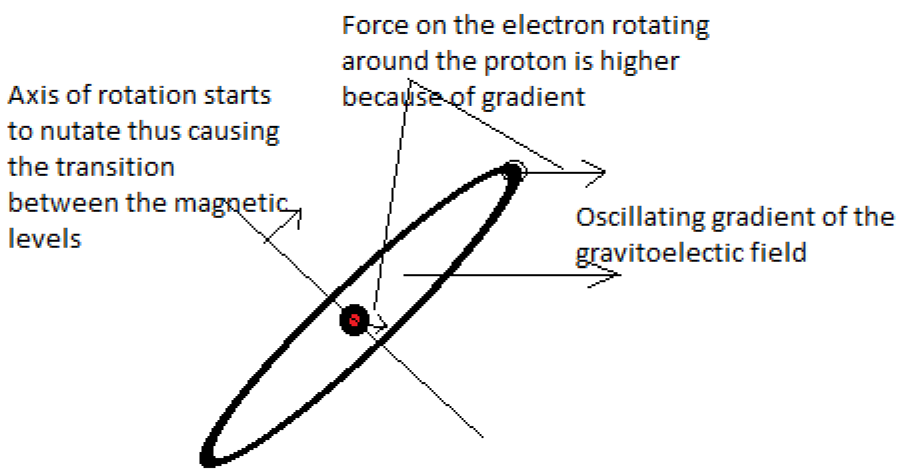
Since the atoms, molecules, radicals, nuclei and elementary particles may have both classical electromagnetic properties and gravitoelectromagnetic properties, some of the combinations of them may work even for relatively small gravitoelectromagnetic fields.

F1.Gravitoelectric Faraday effect.

The easiest would be to create the small oscillations of the charged particles (for example water droplets in the classical Millikan experiment) to observe the oscillations of the electric field created by the oscillating gravity. For the hanging in the strong electric field water droplets with say mass of 10^{-8} kg and charge of around 1000 electrons (the electric field would be no more than 10^9 V/m) the gravitational force in the oscillating gravitoelectric field created by the moving nearby asperities of 10 cm size (mass of around 4 kg) would be equal to $3*10^{-16}$ Newton (and femtonewtons are known to be measured easily already by atomic force microscopy tips). This force, oscillating with the precisely known frequency, would generate the oscillating electric field (because the charge is present) and magnetic field which would be relatively easy to pick up using an ordinary coil around the droplet, similar to Faraday effect, but created by the oscillating gravitoelectric field.

F2.Magnetic gravitoelectric resonance.

The masses in the uniform gravitoelectric field would have the same acceleration, so no transitions between levels are expected. But in the gradient of gravitoelectric field the particle closer to the center of the gravitational pulling body would have stronger force, thus rotating the spin if the angle is appropriate. For example, let's consider the radical H (hydrogen atom) in Rydberg state with high n (main quantum number) and high l- orbital quantum number. In the stationary magnetic field it will start to precess around the main axis of the rotation of the electron around the proton (Ridberg atom may be considered quasi-classically). In the gradient of the gravitational field the electron would be attracted stronger compare to the proton:



If the gravitoelectric field gradient is oscillating with the same frequency as the nutation frequency of the atom (in our case that would be electron paramagnetic resonance frequency determined by the external magnetic field) the electron will have different acceleration compare to proton, and the axis of the rotation should rotate. It means that the oscillating gradient of the gravitoelectric field may work as an analog of the oscillating magnetic field in the case of electron paramagnetic resonance and cause generation of the transitions between states (they may be measured by the same way as the signal of FID – free induction decay in classical EPR). That would be visualized as the magnetic oscillating field. Since the effect of the gravitoelectric field gradient is only possible when the rotation frequency of the orbital moment of the coincide with the frequency of the gravitoelectromangnetic field, the resonance is expected to be as sharp as usual EPR resonance.

A similar idea may be applied to the generation of the NMR free induction decay signal by the gradient of the gravitoelectromagnetic field. In this case the idea of the quantization of the gravitational dipole would be applicable (see chapter 3). The amplitude of the gravitational dipole will strongly depend upon the velocity of the nuclei – the smaller the better, so the experiment is to be performed on ultracold bose-condensate of the atoms. Theoretically EPR-like experiment on ultra-cold atoms may help too, but in this case the orbital contribution just discussed for Ridberg atoms would be prevailing. As far as nuclear gravitoelectric resonance, the frequency would be very different (much higher magnetic field is necessary to cause the precession) very much like the difference in fields and frequencies between EPR and NMR. The resonance here may be very sharp too, but this is a broad field for speculations here.

F3.Magnetic gravitomagnetic resonance and observation of second spin.

If the gravitomagnetic field would be high enough, the set of experiments closer to analog for electromagnetic EPR and NMR may be envisioned. Unfortunately, the direct gravitoelectromagnetic analog of NMR and EPR is not possible even in the very distant future: the static gravitomagnetic field to create the observable separation between the levels is way too high to be produced on Earth. Only a fast rotating neutron star or fast rotating black hole may create the gravitomagnetic field strong enough to correspond to few gauss of the usual magnetic field (this is how much the gravity is weaker compare to electromagnetism). Fortunately, many nuclei and electron and other elementary particles like neutron have both magnetic moment and mechanical spin (for right now they are assumed to be correlated by the gyromagnetic ratio, different for electron and nuclei with no possibility of the presence of the additional mechanical moment not correlated with magnetic). If the hypothesis of second spin is valid (in addition to the mechanical moment associated with electric charge there is another mechanical moment, completely uncorrelated with charge, see above Chapter 5, E2), the experiments with the atom or nuclei or radical, placed in usual magnetic field (precession is generated like in NMR and EPR) may help to reveal such second spin here on Earth, not on a space probe, like in E2. In this case the transitions between the levels, being induced by the gravitomagnetic oscillating field, will create the additional splittings, very easy to see if the second spin is present.

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Chapter 6. Unification of gravity and electromagnetism through the quantum vacuum. Experiments to find cross-members.

While in my opinion the creation of the unified field theory is not possible at all – the number of what we called field is infinite and many of them are to be discovered sooner or later (fifth force, sixth force, seven force etc), it is a possibility to devise the experiments which would demonstrated the cross-members between the different forces – electromagnetism influences gravity and gravity influences electromagnetism. The key here is idea of quantum vacuum.

There is a lot of attempts which were trying to create the complete unified field theory. However, some experiments and observations may help to complete smaller but the most important part - unify gravity with any other fundamental force. The possible way to unify gravity and electromagnetism would be use of idea of common source for both forces - quantum vacuum. Indeed, the idea of the direct influence of the quantum vacuum onto the electromagnetic constants (electric force strength and speed of light) is well established: the virtual pairs of particle-antiparticle (mainly electron-positron) are attenuating the electric field strength (in smaller scale the magnetic field strength) and thus limiting the speed of light. A similar idea about gravity was proposed [1]: a massive pairs particle-gravitational antiparticle in quantum vacuum would be responsible for the main contribution of the gravity strength. However, the charged particles are also having mass and thus more common pairs like positron-electron and proton-antiproton will be influencing the gravity force too. Since the quantum vacuum is the same for both interactions, all of the possible pairs having mass will be responsible for the gravity. But some of such pairs are also having charge. The very strong electric field will be able to polarize the quantum vacuum (electromagnetically responsive part of it), which would influence the speed of light (known phenomenon) and simultaneously the gravitational constant (the phenomenon to be discovered), since any pair which has charge and responded to the electric field has also a mass. In the opposite situation the extremely strong gravitational field excites the quantum vacuum (all of the particles, including those which bear charge) and thus influence the speed of light (this is also known phenomenon - the speed of light is smaller in the vicinity of the star or black hole).
The phenomenon of the influence of the gravity onto the speed of light is well known and usually interpreted as the change of time speed [2]. From quantum vacuum point of view it may be interpreted as the excitation of the quantum vacuum by the strong gravitational field, what leads to the change of the parameters of the electric field constant (permittivity and permeability of free space). Indeed, those parameters are known to be changed in the vicinity of the electron (vacuum screening of electron, see [3], which is a confirmed fact). Why would not strong gravitational field modified the same quantum vacuum in a similar way? All the barionic particles which are responsible for virtual pairs in the quantum vacuum have mass and must respond to the strong gravitational field.
But the gravity is responsible for the presence of space and time in our Universe. As the Universe expands, the gravity potential inside the Universe (away from the black holes and stars) will be smaller and smaller (assuming no new mass is added into the Universe). This will lead to the change of the speed of light (change of both permittivity and permeability of free space) - to the increase of speed of light. This value may be estimated as follows:
Speed of light near the massive ball is (according to Einstein, [2,4]):

$c=c_o-2c_o*\alpha$
here $\alpha=(GM)/(r*c_o*c_o)$
Where G is the gravitational constant, M is the mass of the black hole (star), r is the distance from the center of the star and c_o is the speed of light away from the gravitating star. The value of gravitational potential is expressed as follows:
$\Phi(r)=-GM/r$
$c=c_o+2*\Phi(r)/c_o$
Assuming the whole Universe as a ball partially filled with mass it would be possible to evaluate the speed of light inside such a ball using the formula for calculation of the potential inside the charged ball (the analogy to electrostatic is straightforward). Electric potential inside the uniformly charged ball is [5]:
$\varphi(r)=[k*Q/(2R)]*(3-r^2/R^2)$
Here k is electric field constant, R is radius of ball, r is the distance from the center of the ball, Q is total charge of the ball. Correspondingly for the gravitational potential (for simplicity at the center of the Universe):
$\Phi=-3GM/(2*R)$
Here M is the total mass of the Universe (1.5*10exp(53) kg) , R is the total radius of the Universe (4.4*10exp(26) m) and Φ=-6.82*10exp(16) m^2/s^2 (this parameter is related to the cosmological constant, of course [6]).
Thus we got an equation for the speed of light in gravitation-free space (virtual place because according to Einstein the space-time itself is created by gravity, no gravity means no space):
$c=c_o$-6.38*10exp(16)/c_o
Here c is 3*10exp(8) - is the observable speed of light in the present Universe. Solving the quadratic equation, c_o=4.5*10exp(8) - relatively small change because our Universe is already very inflated.
Assuming no new mass will appear in the Universe, many billions years from now the speed of light will be a just a little larger (if the inflation of the Universe will not influence other properties of the quantum vacuum, for example the probabilities of the appearance of particle-antiparticle pairs).
The difference between the c_o and observed c is due to the polarization of the quantum vacuum by the total masses present in the Universe.
In summary, the same quantum vacuum may be polarized by different fields and this influences the corresponding constants for both electric and gravitational force (because we are talking about the same vacuum). This may help to unify the gravity and electromagnetism
1. Strong gravitational field polarizes the quantum vacuum and changes electric constant (observed through change of speed of light near the star and black hole) [4]
2. Strong electric field changes the permittivity near the charge (vacuum screening of electron [3])
3.Perturbation of the quantum vacuum by the electric field should influence the gravitational constant (because the same virtual pairs would be responsible for both forces)
This experiment is the most difficult one, because the gravitational force so much smaller. In a simple way it should be strongly electrically charged objects in Cavendish experiment on gravity [7], but since the electric force is so hugely strongly compare to the gravity, the change in gravity will be completely invisible. Fortunately powerful lasers may already create the electric

field strong enough to generate electron-positron pairs (breaking the quantum vacuum) are already available [8]. Illumination of the space between the test masses in Cavendish experiment may create the polarization of the quantum vacuum strong enough to be observed through the measurement of the gravitational constant.

4.In principle the polarization of the quantum vacuum by the strong gravitational field will lead to the different outcome of the Cavendish experiment. This experiment may be performed in the vicinity of Sun or Jupiter and the observed result will be a little different compare to Earth experiment. Such idea may be even closer to the reality because the satellites traveling close to Sun or large planet are already present. Another experiment is to be performed beyond the Pluto orbit, see chapter 2.

The discoveries of the more elementary particles which would be present as virtual pairs in the quantum vacuum will eventually allow to calculate exactly the strength of electromagnetic constants and gravitational constant from the same principles and general formulas, effectively unifying both fundamental forces [2].

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Conclusions.

In this publication the author outlined his approach for the search of new physics based on his experience as experimentalist physicist. Contrary to theoretician's approach, I am not relying onto the properties of the Universe as a whole to simplify the picture of the physical interactions, rather proposing the search of new experimental discoveries on the outskirts of the existing research fields. Some of the outlined ideas are not new (high gravity of slow photons and equivalence principle violation, quantum vacuum and force of gravity, superluminal velocity under the barrier, non-zero rest mass of photon), some of the ideas are relatively new but all of them rely more on experiment to be done rather than on theory development (much more expensive approach but assuming the crisis in modern physics seemingly the only possible).