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Gravitation as a Secondary Effect of Electromagnetic Interaction

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Abstract

The unification of gravitation and quantum physics is a still unsolved problem. A convincing solution is not in sight and a simple solution is virtually excluded. It seems that modern physics entered into a dead end here. Most of the proposals for solution try to enforce a breakthrough in the pursued direction with ever more complexer approaches. However, there is a path to circumvent these difficulties. By abandoning one of the prerequisites of the General Relativity Theory, a new degree of freedom is won in return. With that, a theory of gravitation can be formulated, wherein the unification of the forces is possible. In the following, we start with the assumption, that gravitation can be understood as secondary effect of electromagnetic interaction. In doing so, the unification of the forces is taken as a prerequisite and is imposed as a new basic postulate. The covariance principle, a pillar of the General Relativity Theory, is abandoned instead. Under these assumptions, a consistent model of gravitation can be established and justified. It describes gravitation with a variable index of refraction of the vacuum and leads, as a consequence, to a system of variable scales. In weak gravitational fields, the theory agrees well with the General Relativity Theory. In strong fields, however, fundamental differences arise.

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Variable Scales

What would happen, if all things became yet only half as large over night? This philosophical question was posed several times already. Would we recognise the modification? If we assume all standards of comparison having shrunk in the same way, the immediate answer is: No, we would not recognise any difference. Of course, it is not done with the change of the lengths because one could indirectly notice a modified fall velocity or a modified inertia. If, however, the mechanical values would vary in a consistent manner as e.g. Dehnen, Hönl and Westpfahl [1] presented, the value of the local scales can, in principle, not be determined on the basis of a local measurement. From the local invariability of the velocity of light does not necessarily follow, that it is equal at all locations and times. Einstein has introduced the invariability of the speed of light in his Special Theory of Relativity [2] explicitly as postulate.

If Einstein's postulation is weakened accordingly and one only state, that a local measurement always results in the same value c0, then this does not contradict reality, even if the speed of light – and thus, all scales – should vary significantly. We now take this degree of freedom and develop a theory of gravitation, which is based on a system of variable scales and understand gravitation as the effect of a variable index of refraction of the vacuum.

This can be seen, of course, only as another finger exercise, how gravitation can be described in an alternative way. But our claim goes substantially deeper. The greatest efforts of theoretical physics were invested into the unification of General Relativity and quantum physics. As of now, no success is looming and a simple solution is out of reach with the current approach. If it is possible, however, to describe gravitation with a variable index of refraction, then the unification of both worlds is included in the preassumptions already. Gravitation would be a secondary effect of the electromagnetic interaction. The Gordian knot would be cut. The approach is definitely audacious, but in the face of the prospective goals, this attempt should not be put aside carelessly.

Light in a Gravitational Potential

Einstein himself tried to extend his Special Relativity Theory with the assumption of a variable speed of light in a paper of 1911 [3] to describe the effects of gravitation in this way. His starting point is the principle of equivalence. It says that a uniformly accelerated reference system is equal to a system that rests within a field of gravitation of equal gravitational acceleration. This shall be valid for all physical properties without exception. From that, Einstein deduces the deviation of clocks and the red-shift in the gravitational field. He had not done the transition to the geometric interpretation of gravitation in the form of the curved space-time at that time, yet. And so, he stayed for now at the flat Minkowski-space of Special Relativity and he assumed a reduced velocity of light in the gravitational field. His calculation for the deviation of a light beam grazing the surface of the sun by 0.83 arc seconds delivered a value that turned out to be wrong by a factor of 2. The reason for that was, that he silently assumed the spherical potential of the sun to be spatially homogeneous and so he did not take into account the curvature of space or rather the contraction of the wavelength of light. Because of that, the preconditions for the correct calculation were not given. However, from the wrong result it does not follow, that the access via a variable speed of light is fundamentally wrong. Einstein's knowledge of gravitation simply was not mature enough at that time. We take this approach again and try to get a consistent description of gravitation using light walking this very same path.

We consider a laboratory in space that is freely falling directly towards the sun. An experimenter in the laboratory is directing a laser beam backwards from the sun to an opposite receiver. The transmitter laser and the receiver shall be positioned fixed in the space laboratory. No gravitational effects (in first order) arise for the observer, because there is zero gravity in the laboratory. He measures the same frequency the laser is specified for at the sender side as well as at the receiver side. He compares the frequency with his clock and does not observe any deviation. He also verifies the wavelength of the laser beam with his length scale and gets the same result.

A second observer shall be in the laboratory, who wants to find out how the gravitation of the sun affects light. He knows about the acceleration of the lab associated with the gravitational force. Because the receiver is accelerated during the run-time of the light beam in direction of the transmitter, he estimates a blue-shift and accordingly, a reduction of the wavelength for a measurement located at the receiver due to the Doppler-shift acting on frequency and wavelength. The observer concludes, that the gravitational field must have exactly the opposite effect to cancel out both, because the experimenter is not able to measure such a Doppler-shift.

We assume without loss of generality that the laboratory and, thus, the transmitter is at rest at t D 0. The receiver, though, is accelerated during the run-time of the light beam through the lab across the distance h for the time t D h=c to the velocity v D gh=c. It should occur a blue-shift of the frequency R, measured at the receiver with respect to T, measured at the transmitter. The potential ' within the space-lab can be assumed to be homogeneous, because the extension of the laboratory compared to the variation of the attracting force in the potential of the sun is small.

$$\frac{\nu_R}{\nu_T} = 1 + \frac{v}{c} = 1 + \frac{gh}{c^2} = 1 + \frac{\varphi}{c^2} \quad \text{with} \quad \varphi = gh \ll c^2 \qquad (1)$$

Because of that, the observer concludes that the frequency of the laser beam is red-shifted for the same amount, when leaving the gravitational field. He also observes, that clocks are running slower by this factor in a gravitational field (at the transmitter).

The same consideration he makes for the wavelengths. Because the receiver is accelerated towards the sender, he expects a contracted wavelength at the receiver. The observer concludes, that the wavelength of the laser beam – in each case measured locally – is stretched by the same amount when leaving the gravitational field.

$$\frac{\lambda_R}{\lambda_T} = 1 + \frac{v}{c} = 1 + \frac{gh}{c^2} = 1 + \frac{\varphi}{c^2} \qquad (2)$$

Hence, wavelengths are shorter in a gravitational field.

If now the laboratory is held in levitation by a rocket drive or stands on a planet surface, then the compensating Doppler-shift of the acceleration is not there anymore. Now, a local measurement at the transmitter still delivers the specified values of the laser frequency and wavelength. But the frequency is reduced at the receiver, if locally measured, and the wavelength is elongated. Therefore, the locally measured velocity of light is unchanged. However, the conclusion of the speed of light being a global constant is not yet mandatory.

A laser itself is an excellent time and length scale. For that reason, the official definition of time- and length-scales is based on the frequency of an atomic transition of cesium and the distance that light covers in a certain time interval. If we take a laser as reference scale for the measurement of the local speed of light, we must keep in mind that its frequency and wavelength is underlying the same gravitational changes as the laser beam through the lab. Therefore, a local measurement of the velocity of light always shows the constant value c, even if the speed of light should vary spatially or temporally. The supposed prove of the universal constancy of the speed of light by means of a local measurement represents a circular argument.

Within these considerations we assume, that space-time is flat and time- and length-scales change indeed. And we assume that the velocity of light is variable. Contrary to it, General Relativity Theory assumes, that clocks, length-scales and the speed of light are unchanged, but the curved space-time makes sure, that times and lengths seem to be modified. But this is more a question of view than of being. Because both definitions describe the same observations, they can be considered as equivalent, at least in weak gravitational field. We prefer a physical view as represented by the variable speed of light, because it offers a better access for energetic considerations. The geometrical representation of the curved space-time is more a mathematical description of an underlying physics. About this physics strictly speaking, however, nothing is declared.

Now we take the location of the receiver as fixed point of view. He measures a reduced frequency in our thought experiment. Because the potential is temporally constant, he concludes that the light beam was emitted already with the lower frequency. He knows that clocks run slower at the transmitter than his own clocks and also, that the wavelength at the transmitter is contracted. From his point of view energy conservation is valid for the light beam and with E D h the frequency stays constant along the beam, whereas, the wavelength is stretched two times, thus, by the factor .1 C '=c2/2 to arrive at the receiver with greater wavelength. Thus, he concludes on a change of the velocity of light of

$$\frac{c_R}{c_T} = \frac{\nu_R \lambda_R}{\nu_T \lambda_T} = \frac{\lambda_R}{\lambda_T} = \left(1 + \frac{\varphi}{c^2}\right)^2. \tag{3}$$

A complementary situation arises, if a light beam moves through a spatially constant potential, but this potential shall change over time, e.g. it is continuously decreasing. The observer measures a frequency R and a wave-length R. He knows, that T and T were greater at the emission than the standard values, because the potential ' was higher than at the receiver-side measurement. Because of the temporally variation of the potential the energy is not preserved in this system, but the momentum is. Due to the flat potential r D F D 0 there is no change of the momentum F D dp=dt D 0. And with the photon momentum p D h= it follows, that the wavelength does not change along the path of light. This was already recognized by R. Dicke [4]. If we describe a temporal change of the gravitational potential with a variable speed of light, then it is:

$$\frac{c_R}{c_T} = \frac{\nu_R \lambda_R}{\nu_T \lambda_T} = \frac{\nu_R}{\nu_T} = \left(1 + \frac{\varphi}{c^2}\right)^2 \tag{4}$$

The change of the speed of light is expressed here by the modification of the frequency. When emitted, the frequency is higher than the standard value and it is lower at the receiver. A redshift is expected. The reference point is at the receiver, as mentioned. Here is the zero point of the potential and we obtain the standard value for the speed of light c0. According to these considerations, we can regard the expression

$$n = \frac{1}{\left(1 + \frac{\varphi}{c^2}\right)^2} \approx 1 - \frac{2\varphi}{c^2} + \ldots \tag{5}$$

as the relative polarizability of vacuum, which describes the propagation of light and at the same time, the effect of gravitation on light. Thus, we will regard c as variable velocity of light and c0 as the standard value of a local measurement. In General Theory of Relativity, the variable speed of light c is called “coordinate velocity”.

$$c = \frac{c_0}{n} \tag{6}$$

Former Works about Gravitation as a Light Phenomenon

In 1921 Harold Wilson showed, that a variable polarizability of vacuum effects a force onto a charged particle, which can be interpreted as gravitational force [5]. His model included the correct twice as large deflection of light at the sun. Based on this work, Robert Dicke extended in 1957 this insight by explaining three classical tests of General Theory of Relativity by means of a variable refractive index of vacuum [4] [6] (not the scalar-tensor theory). Almost at the same time also H. Dehnen, H. Hönl and K. Westpfahl [1] and later Jan Broekaert [7] demonstrated, that the four classical tests including the perihelion shift of Mercury can be described with the model of a polarizable vacuum. All four classical tests are based on effects of a weak gravitational field. Because General Theory of Relativity as well as the theory of polarizable vacuum have the same solution in weak fields, there is no possibility to decide in favor or against any of the theories. In strong fields, however, both models differ essentially.

James Evans, Kamal Nandi and Anwarul Islam presented a method that enables the exact calculation of the propagation of light and also the movement of matter through a medium of variable index of refraction n [8]. Their method is a manifestation, that gravitation and light are of the same nature and can, therefore, be described by a uniform formalism.

As summarized by Harold Puthoff [9] in a more easily readable way, many values also become dependent on n within a theory of variable speed of light. Alexander Unzicker gives a good overview of the state of the theory in [10].

Many of the authors mentioned regard the formulation with variable speed of light only as a more intuitive and mathematically easier access to General Relativity, whose correctness they do not have doubt about. But it shall be reminded here, that it is not about correctness or falseness of a theory. According this narrow-minded view also Newton's theory is "wrong". Not only because it is inaccurate, but first of all, because it is based on conceptions, which are not valid from a today's point of view any more. Nevertheless, Newton's theory reliably delivers answers on questions to nature within the boundaries of its validity. Nothing more than that can be expected from a theory. And the question, whether the principles of a theory are "correct", can only be judged from the perspective of another theory based on the assumption of fundamental principles on its part as well. The truth itself is not available.

Naturally, there are better and worse models of reality. The criteria, though, are such as the area of validity, the number of necessary parameters, or simplicity.

An essential shortcoming of the previous literature is a certain carelessness of how a "variable velocity of light" is to be understood at all. George Ellis [11] argues righteously, that the naive assumption, photons would not move always with the "speed of light", immediately leads to the question, how to deal with the limit velocity c, which is deep-seated in many physical relations. Each of his particular points of criticism is to be agreed and indeed many papers suffer from the fact, that only certain partial aspects of a variable speed of light are targeted and the consequences are not thought through until the end. It is clear, that the whole network of relations is affected in a consistent formulation.

Ellis considers that both velocities occur inevitably in a theory of variable speed of light and interfere in a problematic manner. Hence, every theory with variable speed of light would be doomed to failure. He argues, that if all units are rescaled, a world would arise, which is indistinguishable from the original one as long as the numerical value of unit-less values like the fine structure constant α remains constant. With that, theories, that propagate a variable speed of light, do not generate new physics, but only a different scaling.

First of all, this is a completely correct and important result. It means that physics always looks identical to a local observer, even if the speed of light would change. A local observer always has the freedom to set the refractive index of his location to one. If it would be only a question of the physics of a local observer, then a modified refractive index of the vacuum could be regarded as a rescaling, meaningless for the physics. And the chapter "variable speed of light" confidently could be concluded. But the story only begins at this point.

The question, whether there is new physics for a local observer in case of a variable speed of light, does not hit the root of the matter. Because what happens, if two locations have a different gravitational potential? How gravitational red-shift is to be interpreted e.g.?

The General Relativity Theory describes this effect with a deformation of space-time at a place with stronger gravitational potential under preservation of the speed of light and the speed of clocks. But it is possible as well, to constitute, that clocks really are running slower in a gravitational field. In a consistent model, a reduced speed of light is involved then. However, the space-time remains flat instead. Now two distinct velocities of light arise in fact: that of the observer and the reduced one at the location of the stronger gravitational potential. But only at the particular locations.

The author believes, there is a fundamental misunderstanding, that is also provoked by the advocates of a variable speed of light, because they are not sufficiently clear about the consequences of such a theory. It is premature, however, to deny the whole concept.

The key to a consistent representation is, at every assignment, to pay strict attention to having in mind the reference point. A fictitious reference observer at a constant potential provides valuable services here. Local measurements always are identical to the standard theory. At non-local relations, we are talking solely about the ratio of values to the reference point. The index of refraction is a pure relative measure in the theory of variable speed of light. Exept for dimensionless quantities like the fine structure constant, there are no absolute quantities. Then it becomes clear, that the same physics can be described in two different ways at least in weak gravitational fields.

However, contrary to a curved space-time, the assumption of a space with variable index of refraction, opens a new perspective how to establish the laws of gravitation. Einstein took the covariance principle as a basis of the General Theory of Relativity in addition to the equivalence principle. As solid and closed the Theory of Relativity looks like in modern formulations, the discussion about the foundations is still ongoing. Einstein himself changed more than once his line of reasoning during the development and also after the completion of his theory. John Norton gives an extensive summary about these developments in [12]. Already in 1917, Erich Kretschmann published an article [13], in which he showed, that also Newton's gravitational theory can be formulated covariant. Even, if it is argued from today's view, that the General Theory of Relativity in conjunction with the covariance principle enables an especially simple formulation and so the covariance principle has a special position, the physical relevance of the covariance principle is weakened after all.

In that sense, now we examine how values behave in a vacuum of variable index of refraction.

Unit Considerations

The following considerations extend the already found relations to further quantities. It is important to make oneself aware of the index of refraction n being a purely relative quantity. This means, it is a comparison between an observer, whose potential is taken as a reference with refractive index n D 1 by definition, and locations with different refractive index. n always describes the relative difference but not an absolute value.

There are essentially two situations, which have to be distinguished:

A measurement is related to the location itself, at which it is conducted (local measurement). Then, the index of refraction n is equal one by definition and there, the standard value of each quantity is valid, explicitly indicated by index "0".

An observer is located at the reference potential and evaluates measurements at a location with different gravitational potential. The scales, clocks and reference masses arranged at reference potential look different to him at the location of the experiment. The local experimenter takes the modified scales as a reference for his tests. Then, the following relations are valid.

Starting point is the definition of the refractive index n on the basis of the speed of light:

$$c = \frac{c_0}{n} = \frac{c_0}{\kappa^2}, \quad \text{with} \quad \kappa := \sqrt{n}$$

Many expressions can be written more simply with the red-shift factor here introduced. We will use practically synonymously to the refractive index n.

As shown above, clocks run slower in a gravitational field, periods are longer, frequencies smaller:

$$\nu = \frac{\nu_0}{\kappa} \qquad (7)$$

The wave-length of light is smaller, lengths are shortened:

$$\lambda = \frac{c}{\nu} = \frac{c_0/\kappa^2}{\nu_0/\kappa} = \frac{\lambda_0}{\kappa} \tag{8}$$

The Planck quantum of action h being unaffected by the gravitational field is an assumption.

Dehnen, Hönl and Westpfahl present a plausible rationale in [1]. Dicke's argument is, that the angular momentum h for a circular polarized photon would not be preserved [4]. From the constancy of Planck's constant, we conclude the energy dependency, which, therefore, varies like a frequency:

$$E = \frac{h\nu_0}{\kappa} = \frac{E_0}{\kappa} \tag{9}$$

This relation is valid not only for photons, but also for matter. If a piece of matter is being moved slowly downwards in the field of gravity, its rest energy is being decreased by detracting gravitational binding energy. This happens in concordance with Special Relativity Theory, whose validity is assumed without restriction.

According to E D mc2, the inertia of matter is increased threefold by this factor:

$$m = \frac{E_0/\kappa}{c_0{}^2/\kappa^4} = m_0\kappa^3 \tag{10}$$

Because the speed of light c is a constant in standard physics, mass and energy are used virtually synonymously, up to the convention setting c D 1. Then mass and energy are even regarded as identical. At a variable speed of light this is not possible any more this way. Energy is the root cause of gravitation. Therefore, the "heavy mass" is described best with energy. Now it is a little bit decoupled from the "inert mass", which more adequately is expressed in kilograms. Nonetheless, the equivalent principle is valid further. Only the conversion factor now is not constant any longer.

Planck's constant has the unit Js. If the modification of all times, lengths and masses according to above relations is assumed, all variabilities cancel each other. The prior accepted assumption of the constancy of h, thus, turns out to be consistent.

$$[h] = \mathrm{J\,s} = \frac{\mathrm{kg\,m^2}}{\mathrm{s}} \tag{11}$$

These relations are valid in strong gravitational fields as well by definition. Additional relations can be stated by consideration of the units.

Newton's gravitational constant is decreased in the gravitational potential, because all lengths, times, and inertias vary:

$$G = \frac{G_0}{\kappa^8} \quad \text{due to} \quad [G] = \frac{\mathrm{m^3}}{\mathrm{kg\,s^2}} \tag{12}$$

Einstein's gravitational constant, however, is independent of a variable polarizability, because the variabilities cancel each other.

$$\varkappa = \frac{8\pi G}{c^4} = \text{const} \quad \text{due to} \quad [\varkappa] = \frac{\mathrm{s^2}}{\mathrm{m\,kg}} \tag{13}$$

The fine structure constant ‚ is constant in any case, because all units and, hence, all values changing in the gravitational field cancel each other.

$$\alpha = \frac{e^2}{4\pi\varepsilon\hbar c} = \text{const} \tag{14}$$

An acceleration g is decreased, because it is composed of lengths and times, whose modification we already know. Gravitational forces Fg stays constant, because the decrease of acceleration is nullified by the increase of inertia:

$$g = \frac{g_0}{\kappa^3} \quad \text{due to} \quad [g] = \frac{\text{m}}{\text{s}^2} \tag{15}$$

$$F_g = mg = m_0 g_0 = \text{const} \tag{16}$$

Looking at the electric and magnetic field quantities, the unit Ampere comes into the game:

$$[\varepsilon] = \frac{\text{A s}}{\text{V m}} = \frac{\text{A}^2\,\text{s}^4}{\text{kg m}^3} \quad \text{and} \quad [\mu] = \frac{\text{V s}}{\text{A m}} = \frac{\text{kg m}}{\text{A}^2\,\text{s}^2} \tag{17}$$

Assuming, that the elementary electric charge is a preserved value in the gravitational field, currents transform inverted to times:

$$I = \frac{I_0}{\kappa}, \quad \text{then} \quad e = \text{const} \quad \text{due to} \quad [e] = \text{A s} \tag{18}$$

Then and only then the field quantities of vacuum vary in equal fashion:

$$\varepsilon = \varepsilon_0 \kappa^2 = \varepsilon_0 n \quad \text{and} \quad \mu = \mu_0 \kappa^2 = \mu_0 n \tag{19}$$

Ampere is canceled out anyway in the relation of the velocity of light, though. The constancy of electrical charge in the gravitational field is no unavoidable choice, therefore, and leaves the door open to the possibility of alternative descriptions.

$$c = \frac{1}{\sqrt{\varepsilon\mu}} = \frac{c_0}{n} \tag{20}$$

electrical force Fe between two elementary charges separated by a distance d does not show any variability as well, although the physical mechanism is different:

$$F_e = \frac{e^2}{4\pi\varepsilon d^2} = \frac{e^2}{4\pi\varepsilon_0\kappa^2 {d_0}^2 \kappa^{-2}} = \text{const} \tag{21}$$

A number of elementary physical lengths are compounded out of universal constants and scale according to these rules just as lengths with 1/κ.

$$\text{The Bohr Radius} \quad a_0 = \frac{4\pi\varepsilon_0\hbar^2}{m_e e^2} \tag{22}$$

$$\text{The Compton wave-length} \quad \lambda_C = \frac{h}{mc} \tag{23}$$

$$\text{The classical electron radius} \quad r_e = \frac{e^2}{4\pi\varepsilon_0 m_e c^2} \tag{24}$$

Moreover, e.g. in a Lennard-Jones potential, the energy minimum is shifted following the same relation. Thus, there are good reasons to assume, that all atom- and molecule distances and, therefore, any material length scale is modified in equal manner just as a length scale in form of a laser.

As mentioned above, these relations present themselves in this way to an observer at the reference location, if the refractive index does not change over time for the investigated object. If movements in a gravitational field are analyzed or if there are temporal changes, then additional considerations have to be made.

Equivalence Principle

How does the situation look like to a local experimenter? This is a measurement related to the local place as its point of reference. Such a measurement is a comparison of a measurement value to a local scale, which, however, underlies the variabilities of the gravitational field as well. At all times nlocal D local D 1 for a local observer.

An experiment to determine Newton's gravitational constant G would end up for instance, as follows: at first, an experimenter measures the mutual attractive force of two test masses M and m separated by the distance d at reference potential with n D 1 by means of a Cavendish balance.

$$G_0 = \frac{F_{g0}\, {d_0}^2}{m_0\, M_0} \tag{25}$$

He obtains the standard value for G. Now he transfers the experiment to a place with deeper gravitational potential nearer to the sun.

An observer, who remained at the reference point evaluates the execution of the second experiment. He gets the result, that the experimenter measures the same force, but the inertia of the test masses has increased. In exchange, though, the distance of the test masses is less than that at the reference experiment. From his point of view, G changes to:

$$G = \frac{F_{g0}\, {d_0}^2 \kappa^{-2}}{m_0 \kappa^3 M_0 \kappa^3} = \frac{G_0}{\kappa^8} \tag{26}$$

From the view of the local experimenter, however, the measurement value did not change. The Cavendish-balance stayed the same. The test masses are unchanged from his point of view and all dimensions of the balance are the same in relation to the local measurement equipment as they were at the reference experiment, although they have shortened in the prospect of the reference observer. The force also did not change its value. For the local experimenter, the value of G also stayed unchanged.

$$G_{\text{local}} = G_0 \tag{27}$$

These considerations, though, only prevail, because all included values here underlie the same variation of the refractive index n. If the sun is taken as test mass M and we investigate the effects of a spatial variation of n within the solar system onto a test mass m, the mass of the sun M stays at its location, the index of refraction n, however, changes for m in case of its displacement, but not for M.

Another interesting question is the ratio of electrical force to gravitational force in a changed gravitational potential.

If we look at the electrical force Fe D e2=4"d2 and the gravitational force Fg D Gmpme=d2 between a proton and an electron, then their ratio is independent of the distance and also of the refractive index. Therefore, it does not change its value.

$$\frac{F_e}{F_g} = \frac{e^2}{4\pi\varepsilon G m_p m_e} = \frac{e^2}{4\pi\varepsilon_0\kappa^2 G_0\kappa^{-8} m_{p0}\kappa^3 m_{e0}\kappa^3} = \frac{e^2}{4\pi\varepsilon_0 G_0 m_{p0} m_{e0}} = 2.3\times 10^{39} \quad (28)$$

Because of that, it is not possible to draw any conclusion towards the gravitational potential out of a precision measurement of this ratio.
In general, it has to be stated that there are no absolute values in the theory of variable speed of light. Distances, velocities and frequencies can only be defined in relation to a reference and have validity only as comparison values. The index of refraction n is only of relative relevance, too. It only expresses the difference of the velocity of light for different locations. The space looks locally identical for each observer. That is nothing else than the Equivalence Principle of General Relativity Theory.

When we considered the units, we have transferred the found relations for mass, frequency and length to other quantities compounded of these units like acceleration and force. In order to get a well-defined framework, it must be assumed, however, that the Heavy Mass is transformed in the same manner as the Inertial Mass. Otherwise, the gravitational force would be distinguishable from the inertial force. Hence, the Equivalence principle is an implicit request of the theory.

The Equivalence Principle is a basic assumption of General Relativity Theory, too, but its assumption does not determine the form of the field equations unambiguously. Einstein decided, that beyond this, the Covariance Principle shall be valid [14]. While the equivalence principle is a strong argument supported by evidence, the covariance principle merely is an argument of mathematical beauty and does not arise from a physical necessity. In the author's opinion, this degree of freedom can be used in a better way, namely the unification of gravity and quantum physics. In the approach outlined here, therefore, the basic assumption, that gravitation is an electromagnetic phenomenon, takes the place of the covariance principle.

Homogeneous Gravitational Potential

We have examined a continuously accelerated laboratory in free space for weak fields. This situation is equivalent to a homogeneous gravitational potential with constant spatial gravity acceleration g, that can be described with ' D gh. Here, h is the height difference in the homogeneous potential. We do not restrict ourselves on weak fields any more, however, and we follow Dehnen, Hönl and Westpfahl how to extend the results on strong fields [1]. We start with equation (1).

$$\frac{\nu}{\nu_0} = 1 - \frac{gh}{c^2} = 1 - \frac{\varphi}{c^2} \quad (29)$$

That means an observer at the location h D 0 observes a light beam propagating from him to position h. The frequency there is red-shifted for the receiver, if h is positive. As long as gh c2, 0 can be regarded as constant. If we look at the situation more closely, we must incorporate, though, that the change of the frequency actually is related to the local frequency, which will vary with the propagation of the light beam noticeably against the starting frequency 0 at some point. Then, the frequency change does not simply add up linearly, but obeys an exponential law.

$$\frac{\mathrm{d}\nu}{\nu} = \frac{g\mathrm{d}h}{c^2} = \frac{\mathrm{d}\varphi}{c^2} \quad (30)$$

$$\int_{\nu_0}^{\nu} \frac{d\nu}{\nu} = -\int_0^h \frac{g}{c^2}\mathrm{d}h \quad (31)$$

$$\ln \nu - \ln \nu_0 = -\frac{gh}{c^2} \quad (32)$$

$$\frac{\nu}{\nu_0} = e^{-gh/c^2} = e^{-\varphi/c^2} = \frac{1}{\kappa} \quad (33)$$

$$\kappa = e^{gh/c^2} = e^{\varphi/c^2} \quad (34)$$

So far Dehnen, Hönl and Westpfahl. About the definition of $\kappa = \nu_0/\nu$ can be said in reverse:

$$\frac{d\nu}{\nu} = \frac{d\varphi}{c^2} = -\frac{d\kappa}{\kappa} \quad (35)$$

The red-shift factor and, thus, the index of refraction n are equal to one at D $_0$ by definition.

At this point now we must be very careful. We have seen, that almost all values that we were so sure about, all of a sudden seem to be uncertain. They depend on the index of refraction and we cannot simply use the reference values any more. At the starting point, we can use the reference values g_0, dh_0, c_0^2 for g, dh and c^2. Here is D 1 by definition. But when and with it also the index of refraction has noticeably changed, the observer at the reference point must use indeed the values of the location of the measurement related to the reference point g_0 [3], dh_0 [1], c_0^2 [4]. The acceleration etc. at the location of the measurement indeed is not g_0 any more from the view of the reference observer. The local observer, in contrast, still measures g_0.

$$\frac{g}{c^2}\, dh = \frac{g_0\, \kappa^{-3}}{c_0{}^2\, \kappa^{-4}}\, dh_0\, \kappa^{-1} = \frac{g_0}{c_0{}^2}\, dh_0 \quad (36)$$

As we can see, the variations by the variable index of refraction cancel each other and the starting values preserve their validity. Hence, a measurement related to the location itself is allowed to calculate with the same values, too. This is, though, not at all self-evident and as we will see, the exact assignment of the reference values is of significant importance. Here it is successful, because all measurement values are related to the same location. And because the exponent does represent a unit-less quantity, all units cancel each other, their correction factors included.

Additionally, a conceptual difficulty becomes evident here, namely the definition of distance. As already mentioned, a flat space is assumed. The reference observer places a coordinate system across the three-dimensional space without regarding the spatial variation of the index of refraction as it does the observer of the Schwarzschild-metric as well by the way. His location and distance indication is always related to this coordinate system related to the reference. The boundary of integration of equation (31) is still h, because it represents the location coordinate of the reference observer. In contrast to this a reference observer valuates the amount of the shift dh with the factor 1, because lengths look shorter to him than for the local observer.

The distance to location h can be defined in a different way by local scales stringed together as well. This distance does not agree, though, to the coordinate distance in the reference system, but to the spatial line element $^R ds$.

The exponential form of the index of refraction of equation (34) has been discussed in the literature several times already. Robert Dicke obtains this form from different reasons in his second paper to that subject [6], Huseyin Yilmaz [15] and Kris Krogh [16] as well. Even Einstein indicated this form of red-shift in a work of 1907 [17] (on page 457 of the original publication), with the hint, that otherwise the zero point of the potential would be exceptional.

The Potential of the Universe

Even if a description was found with this form of the refractive index, which passes the classical tests of General Relativity, because they all happen in the weakfield, the question of a solid physical basis remains. The fact, that this form of the index of refraction can be deduced by mere application of the laws of Special Relativity, we regard as the most important property of this theory. This is because frequency corresponds to the energy E D h. Indeed, this is true not only for the energy of a photon, but also for the rest energy E_m of a massive test body of mass m in general. Without doubt, the rest energy is reduced, if the test body is transferred to a lower potential. In the Newtonian model, the released potential energy is simply linear to the height h.

$$E_{\text{pot}} = mgh \qquad (37)$$

Because there is no concept of rest energy in Newton's model, the potential energy exists simply as separate value.

According to Special Relativity, the rest energy of the test body is reduced by the potential energy. And like the frequency becomes smaller and smaller due to the exponential law, but never reaches zero, also the test body emits a ratio proportional to its remaining rest energy E_m and not to its rest energy at the starting point E_{m0}.

$$\frac{\mathrm{d}E_m}{E_m} = \frac{g\mathrm{d}h}{c^2} \qquad (38)$$

Hence, the result is an exponential law for the frequency instead of a linear one.

$$\frac{E_m}{E_{m0}} = e^{-gh/c^2} = e^{-\varphi/c^2} = \frac{1}{\kappa} \qquad (39)$$

Thus, it is clear, that the application of the laws of Special Relativity Theory is sufficient for a consistent theory of gravitation. The covariance principle is not necessary.

If we take our basic intention seriously, namely that the refractive index of the vacuum is able to describe the effect of gravitation correctly, then the cause of gravitation lies in the mutual electromagnetic interaction of matter. There is no direct electrical attraction or repulsion of stars or galaxies, because ordinary matter consists entirely of charged particles, in fact protons, neutrons – which is included here due to its inner structure – and electrons, and mostly their charge is balanced. Nonetheless, all charged particles are in steady exchange with other charged particles in the universe as far as light reaches. The interaction is stronger for smaller distances and larger aggregations of matter. This sea of virtual photons can be regarded as the reason of the polarizability of vacuum. In the vicinity of a large mass, the polarizability of vacuum, thus, is increased compared to the uniform background. It can be described by a respective increase of the refractive index. And a gradient of the polarizability and the index of refraction leads to a force via a gradient of the rest energy of a test particle, which can be seen as gravitational force.

Now let us see, how this sea of virtual photons can be associated with a gravitational law. As the magnitude of the potential created by a near star can be determined, so the effect of the entire matter in the universe onto the location of the observer can be regarded as a potential, which certainly can be assigned a meaningful number to. The contributions of all matter particles simply have to be superposed. If we assume a plain matter density as an unsophisticated world model, then it has the same value 'u in the whole universe, because no point in this universe is distinguished.

If we again recapitulate equation (30) in a homogeneous gravitational potential

$$\frac{\mathrm{d}\nu}{\nu} = \frac{g\mathrm{d}h}{c^2} = \frac{\mathrm{d}\varphi}{c^2},$$

then we set a relative frequency change equal with a potential change to c^2.

The unit of c^2 is that of a potential. c^2 was associated with the potential of the universe more than once. The first time it was Erwin Schrödinger in a paper from 1925 [18]. We take this idea and claim, that the potential of the universe is represented by $\varphi_u = -{c_0}^2$.

If there is an additional component caused by a local mass concentration, which in addition provides the potential with a gradient d', it turns out, that a relative potential change causes a relative frequency change. This is at the same time the easiest possible field equation of a gravity theory of variable polarizability of the vacuum:

$$\frac{\mathrm{d}\nu}{\nu} = -\frac{\mathrm{d}\varphi}{\varphi_u} \tag{40}$$

If the potential gets stronger, the frequency decreases correspondingly. We regard '$_u$ as the absolute potential of the universe. This suspends the basically free choice of the potential zero point. The free choice is only allowed, if a variation of the potential is small compared to the potential of the universe c_0^2. What we have now is the choice of the reference point. That determines the length scale and the clock speed.

In the consideration of the units, we omitted up to now the potential '. The mechanical potential has the unit m^2=s^2. According to the introduced rules, how a value looks like from the view of a reference observer at a location with different index of refraction, the potential transforms in the same way as c^2 does with

$$\varphi_u = \frac{\varphi_{u0}}{\kappa^4} \tag{41}$$

To get a meaningful image we must overcome the following conceptual difficulties: the reference observer calculates "remotely" from a distance a theoretical value for the Newtonian potential of a central mass ***M***

$$\Delta\varphi = -\frac{MG}{r} \tag{42}$$

according to the 1=r-law. With that it can be said, that "the potential is deeper in the vicinity of a star". He superimposes this theoretical potential across the flat space area of the central mass and determines the refractive index for each location. The absolute potential '$_{abs}$ in the shape of the speed of light c^2 D $c_0^{2\ 4}$ looks different for him depending on the position. And although the (theoretical) potential becomes deeper and, thus, gets a larger absolute value, the speed of light becomes smaller.
A local observer, however, always gets the result

$$\varphi_{\text{abs}0} = -{c_0}^2 \tag{43}$$

and sets $\kappa = 1$ at his location by definition.
In the Standard Model the Schwarzschild equation is valid for the central potential. It describes a point-like mass in an otherwise matter-free universe. Hence, the matter density of the universe is completely ignored by the theory. The zero point of the potential is appointed far away from the central mass at r D 1. The

Schwarzschild model calls for a flat space at $r = \infty$.

The considerations up to now show, that the potential cannot be regarded as vanishing far apart from the point mass at all. Rather, the central potential gets its meaning only in relation to the magnitude of the background potential of the universe. Thus, it seems obvious, that the vacuum in a matter-free universe is not polarizable and, therefore, the speed of light would be infinite. Please note, that it appears like that to a reference observer, who remains at the current potential of the universe. In any case, distances and times cannot be defined in a meaningful way in a matter-free cosmos, because any relation gets lost.

And so, the ideas of Ernst Mach [19] appear entirely realistic, as he speculated, that the texture of space and time can be established only by the presence of matter and the space-time cannot exist independently as it is with Newton.

If we identify c^2 with the potential of the universe, we are able to put Einstein's most famous equation E D mc^2, which virtually has a monolithic character, into a larger context:

$$E = -m\varphi_u = mc^2 \tag{44}$$

The rest energy of a body is equivalent to its potential energy in the absolute potential of the universe. In that way, Newton's gravitational potential energy is connected with the velocity of light.

Central Potential

We assume a point-like mass M in free space. From the time-independence of the potential follows the gravitational energy to be conserved. The gravitational energy is independent, too, of the path of movement equivalent to an irrotational field of gravity r EE g D 0E. Thereby, gE is the acceleration in a gravitational field.

The classical derivation of Newton's law of gravity with the law of Gauss requires additionally, that the gravitational field disappears at infinite distance, g.rE D 1/ D 0E. The differential form of Gauss's law of gravitation is

$$\vec{\nabla} \cdot \vec{g} = -4\pi G \varrho(\vec{r}) \tag{45}$$

Thus, the gravitational field in vacuum, where the matter density is $\varrho(\vec{r}) = 0$, is source-free: the divergence $\vec{\nabla} \cdot \vec{g} = 0$.

For classical physics, Newton's law of gravity follows from these preconditions with its $1/r^2$dependence. In

$$\oint_{\partial V} \vec{g}(\vec{r}) \cdot \mathrm{d}\vec{A} = -4\pi G M \tag{46}$$

it means, that the surface integral across a volume is proportional to the enclosed mass M, which is the volume integral across the density Q. Because of the given spherical symmetry, the acceleration vector g, thus, always points towards the origin, and its absolute value only depends on the distance.

$$\vec{g}(\vec{r}) = g(r)\vec{e}_r \tag{47}$$

If we now integrate across the surface of a sphere around M, the scalar product is reduced to the product of the absolute values:

$$g(r)\oint_{\partial V}\vec{e}_r\cdot\mathrm{d}\vec{A}=-4\pi GM \quad (48)$$

$$g(r)4\pi r^2=-4\pi GM \quad (49)$$

and we get Newton's law of gravity in its classical form:

$$g(r)=-\frac{GM}{r^2} \quad (50)$$

An inconsistency of classical physics becomes evident, if one considers a point-like test mass m, which is moved slowly towards the point-like central mass M. Slowly shall mean we regard the situation as a static one. The energy released by this procedure is extracted out of the body m and it is quasi at rest all the time. This can be imagined by the transportation of m in a slow elevator.

The released potential energy ' $E_{\mathrm{pot}}=-mMG/r$ of the test body grows beyond all limits for $r\to 0.$. The problem arises, because the mass of a body is regarded a constant, independently of its state of motion and its position in a potential and the potential energy E_{pot} represents a separate quantity. It was Einstein, who recognized the significance of the rest energy of mass in his Special Theory of Relativity, and that any kind of energy contributes to the mass and inertia of a body according to $E=mc^2.$

In the Newtonian approach, an unlimited amount of energy is released during the convergence of both (point-like) masses, which even exceeds the rest energy of m. This is obviously wrong in the light of Special Relativity. The rest energy of the body m becomes smaller by approaching M, because potential energy is extracted and, accordingly, less potential energy is released as a consequence. Only the entire rest energy of m can be set free at most.

Even though gravitational binding energy is a well-known phenomenon in physics, it is noticed merely as marginal entity. In our eyes, however, it has such a central significance, that it is suitable to serve as a basement of a theory of gravitation.

If one accepts the precondition of a variable refractive index of vacuum D pn being the reason of gravitation, the expression of the refractive index of vacuum found in equation (34) can be reduced also to Gauss's law of gravity in a modified form, which, however, accommodates the Special Relativity Theory.

A reference observer at r D 1 sets k D 1 for his potential as a reference. From his view, values are modified by a deeper potential closer to the central body M with growing > 1. The quantities with index "0" are values being measured by the reference observer as well as by a local observer at a different potential.

We describe the whole situation from the view of the reference observer, because the constant M of the central body (in opposite to a local observer) remains constant for him indeed. The force FE is not modified for him in case of a modification of the index of refraction. 1

$$\vec{F}=m\vec{g}=m_0\vec{g}_0=-\vec{\nabla}E=-E_0\vec{\nabla}\frac{1}{\kappa} \quad (51)$$

We multiply equation (46) with m_0, then we divide the right side by, because the rest energy of the test body m is reduced by this factor, when it is moved in the potential. The energy is not preserved here; it is extracted out of the system explicitly by the displacement of m in this quasi-static situation.
In this form, Gauss's law of gravity of equation (46) is in accordance with Special Relativity.

$$\oint_{\partial V} m_0 \vec{g}_0(\vec{r}) \cdot \mathrm{d}\vec{A} = -\frac{4\pi m_0 M_0 G_0}{\kappa} \quad (52)$$

$$-\oint_{\partial V} \vec{\nabla} E \cdot \mathrm{d}\vec{A} = -\frac{4\pi m_0 M_0 G_0}{\kappa} \quad (53)$$

Due to the spherical symmetry the energy gradient across the entire surface to be integrated is a vector out of the origin and, thus, parallel to the vector of the surface element dAE. The absolute value of the energy gradient is constant across the entire surface of the sphere.

$$\left|\vec{\nabla} E\right| = \left|\vec{\nabla}\frac{E_0}{\kappa}\right| = E_0 \frac{\partial}{\partial r}\frac{1}{\kappa} \quad (54)$$

The scalar product again is reduced to the product of the absolute values. The integral across the surface element dAE contributes with the area 4r^2. Hence, equation (53) can be converted to:

$$-E_0 4\pi r^2 \frac{\partial}{\partial r}\frac{1}{\kappa} = -\frac{4\pi m_0 M_0 G_0}{\kappa} \quad (55)$$

With $E_0 = m_0 {c_0}^2$ we get

$$\kappa \frac{\partial}{\partial r}\frac{1}{\kappa} = \frac{M_0 G_0}{r^2 {c_0}^2} \quad (56)$$

The expression

$$\kappa = \alpha e^{M_0 G_0 / r {c_0}^2} \quad (57)$$

fulfills equation (56), because

$$\frac{\partial}{\partial r}\frac{1}{\kappa} = \frac{\partial}{\partial r}\left(e^{-M_0 G_0 / r {c_0}^2}\right) = \frac{1}{\alpha}\frac{M_0 G_0}{r^2 {c_0}^2}\, e^{-M_0 G_0 / r {c_0}^2} \quad (58)$$

and both exponential terms in the product $\kappa \frac{\partial}{\partial r}\frac{1}{\kappa}$ cancel each other as well as the arbitrary constant . This constant represents the possibility to choose the reference potential freely. Because, if we set

$$\alpha = e^{-G_0 M_0 / r_1 {c_0}^2}, \quad (59)$$

the refractive index is expanded to

$$\kappa = e^{\frac{G_0 M_0}{{c_0}^2}\left(\frac{1}{r} - \frac{1}{r_1}\right)}. \quad (60)$$

The distance r_1 from the centre is the position of the reference observer, at which becomes equal 1. The distance of the reference observer usually is set at r_1 D 1.

In this way, the expression found for the homogeneous potential can be reproduced for the much more general case of the central potential. Solely by regarding the rest energy of a body being decreased in a lower potential, there is a solution for the central potential, which does not exhibit a divergence at the Schwarzschild radius. There are no “Black Holes” according to the theory of variable speed of light. Light is able to escape from any potential and even huge mass agglomerations form throughout stable entities not collapsing to a singularity.

It should be emphasised here clearly, that the requests of Special Relativity in our eyes are a sufficient condition for a consistent description of gravitation. The covariance principle, that is an essential foundation of General Relativity, is not a necessary condition in the theory of variable speed of light.

Newton's law of gravity of classical physics appears as limiting case of first order, if the force is written as energy gradient:

$$F = -\frac{\partial E}{\partial r} = -\frac{\partial}{\partial r}\frac{E_0}{k} = -E_0\frac{\partial}{\partial r}e^{-G_0M_0/rc_0{}^2} \quad (61)$$

By developing the exponential function up to first order in 1=r and replacing E_0 by $m_0c_0^2$, Newton's law of force unfolds for the energy gradient of a mass m_0:

$$F = m_0c_0{}^2\frac{\partial}{\partial r}\left[1 - \frac{G_0M_0}{rc_0{}^2} + \ldots\right] \approx m_0\frac{G_0M_0}{r^2} \quad (62)$$

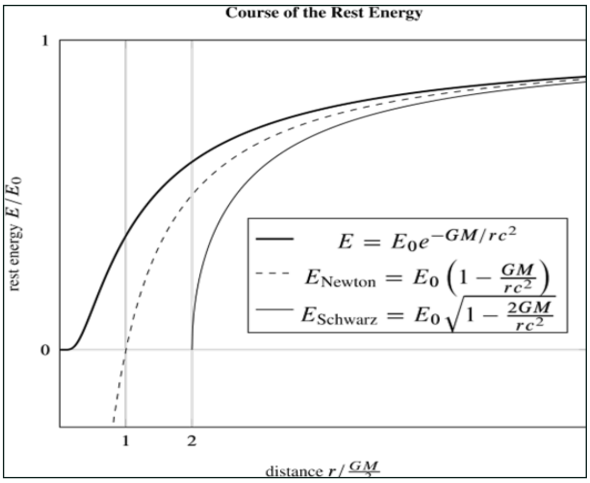

Figure 1: A body with rest energy E_0 loses energy when approaching a central mass. In Newton's model an infinite amount of energy is released, in the General Theory of Relativity the rest energy is consumed at the Schwarzschild-radius 2GM=c² (red-shift infinite). According the laws of Special Relativity the energy is released completely only exactly at the origin.

In a notation equivalent to the isotropic Schwarzschild metric the line element can be expressed as:

$$\mathrm{d}s^2 = \frac{1}{\kappa^2}c_0{}^2\mathrm{d}t^2 - \kappa^2\,\mathrm{d}\vec{r}^2 = e^{-\frac{2GM}{c_0{}^2}\left(\frac{1}{r}-\frac{1}{r_1}\right)}c_0{}^2\mathrm{d}t^2 - e^{\frac{2GM}{c_0{}^2}\left(\frac{1}{r}-\frac{1}{r_1}\right)}\mathrm{d}\vec{r}^2, \quad (63)$$

which agrees in first approximation with the Schwarzschild solution for r_1 D 1, see [9]. But, whereas the Schwarzschild solution exhibits a divergence at a finite distance from the mass center, which leads to the so called event horizon, there is a point of infinity in the refractive index within the solution of the variable speed of light only at r D 0, which is physically no problem, though. Therefore, no "black hole" occurs. An infinite index of refraction n corresponds to a vanishing speed of light. Translated into the Schwarzschild solution this would mean, that the speed of light would be zero at the event horizon and farther inside even "negative". A negative speed of light does not make sense in the picture of a variable speed of light.

Comparison with the Observations

Every prediction in weak gravitational fields – that concerns all phenomena in the solar system – are equivalent, because both theories only differ from the second or third order, respectively. Increasing difference will become evident only with experiments of high precision and including higher order effects, e.g. in strong gravitational fields like Black Holes or concerning the genesis of the universe.

The best proven observations of the General Relativity Theory are observations in weak gravitational fields, altogether. Among them are the four classical tests gravitational red-shift, light deflection at the sun, radar echo delay and perihelion shift of Mercury. Here, both theories agree

[1].

Yet another convincing observation is the energy radiation of a double star system by gravitational waves, most prominent of all the double pulsar PSR 1913+16. While Michael Ibison comes to a different energy radiation for the theory of variable speed of light [20], Kris Krogh, on the other hand, confirms the result of General Relativity and the well assured measurement for the theory of variable speed of light as well [16]. The case is not yet closed.

Even if the direct verification of gravitational waves already has been dignified with a nobel prize, it is the author's opinion, that the sampled data up to now are no crystal-clear proof at all. The measurement is extraordinarily challenging and the signal is smaller than the noise by orders of magnitude. In the theory of variable speed of light, gravitational waves arise like in General Relativity. But only longitudinal waves appear, because the theory is – in opposite to the tensorial GRT – a scalar one. Here, a propagation mode for transversal waves does not exist.

The Lense-Thirring effect does not occur in the theory of variable speed of light. The satellite experiment Gravity Probe B should deliver the unambiguous proof here, but the result turned out to be very weak. A clear null result would speak in favor of the variable speed of light.

The direct proof of Black Holes is not accomplished to this day. Direct observation is rather unlikely, because these objects are very small and, naturally, do not emit radiation themselves. The emission spectrum of matter hitting onto the hard surface of a neutron star should differ, however, clearly from that being emitted from matter disappearing in an event horizon of a Black Hole, nevertheless. On the contrary, Stanley Robertson was able to show, that the spectra of neutron stars are not essentially different from those of Black Hole candidates [21]. Actually, the only remaining argument for the existence of Black Holes is, that General Relativity does not allow another possibility.

The space mission LATOR would have been able to measure the deflection of light at the sun up to the second order with sufficient accuracy [22]. The General Relativity Theory predicts a deflection decreased by 3.5 μarc seconds, the theory of variable speed of light requests a deflection decreased by 7.4 μarc seconds compared to the deflection in first order [16]. Unfortunately, the mission was not executed. The technical feasibility, still, is present.

In summary, it has to be stated, that anywhere, where clear proofs exist, both theories agree and where the measurement results are weak, the theories differ. There are measurements possible, though, which are able to validate or falsify both theories definitely. However, measurements of effects of higher order are complex and expensive. The hurdle to perform such experiments is appropriately high.

Conclusion

A consistent model of gravitation was developed solely based on the assumption, that gravitation can be described as an electromagnetic phenomenon, under abandonment of the covariance principle, which is only based on the Special Relativity Theory. In other words: gravitation and quantum physics can be unified in this way. The classical tests of the General Theory of Relativity are fulfilled. The refractive index of vacuum as a scalar quantity has the central function to describe relative differences in length and time within the framework of a flat space-time. Hereby, as a consequence, the velocity of light is not to be regarded as constant. The exponential law of the refractive index, which was introduced in the literature several times already, can be deduced by giving careful attention to the viewpoints of different observers. Significant differences between the theory of variable speed of light and General Relativity emerge in strong gravitational fields. An event horizon does not occur.

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