What is Light?

On a Universal Correlation between Gravitational and Electromagnetic Waves

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“Light is the Action of the Universe …”

Novalis

Abstract

It is shown that there is a universal relationship between gravitational and electromagnetic waves. The propagation direction and the propagation velocity of the electromagnetic waves are determined by the gravitational waves. In other words, the “vacuum velocity” of light and hence also the magnetic and electric constants of the vacuum μ_0 *and* ε_0 *are not natural constants but are determined by the gravitational constant, the average mass density and the extent of the universe.*

Key words: Newton’s laws and the universe, action-at-a-distance, gravitational waves, origin of light, unified field theories, gravitation and electromagnetism, cosmology, fundamental physics

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1. Introduction

A previous paper demonstrated that one can already derive the results of the Special Theory of Relativity (SR) on the basis of Newton’s Laws [1)]. To do this, one must only assume the existence of the universe and apply Mach’s principle as well as accept the fact that inert and gravitational mass are equal (weak principle of equivalence). A further paper crystalized that, even solely on this physical basis, gravitational waves exist [2)]. The propagation velocity of these waves is determined by the gravitational impact of all the masses of the universe and seems to be identical with the (“vacuum”) light velocity. It is therefore self-evident to investigate whether light could be considered as causative for the excitation of these gravitational waves, and if so, how the propagation of light would be determined by its interaction with gravitational waves. Obviously, this investigation would be related to earlier attempts of establishing a theory for the unification of gravitation and electromagnetism, so called “classical unified field theories”. First, papers were published by Mie (1912)[3)] and Reichenbächer (1916)[4)], even before General Relativity (GR) was formulated. Subsequent papers were based on the mathematical framework of GR and followed different paths of extending differential geometry, e.g. Weyl (infinitesimal geometry)[5)], Kaluza (five-dimensional cylindrical world)[6)], Eddington (affine geometry, and later “E-frames”)[7)], Einstein (variational principle and presumed space-time manifold)[8)], Schrödinger (pure-affine theory)[9)]. All of these theories show a high degree of abstraction, and they were not successful because they were hard to connect with the physical phenomena they intended to describe. At present, classical unified theories are practically not pursued. The present research focusses on creating a quantum theory of gravity and unifying this with the other fundamental theories. Just a few days ago, a completely different approach was published by Wolfram based on discrete mathematics and computer simulations of abstract relations between abstract elements forming "hypergraphs" [10)].

The theory presented here does not claim to establish a general theory for the unification of gravitation and electromagnetism. It aims only to investigate the relationship between gravitational and electromagnetic waves. But this paper will demonstrate that this relationship shows some fundamental correlations on which a general theory may be based. When establishing our theory, we neither follow the actual paths of unified theories nor do we follow the aforementioned classical attempts. The latter are all based on abstract mathematical constructions. In a sense, one could characterize this kind of research as "mathematical engineering". We will explicitly not follow these efforts. Instead, we will rely on the (surprising) results of the papers [1)] and [2)], which are solely based on Newton's laws and Mach's principle. Our goal is to avoid abstract mathematical constructions as much as possible and to base all considerations and calculations on a few and well-known physical laws.

2. Relationship between Gravitational Waves and Light

Light, or any electromagnetic impacts, or even electromagnetic phenomena are not contained at all in the theory developed in [1)] and [2)]. But, of course, these phenomena play an important role with bodies moving inside the universe. This is because a major part of the universe consists of matter that holds mass as well as electric charge, and it is in the plasma state to a prevailing degree. In particular, if we are to consider large-scale (cosmic or collective) oscillations of masses, we have to pay attention to the plasma properties of the universe.

For the further consideration of a possible interaction between light and gravitational waves, we start with the assumption that any arbitrary light beam can be described by a superposition of plane waves, i.e. by a wave package formed by such plane waves. The same also applies to the gravitational waves as described in [2)]: Due to the linearity of the equations (2.20 a, b) in [2)], a gravitational "wave beam" can also be formed by the superposition of plane waves. Therefore, the investigation of the interaction between a light beam (confined in space and time) and a similarly confined gravitational beam can be based on an investigation of the interaction between plane light waves and plane gravitational waves. We will take this assumption as the basis for the subsequent considerations.

As in paper [2)], we start with the perception of the universe as a lattice of mass points. We then have to calculate the motion of all these mass points under the impact of electromagnetic as well as of gravitational waves. This problem was investigated extensively within the framework of plasma physics. We are using and are following here the methods as described by Shen [11)]. (To prevent misunderstandings: Our consideration has nothing to do with the so-called "plasma cosmology" or the "plasma universe" of Alfven (1966), which contain matter and antimatter [12)], or with the so-called "electric universe" that can be found repeatedly in the internet).

The nature of plasma in the universe is very different, depending on its location. There are very hot plasmas with high densities, but also very cold ones with very low densities. Accordingly, they must be described by quite different physical theories. Very thin plasmas must be described by a so-called single particle model. For plasmas with high densities, we must apply a description within the framework of fluid dynamics. In the following, we restrict ourselves to the consideration of only one model, namely the single particle model, which is applicable to plasmas with low densities. We hope that with this approach alone the fundamental properties can be understood. At the end of chapter 2, we will then also briefly go into the circumstances with very dense plasmas.

We start with these assumptions:

1) A certain part of the universe is in a plasma state. The plasma properties are the same in each volume element and can be described by the single particle model.
2) When averaging over sufficiently large volume elements, the plasma can be considered as electrical neutral. There are also no electric currents between these elements, provided there are no external forces.
3) Due to gravitational forces between the volume elements, gravitational waves are possible. This could be a result of transversal "disc oscillations" as described in [2]. We choose the coordinate system in such a way that the propagation vector of these waves shows in the x-direction.

The following gravitational force is acting on the volume element j of the n-th disc (see [2] (2.11) or rather (2.19)):

$$K_{n,z,j} = K_{n,n+1,z,j} + K_{n-1,n,z,j} = G\,\frac{m_{nj}m_{n+1,j}}{a^3}\,(s_{n+1,j} - s_{n,j}) + G\,\frac{m_{nj}m_{n-1,j}}{a^3}\,(s_{n-1,j} - s_{n,j}). \qquad (2.1)$$

Therein we have already neglected the nonlinear terms. Now we set:

$$m_{n,j} = m_{n+1,j} = m_{n-1,j} = m_j = \rho\, a\, \Delta F_j$$

whereas ΔF_j stands for the area of the disc element j of the disc n (in the y-z-plane). The distance (in the x-direction) between adjacent discs is again denominated by a.

With the abbreviation $s^{(n)} = s_{n+1} + s_{n-1} - 2s_n$ we can write (2.1) in the following form:

$$K_{n,z,j} = G\, m_j\, \rho\, \frac{a}{a^3}\, \Delta F_j\, (s_{n+1} + s_{n-1} - 2s_n) = G\, m_j\, \rho \frac{1}{a^2}\, \Delta F_j\, s^{(n)}. \qquad (2.2)$$

According to Shen [11] the power (2.2) causes a drift of the ionized masses $m_{n,j\pm}$, which are part of the total mass m_{nj} , and this is in opposite directions for plus and minus. The drift velocity for a charge q is given in each case by [11]:

$$\mathbf{v}_{nj\pm} = \frac{m_{n,j\pm}}{q}\,\frac{\mathbf{g}_{nj} \times \mathbf{B}_{nj}}{{B_{nj}}^2}\ , \qquad (2.3)$$

wherein the vector $\mathbf{g}_{nj}$ is defined by

$$\mathbf{g}_{nj} = G\, \rho\, \frac{1}{a^2}\, \Delta F_j\, s^{(n)}\, \mathbf{e}_z\ . \qquad (2.4)$$

$\mathbf{B}_{nj}$ is the vector of a magnetic flux density, which is assumed to be present inside the volume element j of the disc n. We know that there are magnetic fields practically everywhere in the universe, but we have little knowledge of its spatial distribution and its direction. Of course, these are also dependent on the movements of the charged particles in the universe. Therefore, we cannot assume that they are impressed to a volume element j, rather they are the result of a self-consistent solution of a higher-level investigation of the total system. But we can assume a magnetic flux density (of unknown strength) $\mathbf{B}_{nj}$ to exist in any volume element. Then, a drift current density will be caused there, given by [11)]

$$\mathbf{j}_{nj} = n_{nj} q \left(\mathbf{v}_{nj+} + \mathbf{v}_{nj-}\right), \tag{2.5}$$

where n_{nj} is the number of carriers within the volume element j of the equator disc n.

If we write m_{je} for the mass of an electron and M_{ji} for the mass of an ion, we can convert (2.5) (using (2.3) and (2.4)):

$$\mathbf{j}_{nj} = n_{nj} \left(m_{je} + M_{ji}\right) \frac{\mathbf{g}_{nj} \times \mathbf{B}_{nj}}{B_{nj}^{\ 2}}. \tag{2.6}$$

(2.6) describes an electric current density, which is generated by a gravitational oscillation of the universe.

In the following, we assume that the form of the Maxwell equations could be taken as valid also for the circumstances to be investigated. We consider them as a mathematical ansatz in which, initially, the parameter “c” (the “vacuum” light velocity) is assumed to be undetermined. We shall see that this approach will lead to consistent solutions for the system of equations and that the parameter “c” is determined by other parameters of the system. Based on this foundation, we have to insert the current density (2.6) into the Maxwell equations. We are then faced with the problem of finding a self-consistent solution for the coupled electromagnetic and gravitational fields (including the field $\mathbf{B}_{nj}$). This is difficult enough even for electromagnetic fields alone (keyword: self-field theory) and, therefore, we will refrain from establishing a mathematically general valid description within the framework of this paper. We are aiming here only to clarify the most fundamental relationship between light and gravitational waves in the universe. Therefore, we are looking only for elementary particulate solutions.

We have seen in paper [2)] that oscillations of universally expanded discs could lead to gravitational wave solutions (see equations (2.21) and (2.29) in [2)]). There, we presumed that these waves could be excited in some ways. This is to be investigated immediately. But at first, we would like to adhere to the concept that these solutions represent (near) plane waves, which propagate e.g. in the x-direction being expanded in the y-z-plane until the edge of the universe (i.e. practically infinite). If such solutions exist, and the nonlinear fractions could be neglected (see [2)] equations (2.19) and (2.26)), then we can compose completely arbitrary wave packages by superposition (which could also form spatial limited objects).

Let us now consider light. As solution of the Maxwell equations, one also finds plane waves for electromagnetic fields, which can be composed by superposition to arbitrary wave packages as well. Insofar, we can attribute physical reality to plane electromagnetic waves, which are expanded to infinity perpendicular to their propagation direction. Such waves are always acting on the scale of the universe, also in the direction perpendicular to their propagation direction, and therefore, they can also interact with the above mentioned universally expanded and oscillating discs: The same power of the electromagnetic field components acts on each volume element j of a disc n. Therefore, the same drift current density (2.5) is generated in each volume element j, as far as the plasma properties are the same in each element j, and also the size of $\mathbf{B}_{nj}$. The latter cannot be presumed, but when considering very large distances we can possibly average the value, i.e. substitute B_{nj} with B_Φ. This is certainly a critical assumption because B_Φ could approach zero when averaging over a large distance. Nevertheless, we will make this assumption here and leave it open for future proof.

The fundamental superposition properties of electromagnetic as well as for gravitational waves enable the formation of arbitrary wave packages. Therefore, we will consider solely plane waves in the following. We hope that elementary relationships could be found already in this way.

We assume (and we will see immediately that this will be provable) that the propagation of a plane electromagnetic wave (i.e. light) will show in the x-direction and will coincide with that of a gravitational wave. In this case, all elements j of the oscillating disc n will experience the same electrical field strength E and the same magnetic flux density B. With the assumptions described above on the plasma properties of each element j within the disc n, we can determine for the total current density of such an oscillating disc n:

$$\mathbf{J}(\mathbf{x}) = \sum_j \mathbf{j}_{nj} = \sum_j n_{nj} (m_{je} + M_{ji}) \frac{\mathbf{g}_{nj} \times \mathbf{B}_\Phi}{B_\Phi{}^2} \,. \tag{2.7}$$

Because of our assumption 1) (see page 2), n_{nj} and $m_{je} + M_{ji}$ are equal for all volume elements j, and we can use (2.4) to write:

$$\mathbf{J}(\mathbf{x}) = \mathbf{J} = n_n(m_e + M_i) \sum_j \frac{G\,\rho\,\frac{1}{a^2}\,\Delta Fj\; s^{(n)}\, \mathbf{e}_z \times \mathbf{B}_\Phi}{B_\Phi{}^2} \,. \tag{2.8}$$

With $\frac{1}{2}\, n_n(m_e + M_i) = m_q$ und $\sum_j \Delta Fj = \pi R_0^2$ (2.9)

we find $$\mathbf{J} = m_q \frac{2\,G\,\rho\,\pi R_0^2\, s^{(n)}\, \mathbf{e}_z \times \mathbf{B}_\Phi}{a^2 B_\Phi{}^2} \,. \tag{2.10a}$$

Here we can again introduce the abbreviation b_0 (see [1] and [2]), given by $b_0{}^2 = 2\pi\rho G\, R_0^2$, and then:

$$\mathbf{J} = m_q \frac{b_0^2\, s^{(n)}\, \mathbf{e}_z \times \mathbf{B}_\Phi}{a^2 B_\Phi{}^2} \,. \tag{2.10b}$$

The relationship between the magnetic flux density, the electric current density and the displacement current in vacuum is given by Maxwell's equation

$$\nabla \times \mathbf{B} = \mu_0\, \mathbf{J} + \mu_0 \varepsilon_0\, \dot{\mathbf{E}}. \tag{2.11}$$

The question here is what the meaning of μ_0 and ε_0 should be. According to the reflections in papers [1] and [2], the perception of a vacuum in the "traditional" form is doubtable, at the least. In Maxwell's theory, the parameters μ_0 and ε_0 are seen as natural constants for the vacuum.

We are expressly not following this view, but leave open the respective figures as a start. We see the Maxwell equations as an "ansatz" with the still undetermined parameters ε_0 and μ_0. It will arise that these will be fixed by the interaction between the electromagnetic and the gravitational waves!

By differentiating (2.11) with respect to time we find

$$\nabla \times \dot{\mathbf{B}} = \mu_0 \dot{\mathbf{j}} + \mu_0 \varepsilon_0 \ddot{\mathbf{E}} \tag{2.12}$$

and with another Maxwell equation

$$- \nabla \times \mathbf{E} = \dot{\mathbf{B}} \tag{2.13}$$

it follows as usual

$$- \nabla \times (\nabla \times \mathbf{E}) = \mu_0 \dot{\mathbf{j}} + \mu_0 \varepsilon_0 \ddot{\mathbf{E}} \tag{2.14}$$

or

$$\nabla(\nabla \mathbf{E}) - \Delta \mathbf{E} = - \mu_0 \dot{\mathbf{j}} - \mu_0 \varepsilon_0 \ddot{\mathbf{E}}. \tag{2.15}$$

For the considered volume of an oscillating disc, we assume that it is neutral on average. This means $\nabla \mathbf{E} = 0$ and, therefore, eventually:

$$\Delta \mathbf{E} - \mu_0 \varepsilon_0 \ddot{\mathbf{E}} = \mu_0 \dot{\mathbf{j}}\ . \tag{2.16}$$

We now set the electric field vector to show in the y-direction. Then, we arrive at

$$\Delta \mathbf{E} = \frac{\partial^2}{\partial x^2} E_y \, \mathbf{e}_y \ ,$$

and we find

$$\ddot{\mathbf{E}} = \frac{\partial^2}{\partial t^2} E_y \, \mathbf{e}_y. \tag{2.17}$$

Based on the solution of the homogeneous equation, we use the following ansatz for E_y:

$$E_y = E_{01} \left(e^{i(k'x-\omega' t)} + e^{-i(k'x-\omega' t)}\right) - i\, E_{02} \left(e^{i(k'x-\omega \quad)} - e^{-i(k'x-\omega' t)}\right). \tag{2.18}$$

According to this ansatz, the strength of the electrical field propagates in the x-direction and oscillates perpendicular to it in the y-direction, transversely.

$$\frac{\partial^2}{\partial x^2} E_y = - k'^2 E_y \quad \text{and} \quad \frac{\partial^2}{\partial t^2} E_y = -\omega'^2 E_y. \tag{2.19}$$

This is obviously compatible with our assumptions on the oscillation mode of light as related to plane gravitational waves formed by oscillating discs. We make the same ansatz for them, starting with the homogeneous solution. In this case, the discs oscillate transversely, too (see paper [2)], equations (2.4) and (2.20)):

$$s_n = s_{01} \left(e^{i(kn \qquad)} + e^{-i(kna-\omega t)}\right) - i\, s_{02} \left(e^{i(kna-\omega \ )} - e^{-i(kna-\omega t)}\right). \tag{2.20}$$

The amplitudes s_{01} and s_{02} are initially undetermined (as well as E_{01} and E_{02} in (2.18)).

For the above defined variable $s^{(n)}$, we have the results:

$$s^{(n)} = s_{n+1} + s_{n-1} - 2s_n$$

$$= -4\ \sin^2\frac{ka}{2}\left[s_{01}\left(e^{i(kna\ \ \omega t)} + e^{-i(kna\ \ \omega t)}\right) - is_{02}\left(e^{i(kna-\omega t)} - e^{-i(kna\ \ \omega t)}\right)\right]$$

or

$$s^{(n)} = -\ 4\ \sin^2\frac{ka}{2}\ s_n. \tag{2.21}$$

Now, we make use of the equations (2.10) and (2.16), which couple the electromagnetic with the gravitational oscillations.

Firstly, we differentiate (2.21) with respect to time. We assume that we can migrate from a universe represented by a lattice of mass points to a universe described by a continuum. This might be a critical assumption (see paper [2)]), but we will make it here, anyhow. In this case, we can set na = x (see paper [2)] with the values for a described there), and it is:

$$\dot{s}^{(n)} = 4\ \sin^2\frac{ka}{2}\ i\omega\left[s_{01}\left(e^{i(kx-\omega t)} - e^{-i(kx-\omega t)}\right) - is_{02}\left(e^{i(kx-\omega t)} + e^{-i(kx-\omega t)}\right)\right]. \tag{2.22}$$

When we insert this (together with (2.10) and (2.18)) into (2.16) we find:

$$(-k'^2 + \mu_0\varepsilon_0\omega'^2)\left[E_{01}\left(e^{i(k'x-\omega' t)} + e^{-i(k'x-\omega' t)}\right) - i\,E_{02}\left(e^{i(k'x-\omega' t)} - e^{-i(k'x-\omega\ \ )}\right)\right] =$$

$$\frac{\mu_0}{B_{\Phi x}}\frac{m_q}{a^2}\,b_0^2\ 4\ \sin^2\frac{ka}{2}\ i\omega\left[s_{01}\left(e^{i(kx\ \ \omega t)} - e^{-i(kx-\omega t)}\right) - is_{02}\left(e^{i(kx-\omega t)} + e^{-i(kx-\omega t)}\right)\right]. \tag{2.23}$$

Nontrivial solutions of (2.23) are only possible, if

$$k'x - \omega' t\ = 0 =\ kx - \ \omega t\ . \tag{2.24}$$

Therefore, the real and the imaginary part of (2.23) result in:

$$(\mu_0\varepsilon_0\omega'^2 - k'^2)\,E_{01}B_{\Phi x} =\ \mu_0 m_q\ \ b_0^2\,k^2\,\omega\,s_{02} = \Gamma\,k^2\,\omega\,s_{02} \tag{2.25}$$

$$-\ (\mu_0\varepsilon_0\omega'^2 - k'^2)\,E_{02}B_{\Phi x}\ =\ \mu_0 m_q\ \ b_0^2\,k^2\,\omega\,s_{01} = \Gamma\,k^2\,\omega\,s_{01}. \tag{2.26}$$

Therein we have used the abbreviation $\Gamma = \mu_0\ m_q\ b_0^2$, and we have restricted ourselves to the values $ka \ll 1$, i.e. we can set $\sin^2\frac{ka}{2} \approx \frac{k^2a^2}{4}$. In this case, it follows that $\omega = b_0\ k\ f_G$ (see paper [2)]) and then, if $f_G = 1$, we have $\omega = b_0\ k$. Since (2.24) can only be fulfilled for arbitrary values of x and t if k' = k and $\omega' = \omega$, it follows that

$$\omega' = b_0\ k'. \tag{2.27}$$

Applying the usual definition $\mu_0\varepsilon_0 = \frac{1}{c^2}$, we can transform (2.25) and (2.26) into the following form:

$$E_{01} = \frac{A}{(b_0{}^2 - c^2)}\ s_{02} \tag{2.28a}$$

$$E_{02} = \frac{A}{(c^2 - b_0{}^2)}\ s_{01} \tag{2.28b}$$

with $$A = \frac{\Gamma\omega c^2}{B_{\Phi x}} \; . \qquad (2.28c)$$

This is obviously a "resonance" relation. What does this mean? Let us consider, for instance, cosmic background radiation. According to our description above, this couples with gravitational waves, and (according to (2.28)) the amplitudes of these gravitational waves will certainly be very small as long as the light velocity c is near the velocity of the gravitational waves b_0. Or, in other words, the universe is transparent for light, even for light with a very small intensity like the cosmological background radiation, provided c = b_0. On the other hand: If the electric field component of any electromagnetic wave would try to propagate with a velocity c' ≠ b_0, it would excite gravitational waves, which could possibly lead to a massive damping of the electromagnetic wave. We have not included any damping in our consideration up to now, the influence of damping effects will be studied subsequently. The fundamental resonance character of the equation (2.28) does not seem to be destroyed by this simplification, at least for small damping effects. The preliminary conclusion appears to be justified: Light can easily propagate only if c = b_0 at any location of the universe. The light velocity c and therefore also the product of the "vacuum values" ε_0 and μ_0 are apparently determined by the propagation velocity of gravitational waves.

Before looking at the question of damping, we would like to determine the wave components of the magnetic flux density **B,** which are related to the waves (2.18). They are determined, e.g., by (2.13).

Since (according to our ansatz) the electric field has only a component in y-direction, we find

$$\nabla \times \mathbf{E} = \frac{\partial}{\partial x} E_y \, \mathbf{e}_z = - \dot{\mathbf{B}} = - \frac{\partial}{\partial t} B_z \, \mathbf{e}_z \, . \qquad (2.29)$$

Let us insert here the value E_y of equation (2.18):

$$E_{01}\,(ik'e^{i(k'x-\omega' t)} - ik'\,e^{-i(k'x-\omega\;)}) - i\,E_{02}\,(ik'e^{i(k'x-\omega' t)} + ik'\,e^{-i(k'x\;\;)}) = - \dot{B}_z$$

or $$E_{01}ik'\,(e^{i(k'x-\omega' t)} - e^{-i(k'x-\omega\;)}) + E_{02}k'\,(e^{i(k'x-\omega' t)} + e^{-i(k'x-\omega\;)}) = - \dot{B}_z \, . \qquad (2.30)$$

Ansatz: $$B_z = B_{01}\,(e^{i(k'x-\omega\;)} + e^{-i(k'x-\omega' t)}) - i\,B_{02}\,(e^{i(k'x-\omega\;)} - e^{-i(k'x-\omega' t)}). \qquad (2.31)$$

Then:

$$- \dot{B}_z = B_{01}\,(-i\omega' e^{i(k'x-\omega\;)} + i\omega'\,e^{-i(k'x-\omega' t)}) - i\,B_{02}\,(-i\omega' e^{i(k'x-\omega\;)} - i\omega'\,e^{-i(k'x-\omega' t)}).$$

$$= i\omega'\,B_{01}\left(e^{i(k'x-\omega' t)} - e^{-i(k'x-\omega' t)}\right) + \omega'\,B_{02}(e^{i(k'x-\omega' t)} + e^{-i(k'x\;\;)}). \qquad (2.32)$$

Comparison of the real part:

$$E_{02}\,k' = \omega'\,B_{02} \;\text{ or }\; B_{02} = \frac{k'}{\omega'} E_{02}$$

and of the imaginary part (2.33)

$$E_{01}\,k' = \omega'\,B_{01} \;\text{ or }\; B_{01} = \frac{k'}{\omega'} E_{01}.$$

The interlinked components of the "electro-magneto-gravitational" wave field can be presented in the following more compact form:

$$\mathbf{E} = E_y\,(x,t,\,s_{01},\,s_{02})\,\mathbf{e}_y \tag{2.34}$$

$$\mathbf{B} = B_z\,(x,t,\,s_{01},\,s_{02})\,\mathbf{e}_z, \tag{2.35}$$

$$\mathbf{g} = -\,\tfrac{1}{2}\,b_0^{\,2}\,k^2\,s_n\,(x,t,\,s_{01},\,s_{02})\,\mathbf{e}_z \tag{2.36}$$

whereas E_y and B_z are described by (2.18) and (2.31), and (2.36) is determined by the summation over all j of (2.4).

The equations (2.34) and (2.35), together with the relations (2.33), describe the propagation of a plane light wave with the amplitude of the electrical field stretched out in the y-direction and that of the magnetic flux density stretched out into the z-direction, both propagating in the x-direction. This light wave is coupled to a gravitational wave via the interactions described by (2.4) and (2.5). The gravitational wave oscillates in the z-direction, transversally to its propagation in the x-direction. The phase velocity of the light wave is correlated in a "resonant" manner with the phase velocity of the gravitational wave, namely by the "resonance" relations (2.28).

As we know, any profile of a light wave can be composed by the superposition of plane waves. Therefore, the relationships described above seem to dictate any arbitrary propagation of light. The same is valid for gravitational waves, which can also be composed of plane waves by superposition.

In the beginning of this paper, we postulated the existence of a magnetic flux density B_{nj} in the x-direction but left its magnitude open. This flux density plays the role of a field, which enables the physical mechanisms considered here to be effective, but which is static and arbitrary small. Because we know that magnetic fields are present in practically all regions of the universe, our assumption of the existence of an "initiating" flux density B_{nj} might be justified. Admittedly, it is questionable whether one could average this flux over the distance of our oscillating discs to form a mean value $B_{n\Phi}$. Furthermore, it is required that the values of B_{nj} or $B_{n\Phi}$ should be the result of a self-consistent solution of all involved equations, particle movements, and boundary conditions. We are not touching on this possibly very complicated set of problems here. Furthermore, we must remember that we based our consideration on the simplified description of the plasma within a single particle model. But we will certainly find fractions of an equator disc (that is stretched out over the whole universe), where $B_{n\Phi} \neq 0$. Possibly, it will be necessary to develop the theory step by step over smaller distances towards a solution that comprises the total universe.

In any case, if we are going to consider large distances, we must include damping even for very thin plasmas. It will not be adequate to neglect collisions between charged particles.

Therefore, we supplement the equation of motion of an oscillating disc (see [2)] equation (2.20)) by a damping term.

$$-\gamma\dot{s}_n - M_s\,\ddot{s}_n = -\,M_s\,D'\,(s_{n+1} + s_{n-1} - 2\,s_n\,). \tag{2.21a}$$

There it is again (see [2)] (2.21)) $\quad D' = G'\,\frac{M_s}{a^3} = 2\,G\,\frac{M_s}{a^3}$.

We use now wiggled symbols for the (now damped) displacements, and we abbreviate M_s=m:

$$\ddot{\tilde{s}}_n = - \frac{\gamma}{m}\,\dot{\tilde{s}}_n + D'\,(\tilde{s}_{n+1} + \tilde{s}_{n-1} - 2\,\tilde{s}_n). \tag{2.37}$$

We are looking for a solution with the ansatz

$$\tilde{s}_n = s_n\, e^{-\lambda t}. \tag{2.38}$$

Herein s_n is given by (2.20). The solution of this problem is elementary. Nevertheless, we will describe it here in detail:

We find with the ansatz (2.38) at first

$$\dot{\tilde{s}}_n = \dot{s}_n e^{-\lambda t} - \lambda\, s_n\, e^{-\lambda t} \tag{2.39}$$

and then

$$\ddot{\tilde{s}}_n = \ddot{s}_n\, e^{-\lambda t} - 2\,\lambda\,\dot{s}_n e^{-\lambda} + \lambda^2\, s_n\, e^{-\lambda t}. \tag{2.40}$$

It is in addition

$$\tilde{s}_{n+1} + \tilde{s}_{n-1} - 2\,\tilde{s}_n = -4\,\sin^2\frac{ka}{2}\, s_n\, e^{-\lambda t}. \tag{2.41}$$

With

$$\dot{s}_n = - i\,\omega\, s_{01}\left(e^{i(kx-\omega t)} - e^{-i(kx-\omega t)}\right) - \omega\, s_{02}\left(e^{i(kx-\omega t)} + e^{-i(kx-\omega t)}\right) \tag{2.42}$$

and

$$\ddot{s}_n = -\,\omega^2\, s_n\,, \tag{2.43}$$

as well as

$$4\,\alpha\,\sin^2\frac{ka}{2} \approx \pi\,\rho G\, R_0^2\, k^2 = \frac{1}{2}\, b^2\, k^2\,. \tag{2.44}$$

There is further:

$$\ddot{s}_n + \dot{s}_n\left(\frac{\gamma}{m} - 2\,\lambda\right) + s_n\left(\lambda^2 + \frac{1}{2}\, b_0{}^2\, k^2 - \frac{\gamma}{m}\,\lambda\right) = 0. \tag{2.45}$$

Therein, we have written $2\pi\rho G R_0^2 = b_0^2$ (for the meaning and importance of b_0 see [1] equations (2.3) and (3.7), and [2] equation (2.25)).

If we now insert (2.20), (2.42) and (2.43), we find

$$\begin{aligned}
&-\,\omega^2\left[s_{01}\left(e^{i(kx-\omega t)} + e^{-i(kx-\omega t)}\right) - i\, s_{02}\left(e^{i(kx-\omega t)} - e^{-i(kx-\omega t)}\right)\right] \\
&+ \left(\frac{\gamma}{m} - 2\,\lambda\right)\omega\left[-i\, s_{01}\left(e^{i(kx-\omega t)} - e^{-i(kx-\omega t)}\right) - s_{02}\left(e^{i(kx-\omega t)} + e^{-i(kx-\omega t)}\right)\right] \\
&+ \left(\lambda^2 + \frac{1}{2}b_0^2\, k^2 - \frac{\gamma}{m}\,\lambda\right)\left[s_{01}\left(e^{i(kx-\omega t)} + e^{-i(kx-\omega t)}\right) - i\, s_{02}\left(e^{i(kx-\omega t)} - e^{-i(kx-\omega t)}\right)\right] = 0\,.
\end{aligned} \tag{2.46}$$

We compare the real and imaginary parts before $e^{i(kx-\omega t)}$ und $e^{-i(kx-\omega t)}$ and arrive at:

$$-\,\omega^2\, s_{01} - \left(\frac{\gamma}{m} - 2\,\lambda\right)\omega\, s_{02} + \left(\lambda^2 + \frac{1}{2}b_0^2\, k^2 - \frac{\gamma}{m}\,\lambda\right) s_{01} = 0 \tag{2.47a}$$

$$\omega^2\, s_{02} - \left(\frac{\gamma}{m} - 2\,\lambda\right)\omega\, s_{01} - \left(\lambda^2 + \frac{1}{2}b_0^2\, k^2 - \frac{\gamma}{m}\,\lambda\right) s_{02} = 0 \tag{2.47b}$$

or in another form:

$$(\lambda^2 + \tfrac{1}{2}b_0^2\, b^2\, k^2 - \tfrac{\gamma}{m}\lambda - \omega^2)\, s_{01} - (\tfrac{\gamma}{m} - 2\lambda)\, \omega\, s_{02} = 0 \qquad (2.48a)$$

$$-(\tfrac{\gamma}{m} - 2\lambda)\, \omega\, s_{01} - (\lambda^2 + \tfrac{1}{2}b_0^2\, b^2\, k^2 - \tfrac{\gamma}{m}\lambda - \omega^2)\, s_{02} = 0\,. \qquad (2.48b)$$

The determinant condition for non-trivial solutions yields several solutions, e.g.:

$$\lambda = i\,\omega + \frac{1}{2}\frac{\gamma}{m} \pm \sqrt{\frac{1}{4}\frac{\gamma^2}{m^2} - \frac{1}{2}b_0^2\, k^2}\;. \qquad (2.49)$$

We convert this into:

$$\lambda = i\,\omega + \frac{1}{2}\frac{\gamma}{m} \pm i\,\frac{1}{2}b_0\, k\sqrt{1 - \frac{\gamma^2}{m^2 {b_0}^2\, k^2}}\,.$$

For $O(\lambda^2) \ll O(\lambda)$, we find approximately:

$$\lambda_1 \approx i\frac{3}{2}\omega + \frac{1}{2}\frac{\gamma}{m} \quad \text{or} \quad \lambda_2 \approx i\frac{1}{2}\omega + \frac{1}{2}\frac{\gamma}{m}\,. \qquad (2.50)$$

Hence it returns a mixed term with damping and frequency shift.

Starting from (2.10) and (2.12), we find now for the drift current density:

$$\mathbf{J} = \frac{m_q}{a^2}\, {b_0}^2\, \tilde{s}_n^{(n)} \frac{\mathbf{e}_z \times \mathbf{B}_\Phi}{B_\Phi^2} = -\frac{m_q}{a^2}\, {b_0}^2\, \frac{\mathbf{e}_z \times \mathbf{B}_\Phi}{B_\Phi^2}\, 4\sin^2\frac{ka}{2}\, \tilde{s}_n \qquad (2.51)$$

For small values of ka and with (2.39) one finds the derivation:

$$\mathbf{j} = -\frac{m_q}{B_\Phi}\, {b_0}^2\, k^2\, (\dot{s}_n e^{-\lambda t} - \lambda\, s_n\, e^{-\lambda t})\, \mathbf{e}_y, \qquad (2.52)$$

or with (2.20) und (2.42):

$$\mu_0 \mathbf{j} = \mu_0 \frac{m_q}{B_\Phi}\, {b_0}^2\, k^2 \Big[\omega\big(i s_{01}\, (e^{i(kx-\omega t)} - e^{-i(kx-\omega t)}) + s_{02}(e^{i(kx-\omega t)} + e^{-i(kx-\omega t)})\big)$$

$$+\lambda\big(s_{01}\, (e^{i(kx-\omega t)} + e^{-i(kx-\omega t)}) - i\, s_{02}(e^{i(kx-\omega t)} - e^{-i(kx-\omega t)})\big)\Big]\, e^{-\lambda t}\, \mathbf{e}_y. \qquad (2.53)$$

We try a similar ansatz as with (2.18) for the electric field, but now again with a damping term:

$$E_y = \big[E_{01}(e^{i(k'x-\omega' t)} + e^{-i(k'x-\omega' t)}) - iE_{02}(e^{i(k'x-\omega' t)} - e^{-i(k'x-\omega' t)})\big]\, e^{-\lambda_E t}. \qquad (2.54)$$

We leave the value of the damping constant λ_E undetermined for a start.

With this ansatz we again obtain the following (as in the case without damping)

$$\frac{\partial^2}{\partial x^2} E_y = -{k'}^2\, E_y\,. \qquad (2.55)$$

But at the derivations with respect to time, damping comes into the play now:

$$\frac{\partial^2}{\partial t^2} E_y = (\lambda_E{}^2 - \omega'^2)\left[E_{01}(e^{i(k'x-\omega' t)} + e^{-i(k'x-\omega' t)}) - i\, E_{02}(e^{i(k'x-\omega' t)} - e^{-i(k'x-\omega' t)})\right] e^{-\lambda_E t}$$

$$+2i\lambda_E\omega' \left[E_{01}(e^{i(k'x-\omega' t)} - e^{-i(k'x-\omega' t)}) - iE_{02}(e^{i(k'x-\omega' t)} + e^{-i(k'x-\omega' t)})\right] e^{-\lambda_E t}. \quad (2.56)$$

We can insert again (2.53), (2.55) and (2.56) into (2.16):

$$- k'^2 \left[E_{01} (e^{i(k'x-\omega' t)} + e^{-i(k'x-\omega' t)}) - i\, E_{02} (e^{i(k'x-\omega' t)} - e^{-i(k'x-\omega' t)}) \right] e^{-\lambda_E t}$$

$$- \mu_0\varepsilon_0 \Big\{(\lambda_E{}^2 - \omega'^2)\left[E_{01} (e^{i(k'x \quad)} + e^{-i(k'x-\omega' t)}) - i\, E_{02} (e^{i(k'x-\omega' t)} - e^{-i(k'x-\omega' t)})\right]$$

$$+2i\lambda_E\omega'\left[E_{01} (e^{i(k'x-\omega \quad)} - e^{-i(k'x-\omega' t)}) - i\, E_{02} (e^{i(k'x-\omega' t)} + e^{-i(k'x-\omega' t)})\right]\Big\} e^{-\lambda_E t}$$

$$= \mu_0 \frac{m_q}{B_\Phi} b_0{}^2\; k^2\Big[\omega\Big(is_{01}\; \big(e^{i(kx-\,\omega t)} - e^{-i(kx \quad \omega t)}\big) + s_{02}\big(e^{i(kx-\,\omega t)} + e^{-i(kx-\,\omega t)}\big)\Big)$$

$$+\lambda\Big(s_{01}\; \big(e^{i(kx-\,\omega t)} + e^{-i(kx-\,\omega t)}\big) - i\, s_{02}\big(e^{i(kx-\,\omega t)} - e^{-i(kx-\,\omega t)}\big)\Big)\Big] e^{-\lambda t}. \quad (2.57)$$

Non-trivial solutions are only possible, if

$$k'x - (\omega' - i\lambda_E)t = 0 = kx - (\omega - i\lambda)t \quad (2.24a)$$

and

$$k'x - (\omega' + i\lambda_E)t = 0 = kx - (\omega + i\lambda)t\,. \quad (2.24b)$$

This is fulfilled for all arbitrary values of x and t only if:

$$k' = k,\;\; \omega' = \;\omega \;\text{ und } \lambda_E = \lambda_1 \text{ (oder } = \;\lambda_2) \quad (2.24c)$$

The real and the imaginary parts of (2.57) then deliver two equations again for the amplitudes of E_{01}, E_{02}, s_{01} und s_{02}:

We abbreviate $$p = \frac{\mu_0\, m_q\, b_0{}^2}{B_\Phi}\, k^2$$

and find ($\lambda \;=\; \lambda_1 \text{ or} = \;\lambda_2$):

$$\left[- k^2 - \mu_0\varepsilon_0(\lambda^2 - \omega^2)\right] E_{01} \;\; - 2\mu_0\varepsilon_0\lambda\, \omega E_{02} \;\;- p\, \lambda\, s_{01} \;\;- p\, \omega\, s_{02} = 0 \quad (2.58)$$

$$- 2\mu_0\varepsilon_0\lambda\, \omega\, E_{01} + \left[k^2 + \mu_0\varepsilon_0(\lambda^2 - \omega^2)\right]E_{02} \;\; - p\, \omega\, s_{01} \;\;+ p\lambda\; s_{02} = 0. \quad (2.59)$$

Multiplication with λ or ω yields:

$$\lambda\left[- k^2 - \mu_0\varepsilon_0(\lambda^2 - \omega^2)\right] E_{01} \;\; - 2\mu_0\varepsilon_0\lambda^2\omega E_{02} - p\lambda^2\, s_{01} \;- p\, \omega\, \lambda\, s_{02} = 0 \quad (2.60)$$

$$- 2\mu_0\varepsilon_0\lambda\omega^2\, E_{01} + \omega\left[k^2 + \mu_0\varepsilon_0(\lambda^2 - \omega^2)\right]E_{02} \;\; - p\, \omega^2 s_{01} \;+ p\, \omega\lambda\; s_{02} = 0. \quad (2.61)$$

And we find by addition:

$$\left(\lambda\left[- k^2 - \mu_0\varepsilon_0\lambda^2\right] - \mu_0\varepsilon_0\lambda\, \omega^2\right) E_{01}$$

$$- \omega \left(\mu_0 \varepsilon_0 \lambda^2 - k^2 + \mu_0 \varepsilon_0\, \omega^2\right) E_{02} – p(\lambda^2 + \omega^2)\, s_{01} = 0$$

or with $\frac{1}{c^2} = \mu_0 \varepsilon_0$ and $\frac{1}{b_0^2} = \frac{k^2}{\omega^2}$, and with the assumption $\lambda \ll \omega$ (note: λ is a parameter here, not a wavelength!) we find eventually:

$$s_{01} = - \frac{\lambda \left(1 + \frac{b_0^2}{c^2}\right) E_{01} + \omega \left(\frac{b_0^2}{c^2} - 1\right) E_{02}}{p b_0^2} \,. \tag{2.62}$$

There is a similar dependency also for s_{02}.

The figure s_{01} approaches the value described by (2.28b) if $\lambda \to 0$. In that case, it converges to zero if $c \to b_0$. But with a finite damping value, there is also a finite value for s_{01}, even in the case that $c \to b_0$. In other words, gravitational waves will be excited for each value of c. A “resonance” correlation remains between the amplitudes E_{01} and E_{02} and the gravitational excitations s_{01} und s_{02}, even when damping occurs. Now it becomes obvious that plane electromagnetic waves can exist in the universe only if $c = b_0$. Otherwise they would suffer damping over very large distances, which seem to prevent their existence. Finite values for the electromagnetic field amplitudes seem to be possible only if $c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} = b_0$.

We would like to recall our basic assumption, namely that all arbitrary shapes of electromagnetic or gravitational waves can be assembled by super-composing the respective plane waves. In that case, the behavior of these plane waves determines the behavior of any composition. If this fundamental assumption is justified, with the above investigation we find that gravitational waves dictate the existence and propagation of light. The “vacuum” parameters μ_0 and ε_0 are not natural constants but are determined by the gravitational constant as well as by the mean density of the universe and its extent.

The equation (2.62) interconnects the physical quantities s_{01}, E_{01} and E_{02}, which are measurable in principle. This is also valid for all similar equations, containing components of the electric, the magnetic or the displacement field. If respective experiments could be realized, it would be possible to determine the unknown parameters λ, m_q and B_Φ and to prove or to disprove the theory developed here.

3. Special Case: Dense Plasmas and Damping

Now we would like to look to damping within another context. It plays an important role with very dense plasmas, where a great number of collisions occur. In this case, damping is decisive and, of course, cannot be neglected. We shall immediately see that, in dense plasmas, damping could be causative for the coupling of light to gravitational waves. Depending on these damping effects, drift currents can occur.

Let us consider two particles of opposite charge within plasma of high density. If a gravitational field is acting there, we can write the equations of motion in the following form:

$$- m_e \dot{v}_e - \gamma_e v_e + m_e g = 0 \tag{3.1a}$$

$$- m_i \dot{v}_i - \gamma_i v_i + m_i g = 0 \,. \tag{3.1b}$$

If there would be no damping, i.e. if $\gamma_e = 0 = \gamma_i$, then the change of the velocities of both particles would always be the same. Also, their distance would remain the same, they could not be "polarized" by the gravitational field. This is different if the damping constants (and possibly also the masses) have a different size. In general, this will be the case and, therefore, the velocities will also become different: $v_e \neq v_i$. If the particles are identical, but have the opposite charge, and if n particles are contained within a volume element, they generate the current density

$$j = n\, q\, (v_e - v_i). \tag{3.2}$$

Therefore, in this case there is also a coupling between the electric and the gravitational field as described by (2.16). If we set for g again the gravitation factor g_{nj} of an oscillating disc (see (2.4)), and proceed analogous to the above consideration from (2.16) to (2.33), we arrive at structurally similar equations for the description of coupled electromagnetic and gravitational waves. In this case, the existence of an initial magnetic flux density $B_{n\Phi}$ is not demanded. On the other hand, electromagnetic waves can penetrate dense plasmas only on a limited scale (penetration depth). The effect occurs only at the skin of such plasmas, i.e. at the skin of stars. We will resign ourselves here to a more detailed investigation of the relationships. They seem to be much more complicated than with thin plasmas and the single particle model. And, here as well, a self-consistent solution that pays regard to all fields, to the motion of the particles, and to the boundary conditions must be found.

Finally, we would like to refer to the papers [1)] and [2)]. There we discussed the behavior of oscillating discs stretched out over a universal distance. We cannot assume that such discs are plane in the whole space, although we used this model for a simplified description. Rather, curved discs are to be expected even upon the effect of boundary conditions. According to these circumstances and due to the considerations and results of this paper, one would expect curved paths for the light propagation in the universe on large scales. This could imply that light beams at the edge of the universe will propagate parallel to the "outer surface" of the universe, i.e. on closed pathways. In this sense the universe could be seen as closed. Although space and time are separate entities in our theory, "space-time" is flat. Our theory is based on Euclidean geometry.

4. Summary and Conclusion

There is evidence that gravitational waves do exist even in the framework of Newton's laws alone [2)]. Based on this finding, it seems very reasonable that these gravitational waves are coupling to electromagnetic waves on a universal scale. An equation for this universally valid coupling can be derived. The collective excitation of gravitational waves on a universal scale seems to play a decisive role for the formation of light. The reason for that is the long range order of Newton's force of gravity. The theory established here is fundamentally based on this long range, i.e. universal scale character of Newton's law of gravity.

It seems that a non-locality of all incidents within the universe does exist. Everything depends on everything, everywhere and instantaneously (but nonetheless, there is a maximum velocity that particles must obey!). It is not only that gravitational waves seem to be possible; apparently they are omnipresent, are manifesting themselves by their interaction with electromagnetic waves, and in doing so determine the light velocity. It seems that there is a certain relationship of these universal properties to the properties envisaged of Einstein. Einstein believed, that in an ultimate theory the laws should apply everywhere, becoming manifest in solitons propagating within the framework of a large-scale topology of the universe [8)]. We intend to investigate this relationship in a forthcoming paper. To this end, we will have to abandon our restriction on linearized equations and will have to consider Frenkel-Kontorova-like equations instead (see also [2)]).

It is one of the results of paper [1)] that also the equation of motion for a massive light source is Lorentz invariant, i.e. light emitted from a moving light source is not dependent on the velocity of this source. If we see this result together with the findings in this paper on the correlation of gravitational and electromagnetic waves on universal scale, it seems that we have found something like the “lost ether” (which determines light propagation) without having looked for it. But the way on which we have found that result is quite different from all attempts from Lorentz’s time until now. It is found quite naturally, without any arbitrary assumptions or model imaginations, only on the basis of Newton’s laws and on the assumption that the universe exists. The universe with all its masses **is** the ether!

In the major part of the investigation in this paper, we have restricted ourselves to a homogeneous distribution of the masses in the universe. Of course, this restriction could be dropped, i.e. a space-dependent density distribution could be considered. In this case, plane waves will no longer describe the propagation of light. An inhomogeneous mass distribution would certainly lead to curved paths of propagation. Of course, it must be investigated, whether a respective extension of our theory will yield results that coincide with those of GR or not. But such an extension exceeds by far the frame set out here.

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