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GRAVITATIONAL EFFECTS' CONSIDERATION IN WAVE PROPAGATION IN CONTINUOUS MEDIA SUCH AS SOLIDS AND A VACUUM

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ABSTRACT

This short work belongs to interdisciplinary fields (like all modern science) because several separate fields such as physical acoustics, mechanics, electromagnetism, and gravity are stitched together. Practical applications are even more interdisciplinary because this already affects chemistry, biology, medicine, communications technologies, and everything else, since there are currently a huge number of technical devices on acoustic waves such as biological and chemical sensors, filters, delay lines, energy harvesters, etc. It is discussed that taking into account gravitational phenomena leads to the possibility of developing instantaneous interplanetary communication on new fast waves, the speed of which in a vacuum (solid) can be approximately thirteen orders of magnitude faster than the speed of light (electromagnetic waves).

Keywords: Wave propagation, electromagnetism, gravitational phenomena, torsional field, acoustic waves, new fast waves, energy harvesting.

INTRODUCTION

The study of acoustic wave propagation in piezoelectrics, piezomagnets, piezoelectromagnets (also known as magnetoelectroelastics and segnetomagnetics) eventually leads to more complex problems of acoustic wave propagation when their propagation is already coupled with all four potentials (electrical, magnetic, gravitational, and cogravitational ones, where the cogravitational potential can be also called the torsional one) that is already taking into account gravitational effects. Einstein also noted at the time that if there is energy, then gravity is also present, that is, it is always necessary to take into account gravitational effects (Zakharenko, 2019). And a wave of any kind carries energy. Therefore, it is necessary to discuss what the consideration of gravitational effects can lead to.

Discussion and results

When considering gravitational effects during the propagation of acoustic waves (Zakharenko, 2016, 2017a, 2017b) it turns out that the propagation velocity of acoustic waves in a solid (slow waves with a propagation velocity of several thousand m/s) can depend on velocities of the following waves:

1) The speed of an electromagnetic wave that propagates at a speed comparable to the speed of light in a vacuum. In solids, this speed is usually slightly less than in a vacuum. It should be mentioned here that the speed of light in a vacuum was accurately measured only in the 1970s.

2) The speed of a gravitational wave, which propagates at a speed is also comparable to the speed of light in a vacuum. It is well known that in 2017, the Nobel Prize in Physics was awarded to several researchers who experimentally proved that the speed of gravitational waves is approximately equal to the speed of light. This experimental work was published in 2016 (Abbott *et al*., 2016) that proves the existence of gravitational waves predicted by Albert Einstein more than a hundred years ago (Einstein, 1916).

3) The speeds of two fast waves that are by about 13 orders of magnitude higher than the speed of light. These fast waves also relate to gravitational effects because they propagate due to the connection between four subsystems, namely the electrical, magnetic, gravitational, and cogravitational ones. It should be mentioned here that for the first time the analogy between electromagnetism and gravitoelectromagnetism was studied by Heaviside more than a hundred years ago in his work (Heaviside, 1893) because there is some analogy between an electric field and a gravitoelectric field (i.e. gravitational) field, as well as between the magnetic field and the gravitomagnetic (i.e. cogravitational) field.

The gravitomagnetic (i.e. cogravitational) field can also be called the mascon field from the English expression mascon (Muller and Sjogren, 1968) that means mass concentration, if it turns out that the cogravitational field is responsible for the concentration (that is, some

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redistribution) of mass. There is another name for the gravitomagnetic (cogravitational) field such as the kinemassic field (Zakharenko, 2016). Also, Dunning-Davies and Dunning-Davies (2022) have recently recognized the cogravitational phenomenon as some gravitational vortex. However, it also can be called the original name such as the torsional field (Zakharenko, 2016, 2020a, 2020b) because Cartan, the French researcher who worked with Einstein ~ 100 years ago, has originally use the French word "torsion" (Shkatov and Zamsha, 2015) for the cogravitational phenomenon. Inspired by Albert Einstein's work on general relativity, Cartan pursued a unified field theory. His theory of spaces with torsion remains an important contribution to the study of torsional fields. For convenience to grasp the physical sense, the author here uses the terminology of gravitational and cogravitational fields, potentials, etc., as in the book by Jefimenko (2006). This is natural because the electrical and magnetic fields can be called the electrical and coelectrical fields or the comagnetic and magnetic fields, respectively.

So, when propagating the acoustic waves associated with electrical, magnetic, gravitational, and cogravitational (torsional) potentials, it is necessary to use a quasi-static approximation because the speed of the electromagnetic wave is five orders of magnitude higher than the speed of the acoustic wave. When waves propagate in a continuous medium, it is customary to use the four-dimensional Minkowski space (three coordinates of real space x_1, x_2, and x_3, and the fourth coordinate representing the wave propagation velocity V multiplied by time t):

$$\left(x_1, x_2, x_3, Vt\right) \tag{1}$$

Having considered the corresponding equations of motion (Zakharenko, 2016), the velocity of propagation of an acoustic wave associated with the electrical, magnetic, gravitational, and cogravitational (torsional) potentials can be written in the following highly simplified form:

$$V_A = A\sqrt{C/\rho} \sim 10^3 \text{ [m/s]} \tag{2}$$

where ρ and C represent the density of a solid [kg/m^3] and the elastic shear constant [N/m^2], respectively. And the dimensionless multiplier A is a very complex mathematical expression that depends on both the velocity of the electromagnetic wave V_{EM} and the velocity of the gravitational wave V_{GC}, namely the gravito-cogravitational wave (i.e. the gravito-torsional one) that are respectively defined in the following forms:

$$V_{EM} = \frac{1}{\sqrt{\varepsilon\mu}} \sim 10^8 \text{ [m/s]} \tag{3}$$

$$V_{GC} = \frac{1}{\sqrt{\gamma\eta}} \sim 10^8 \text{ [m/s]} \tag{4}$$

In the expressions written above, the material parameters of a continuous medium such as ε [s^2/m^2] and the dimensionless parameter μ are called the electrical and magnetic constants, respectively, that is, the dielectric constant and the magnetic susceptibility of the medium, which in this case is a solid. Also, the gravitational parameters of a continuous medium such as γ [kg×s^2/m^3] and η [m/kg] are called the gravitational and cogravitational (torsional) constants, respectively.

However, considering the gravitational effects it leads to the dependence of the dimensionless multiplier A on two other fast waves, whose speeds are estimated to be up to 13 orders of magnitude faster than the speed of light, depending on the medium. Moreover, the speeds of these two fast waves are already commensurate with the speeds that are needed to instantly cross the entire universe from one of its borders to the opposite one. These speeds are defined as follows:

$$\Lambda_1 = \frac{1}{\sqrt{\zeta\lambda}} \sim 10^{21} \text{ [m/s]} \tag{5}$$

$$\Lambda_2 = \frac{1}{\sqrt{\xi\beta}} \sim 10^{21} \text{ [m/s]} \tag{6}$$

where the exchange parameters of a continuous medium such as ζ, λ, ξ, and β are called the gravitoelectric constant [kg$^{1/2}$×s^2/m$^{5/2}$] = [CF/m^2], torsionomagnetic constant [m$^{1/2}$/kg$^{1/2}$] = [m/C], torsionoelectric constant [s/(kg$^{1/2}$×m$^{1/2}$)]= [m/Wb], and gravitomagnetic constant [kg$^{1/2}$×s/m$^{3/2}$] = [WbF/m^2], respectively. So, both the fast waves propagating at the speeds defined by expressions (5) and (6) can be naturally called the gravito-torsiono-electro-magnetic waves (gravito-cogravito-electro-magnetic waves).

It should be noted that the electromagnetic and gravito-cogravitational (gravito-torsional) waves propagating at speeds (3) and (4) can also propagate in solids as separate types of waves, that is, regardless of the acoustic waves. It should be noted here that the acoustic waves in piezoelectromagnetics, for instance, new shear waves (Zakharenko, 2018a) can be excited by noncontact methods, for example, using a concentrated light beam (laser). For this purpose, piezoelectromagnetics are preferable than traditional piezoelectrics (Thompson, 1990; Hirao and Ogi, 2003; Ribichini *et al.*, 2010). The analogy between the electromagnetism and gravitoelectromagnetism suggests that the acoustic waves can also be excited using a kind of gravitational beam (grazer). However, such technical devices have not been created today. The possibility of exciting an acoustic wave using other fast waves, the speeds of which are determined by expressions (5) and (6), is not discussed here because this task may be more expensive both in energy and in other material resources. Although it is currently not obvious.

It is well-known that any acoustic waves cannot propagate in a vacuum because they are a rarefied continuous medium, especially a deep vacuum. However, the other four waves including the two fast waves can propagate in a vacuum at the following speeds (here "0" is used for the corresponding vacuum parameters and C_L stands for the speed of light in a vacuum):

$$C_L = \frac{1}{\sqrt{\varepsilon_0 \mu_0}} \sim \frac{1}{\sqrt{\gamma_0 \eta_0}} \sim 10^8 \text{ [m/s]} \quad (7)$$

$$\Lambda_{01} = \frac{1}{\sqrt{\zeta_0 \lambda_0}} \sim 10^{21} \text{ [m/s]} \quad (8)$$

$$\Lambda_{02} = \frac{1}{\sqrt{\xi_0 \beta_0}} \sim 10^{21} \text{ [m/s]} \quad (9)$$

Although velocities (8) and (9) have the same order of magnitude, according to some estimates they can significantly differ from each other, even by an order of magnitude for a vacuum. For solids, it is possible that for velocities (5) and (6) it can be found that for some solids $\Lambda_1 > \Lambda_2$ but for others $\Lambda_1 < \Lambda_2$. Expressions (8) and (9) are of great interest, which can provide great opportunities for the entire human civilization. Currently, instantaneous interplanetary and even interstellar (intergalactic) communication is proposed (Zakharenko, 2018b, 2018c) on these new fast waves, the speed of which is approximately 13 orders of magnitude faster than the speed of light and which already belong to gravitational phenomena. It is also discussed "fuel-free" engines for interstellar flights (Zakharenko, 2018c) and processors on such fast waves. The word "fuel-free" here is, of course, a convention, which can mean harvesting energy from the surrounding continuous environment called a vacuum. In this case, the energy harvest is already being harvested from the entire universe but not just from the nearest star, as in the case of solar panels on space satellites. Currently, the field of energy harvesting research using the traditional piezoelectrics is rapidly developing (Sharma and Baredar, 2019; Iannacci, 2019; Nechibvute *et al*., 2012; Priya *et al*., 2017) because such materials are the most studied. However, such studies do not consider the gravitational effects.

Sound energy harvesting is one of the promising technologies due to the abundant and clean sound sources (Choi *et al*., 2019). It can be the semi-permanent alternative power supplies for wireless sensor networks (WSNs), which is significant in the Internet of Things (IoT). Choi *et al*. (2019) presented two typical types of energy harvesters for sound pressure amplification, where one utilizes a resonator and the other uses an acoustic metamaterial. They are based on piezoelectric, electromagnetic, and triboelectric mechanisms to convert sound energy to the electrical one. Also, a vast majority of electrical devices have integrated magnetic units, which generate constant magnetic fields with noticeable vibrations (Gowda *et al*., 2024). The majority of existing nanogenerators acquire energy through friction/mechanical forces and most of these instances overlook acoustic vibrations and magnetic fields. Magnetic two-dimensional structures can present a wide range of possibilities for devising a potential flexible energy harvester. The structures can exhibit stable high remnant magnetization, making them potential materials for harvesting magneto-acoustic waves.

It should be mentioned that in Einstein's theory of relativity there is a limit on the speed of light. However, in Lorentz's theory of relativity there is no such limit. It is also generally accepted nowadays that bodies with mass (this also applies to elementary particles that have mass) cannot move faster than the speed of light, and photons are known to be massless, although there are tentative attempts to estimate the mass of a photon. There is a well-known formula for time that if a mass particle has a velocity close to the speed of light, then time can be considered as stopped. But after all, electromagnetic, gravito-cogravitational, and two fast waves are some waves, that is, they can be considered as massless. Even formula (2) for the velocity of acoustic waves contains the density of the material, not the mass.

Why is there some limitation namely by the speed of light? The answer is obvious, since at that time, Einstein's time, namely more than a hundred years ago, only the speed of light was well known as the ultimate speed, which was accurately measured only in the 1970s. It is necessary to mention the original work by Newton (1687, 1989) has one problem such as the gravity speed is infinitely large that was discussed in the review by Zakharenko (2020b). This problem was understood as soon as this fundamental work by Newton was released. This problem was resolved by Fatio, Newton's closest friend, who has evaluated that the gravity speed can be thirteen orders faster than the speed of light. This evaluation was well accepted by Newton and all researchers about Newton. However, this evaluation was well-known only before Maxwell who strongly criticized Fatio's results because he was unhappy with Fatio's method of evaluation. Maxwell did not introduce any improved method and as a result of Maxwell's criticism, Fatio's method of evaluation was not mentioned anymore and was almost forgotten at the end. It is well-known that

Maxwell has developed Maxwell's theory of electromagnetism. It is also well known that Einstein was a follower of Maxwell theory and did not know about the results of Fatio. As a result, only the speed of light was the possible fastest speed for Einstein. And the second question is if the velocity of a mass particle is faster than the speed of light, does time become negative or imaginary? Apparently, the time is coming when it is already possible to remove restrictions on the speed of light in certain cases.

CONCLUSION

In this brief paper, the problem of considering the gravitational effects during the propagation of acoustic waves in solids was considered. This leads to the existence of new fast waves that can propagate thirteen orders of magnitude faster than the speed of electromagnetic waves in solids. Of greatest interest is the possibility of propagating these new fast waves in a vacuum for instantaneous interplanetary communication, for instance, instantaneous interplanetary Internet. The development of this method of rapid interplanetary communications can be facilitated by the comprehensive development of gravitational technologies, which, in the end, in combination with electromagnetic communication technologies, can lead to a well-developed infrastructure of instantaneous interplanetary communications.

For acoustic waves' energy harvesting, today it is already widely used many systems consisting of mechanical, electrical, and magnetic subsystems together. It is expected that both the gravitational and cogravitational (torsional) subsystems can be also treated in this research direction. Indeed, this inclusion can significantly complicate such investigations. However, it was mentioned in the introductory part of this paper that Einstein noted that if there is energy, then gravity is also present.

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