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ON EVALUATIONS OF FAST SPEEDS OF PROPAGATION OF GRAVITATIONAL PHENOMENA: A REVIEW

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ABSTRACT

To discuss of evaluations of propagation speeds of gravitational phenomena in continuous media is the main purpose of this review. This work touches the original work by Newton published in 1687, in which the gravitational phenomena propagate with an instant speed. In the second half of 1700s, Le Sage and Laplace have independently evaluated the propagation speeds of the gravitational phenomena to resolve the problem of the instant propagation. Each of them has actually obtained noninstant speeds for the phenomena but many orders faster than the speed of light in a vacuum. Several interesting independent evaluations were carried out in the last and this centuries by Kozyrev, Atsukovsky, Fedulaev, and the others. These evaluations have confirmed that the propagation speeds are almost instant but not instant. In the 1950s, Kozyrev has even created his own nonoptic experimental tools to observe true positions of stars distant from the earth on 10 to 1000 light years. Today some research teams have successfully realized new communication based on the fast speed gravitational phenomena that can be used for the instant interplanetary communication. Also, some researchers have recently proposed fast interplanetary spaceships with gravitational phenomena engines. It is expected that this review can be useful for both researchers-engineers working in the gravitational phenomena research arena and students for educational purposes. This review can also contribute to the successful creation of perfect infrastructure for the instant interplanetary (interstellar and even intergalactic) communication because some developing research directions were discussed.

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INTRODUCTION

The Danish astronomer Tycho Brahe (Tyge Ottesen Brahe, 1546-1601) was an accurate and comprehensive observer of astronomical objects. Working without a telescope for his astronomical observations, he has created his own model of the universe called the Tychonic system. For this model, he has incorporated the geometrical benefits of the Copernican system with the philosophical benefits of the Ptolemaic system. The polish astronomer and mathematician Nicolaus Copernicus (Mikołaj Kopernik, Niklas Koppernigk, 1473-1543) has formulated a heliocentric model of the universe, in which the Earth is orbiting the Sun. Copernicus has described this model in his main work (Copernicus, 1543), see also book (Armitage, 2012). However, the ancient Greek astronomer and mathematician Aristarchus of Samos (310-230 BC) influenced by Philolaus of Croton has presented the first known heliocentric model (Draper, 1875).

The Copernicus heliocentric model had many followers and the most famous of them are Giordano Bruno, Galileo Galilei, Johannes Kepler, and Isaac Newton who have further developed this model. The Italian philosopher Giordano Bruno (1548-1600) has developed the Copernicus heliocentric model and created his doctrine of the infinity of the universe and the multitude of worlds. The other Italian physicist, astronomer, and mathematician Galileo Galilei (1564-1642) was the first to use a telescope to observe celestial bodies.

The German mathematician and astronomer, Johannes Kepler (1571-1630) was one of the key scientists in the 17th-century scientific revolution. He became an assistant to the astronomer Tycho Brahe in Prague. After the death of Tycho Brahe, all unique data on astronomic observations obtained by Tycho Brahe were in his hands. As a result, Kepler was able to create his laws of planetary motion. Additionally, he did fundamental work in the field of optics, invented an improved version of the refracting (or Keplerian) telescope. Kepler is also famous for his books (Kepler, 1619) and (Kepler, 1617). The final

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section of book (Kepler, 1619) relates to his discovery of the third law of planetary motion. Seven books of his astronomy work (Kepler, 1617) on the heliocentric system were published in three volumes in the period from 1617 to 1621. The first, second, and third books united in the first volume were printed in 1617, the fourth book (second volume) in 1620, and the fifth, sixth, and seventh books (third volume) in 1621. These books also provided a basis for the theory of universal gravitation by Newton.

The English physicist, mathematician, and astronomer Isaac Newton (1642-1727) has published his outstanding work entitled “Philosophiae naturalis principia mathematica” (“Mathematical principles of natural philosophy”) in (Newton, 1687). In this book (Newton, 1687, 1989) Newton has formulated the laws of motion and universal gravitation. Newton has developed his mathematical description of universal gravitation to prove Kepler's laws of planetary motion in the framework of the heliocentric system. However, Newton’s theory of gravitation assumes an instant speed for propagation of gravitational phenomena.

The problem of evaluation of the speed of gravitational phenomena was stated right away when Newton has represented his theory of gravitation in 1687. Already in 1690 there appeared the known first attempt done by Nicolas Fatio de Duillier, a close friend of Newton for many years, to explain Newton's law of gravitation. In 1748, Georges-Louis Le Sage (Le Sage, 1761) has further developed Fatio’s ideas, namely a kinetic theory of gravity originally proposed by Fatio. This theory proposed a mechanical explanation for Newton's gravitational force in terms of streams of tiny unseen particles impacting all material objects from all directions (Le Sage, 1761). Concerning the movements of planets in the Solar system in the fluid consisting of these particles, Le Sage (1761) has used an argument to demonstrate that the speed of the fluid must be thirteen orders faster than the speed of light. To the end of the 1700s, the French mathematician Pierre-Simon Laplace (Laplace, 2007, 1982), also known as the French Newton, has evaluated the stability of the Solar system. He has investigated the motion of space bodies in the Solar system and concluded that the speed of gravitational phenomena must be millions of times faster than the speed of light, since otherwise violation of Newton's law of universal gravitation would be observed.

In his book, Jefimenko (2006) has stated that Newton's theory of gravitation is incomplete. In addition to the Newtonian gravitational field, Jefimenko has used the second gravitational field called the Heavisidian cogravitational field. This is similar to the theory of electromagnetism developed by Maxwell (1865), where the coupling between the electrical field and magnetic field is used in Maxwell’s equations. Heaviside (1893) was the first researcher who has mentioned a gravitational and electromagnetic analogy. This analogy leads to the Maxwell-like equations for gravitation, where the electric field and the electric constant can be substituted by the gravitational field and the gravitational constant, respectively, as well as the magnetic field and the magnetic constant can be substituted by the cogravitational field and the cogravitational constant, respectively. As a result, this type of the gravitational phenomena can propagate with the speed of light in a vacuum. These gravitational-cogravitational waves were detected by Abbott *et al*. (2016), i.e. in one hundred years after the prediction of the wave existence done by Einstein (1916). Let’s now return to the other possible gravitational phenomena, the very fast speeds of which were evaluated by Fatio, Le Sage, and Laplace that was mentioned above. Further experimental and theoretical achievements in this direction were done in the second half of the last century.

In the 1950s-1970s, the famous Russian astronomer and astrophysicist Kozyrev (1991) has created his own nonoptic tools at his observatory, Leningrad, USSR, with which he has observed true positions of stars distant from the Earth on many light years. For this purpose, Kozyrev has first used some optic tools to observe a star, then calculated the true position of the star, and used his own tools to observe this star at the true position. When the telescope was directed at a certain star, the detector (designed by Kozyrev and Nasonov) positioned within the telescope registered the incoming signals even if the main mirror of the telescope was shielded by metal screens. When the telescope was directed at the true position of the star, the detector then registered much stronger incoming signals (Kozyrev and Nasonov, 1980). This means that some nonoptic signals can propagate in a vacuum billions of times faster than the speed of light. To explain this phenomenon, Kozyrev has developed his own theory called the theory of time (Kozyrev, 1958, 1971). According to the theory, time and rotation are closely interconnected. In order to verify his theory, he also conducted a series of experiments with spinning gyroscopes. The breakthroughs of Kozyrev are described by Wilcock in Chapter 2 of his on-line book (https://divinecosmos.com/book/20-the-divine-cosmos).

A major research of gyroscopes and gyroscopic systems was also carried out by Veinik (1991) in the 1970s because he wanted to validate Kozyrev's theory. Veinik has confirmed the Kozyrev results. However, Veinik has created his own theory to explain the observed results. According to Veinik’s theory, every substance has its own chronal charge defined by the quantity of chronal particles (chronons). While the object is spinning, chronons are interacting with each other and they can generate the chronal field. Also, he has experimentally found that strong chronal fields can be generated by spinning masses. By measuring some properties of the chronal fields, he has concluded that plus-signed and minus-signed chronons can exist and the sign of the chronon depends on orientation of its spin (Veinik, 1991). This is an evidence that there are two types of particles, i.e. two types of interactions. This is a connection to the modern theory of gravitational torsional field (Shkatov and Zamsha, 2015) that operates with the left-handed and right-handed torsions. This theory was formulated by the Russian physicist Shipov (1998). Probably, Myshkin (1906) was the first who experimentally detected unusual effects associated with torsion and his experiments were successfully repeated in the 1960s by Kozyrev and Nasonov.

In the 1980s-1990s, astronomical observations using the Kozyrev-type detector were successfully carried out by the Lavrentiev group in Russian. Lavrentiev *et al*. did not give a theoretical interpretation to the observed facts (Lavrentiev *et al*., 1990a, 1990b, 1992) when the registered signals were coming from the visible position of observed star, the true position, and also the position symmetrical to the visible position of the star relative to its true position. In 1992, their results were interpreted by Akimov as registration of torsional waves. It is also possible here to mention one research report entitled "The estimation of the possibility to use gravitational waves for communication purposes" by the Perebeynos group in the USSR that was released in 1966. Perebeynos *et al*. have demonstrated an experimental communication system, in which the transmitter and the receiver were constructed as rotating masses. They received the transmitted information even when the receiver was shielded by massive screens. They interpreted their method as the generation and reception of gravitational phenomena.

Veinik (1991) has also constructed tens of types of generators based on rotating masses. The generators of the Veinik chronal fields (torsional fields) can affect practically all physical and biological objects. The generated radiation cannot be shielded by screens (Veinik, 1991; Veinik and Komlik, 1992) used for protection from the usual electromagnetic radiation. Yurovitsky has patented generators based on spinning magnets and first pointed out that many phenomena can be explained as manifestations of existence of long-range fields generated by spin or angular momentum density. Later some generators based on mechanically rotating magnets were also developed by Bobyr and many others. Today the torsional field generators and detectors manufactured by the Shkatov group and the others are commercially available (http://www.rexresearch.com/zamshatorsion/shkatovzamsha.html). Using some of them, this group has successfully transmitted the fast signals of gravitational phenomena that propagate at almost instant speeds. These signals were successfully transferred from Perth, Australia to Tomsk, Siberia, Russia and from New York city, USA to Tomsk, Siberia, Russia (Shkatov and Zamsha, 2015; Shkatov *et al*., 2017). Another study Shkatov and Zamsha (2015) offer a commercial interstellar communication system. The Shkatov-Zamsha photo image addressing method for communication was confirmed in the remote-control experiments (Kernbach *et al*., 2013; Maslobrod *et al.*, 2013).

The word "torsion" ("torsional") instead of the word "cogravitation" ("cogravitational") will be used further in this review. This is natural because the same Maxwell-like equations for gravitation are used in the theory of torsional fields with the gravitational and torsional fields instead of the gravitational and cogravitational fields, respectively. In the theory of the gravitoelectromagnetism representing the purely gravitational theory there are also the same Maxwell-like equations for gravitation with the gravitoelectric and gravitomagnetic fields instead of the gravitational and cogravitational fields, respectively. However, it is natural not to use the words "gravitoelectric" and "gravitomagnetic" to avoid any confusion because the reader can understand "gravitoelectric" as some interaction between the gravitational and electric subsystems. Similarly, "gravitomagnetic" means "cogravitational" but not an interaction between the gravitational and magnetic subsystems. For instance, there is the book by Khmelnik (2017) on the gravitomagnetism, i.e. cogravitation. So, it is preferable to use "torsional" instead of "cogravitational" and "gravitomagnetic". Indeed, nobody uses "electric field" and "coelectric field" or "comagnetic field" and "magnetic field" instead of the electric field and the magnetic field, respectively, for this pair of coexisting fields. It is worth noting that Eli Cartan has introduced the conception of spinor in 1913 and proposed the conception of torsional field as field of rotation (spiraling) in 1922 (Shkatov and Zamsha, 2015). The torsional field is also called the spin-torsion field, spin-field, s-field, etc.

So, let's use the word "torsion" instead of "cogravitation" in the recently developed theory (Zakharenko, 2016) due to the aforementioned arguments. This theory incorporates the gravitational phenomena in the problem of the acoustic wave propagation in the piezoelectromagnetic solids. Theory (Zakharenko, 2016) has also revealed the shear-horizontal surface acoustic wave, the propagation of which is coupled with the electrical, magnetic, gravitational, and torsional potentials, i.e. the shear-horizontal surface piezogravitotorsionoelectromagnetic (PGTEM) wave. Later, the dispersive PGTEM-waves were discovered in plates (Zakharenko, 2018a) and the nondispersive interfacial PGTEM-wave can also propagate along the common interface between two dissimilar solids (Zakharenko, 2017a). It is well-known that plate waves are utilized for further microminiaturization of technical devices. It is expected that different types of the acoustic PGTEM-waves' technical devices can be readily integrated in the modern acoustoelectronics and help in infrastructure development for the instant interplanetary (tele)-communication (Zakharenko, 2018b).

Various acoustic wave technical devices (sensors, filters, delay lines, etc.) became commercially available more than 60 years ago. Today, the (tele)-communicational industry annually needs over 3 billion acoustic wave filters, mainly in mobile phones and base stations. Basically, these are devices that work with surface acoustic waves and serve as bandpass filters in transmitters for both intermediate frequencies and radio wave frequencies. In addition, acoustic wave sensors are used in the automotive industry (torque and tire pressure sensors), medicine (chemical and biological sensors) and many other areas as sensors of humidity, temperature, etc. The reasons for such widespread utilization of this technology in industry is their low cost, reliability, sensitivity and endurance of devices. Moreover, some of them do not need power supplies (Durdag, 2009).

The structure of this review is as follows. The following section describes the theory of the propagation of the acoustic PGTEM-waves in the corresponding solids and also touches the propagation of possible waves in a vacuum incorporating the gravitational phenomena as well as analogies between the electromagnetism and mechanical (gravitational) system. The next section relates to the theoretical achievements by Atsyukovsky concerning his evaluation of some vacuum parameters and his theory of aetherodynamics. The following section after Atsyukovsky's results is for the interesting theoretical evaluation of the speed of the gravitational interaction by Fedulaev. The final section before Conclusion is for discussion, in which some phenomena and their applications are touched.

Wave phenomena resulted from interactions among electrical, magnetic, gravitational, and torsional fields

Investigations of acoustic wave propagation in piezoelectromagnetic (PEM) solids incorporating the gravitational phenomena were carried out in (Zakharenko, 2016). To incorporate gravitational phenomena is necessary because Einstein has postulated that any kind of energy (and any change in energy) is coupled with gravitation (Zakharenko, 2018c). Indeed, the propagation of any acoustic wave results in energy transfer from the wave generator to the wave detector. Therefore, this is the further development of the theory concerning the acoustic wave propagation in piezoelectromagnetics without taking into account the gravitational phenomena (Zakharenko, 2010, 2011).

For the piezoelectromagnetics of symmetry class 6 *mm*, the first results concerning the propagation of the shear-horizontal surface acoustic wave (SH-SAWs) was obtained by Melkumyan (Melkumyan, 2007; Zakharenko, 2013a). Further investigations have revealed the existence of many SH-SAWs discovered in (Zakharenko, 2013b, 2015, 2018d, 2019a). This is the fact that to study the acoustic wave propagation in the PEM materials is more complicated in comparison with the conventional piezoelectrics. In the piezoelectrics, the surface Bleustein-Gulyaev wave (Gulyaev, 1969; Bleustein, 1968) can propagate. The surface Bleustein-Gulyaev-Melkumyan wave (Melkumyan, 2007; Zakharenko, 2013a) propagates in the transversely-isotropic PEM materials of class 6 *mm*. These two SH-SAWs respectively depend on the material characteristics called the coefficient of the electromechanical coupling K_e^2 and the coefficient of the magnetoelectromechanical coupling K_{em}^2, where $K_e^2 = e^2/C\varepsilon$ and $K_{em}^2 = (\mu e^2 + \varepsilon h^2 - 2\alpha e h)/[C(\varepsilon\mu - \alpha^2)]$. All the material constants are listed in table 1. There are two bibles (Auld, 1990) and (Dieulesaint and Royer, 1980) on the acoustic wave propagation in the piezoelectrics that can help the reader to better understand the acoustic wave technology.

Theory (Zakharenko, 2016) considers a bulk solid continuum that must simultaneously possess the mechanical, electrical, magnetic, gravitational, and torsional subsystems. It is natural here to deal with the thermodynamic potential called the enthalpy H_e to obtain adiabatic rather than isothermal conditions. An adiabatic process can be characterized by the constant entropy: $S_a = S_0$ = const. The entropy illuminates a level of disorder in the system and the constant entropy condition means $dS_a = 0$. Therefore, there are five thermodynamic functions and each of them depends on five thermodynamic variables. The thermodynamic functions are the mechanical stressσ, electrical displacement D, magnetic displacement B, gravitational displacement Q, and torsional displacement K. The thermodynamic variables are the mechanical strain τ, electrical field E, magnetic field H, gravitational field G, and torsional field T. So, this thermodynamic system consists of five subsystems. These thermodynamic subsystems can interact among each other that is schematically shown in Figure 1.

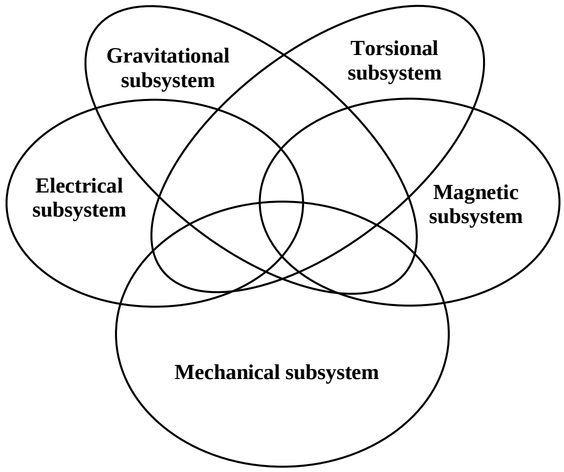

Fig. 1. The schematic demonstration of possible connections among the mechanical, electrical, magnetic, gravitational, and torsional subsystems in solids.

Table 1. The material parameters of the transversely isotropic solid of symmetry class 6 *mm*.

Material parameter	**Symbol [dimension]**
Mass density	ρ [kg/m^3]
Elastic stiffness constant	C [kg/(m×s^2)]
Piezoelectric constant	e [kg$^{1/2}$/m$^{3/2}$]
Piezomagnetic coefficient	h [kg$^{1/2}$/(m$^{1/2}$×s)]
Piezogravitic constant	g [kg/m^2]
Piezotorsionic coefficient	f [s^{-1}]
Electric constant	ε [s^2/m^2]
Magnetic constant	μ [-]
Electromagnetic constant	α [s/m]
Gravitic constant	γ [kg×s^2/m^3]
Torsionic constant	η [m/kg]
Gravitotorsionic constant	ϑ [s/m]
Gravitoelectric constant	ζ [kg$^{1/2}$×s^2/m$^{5/2}$]
Torsionoelectric constant	ξ [s/(kg$^{1/2}$×m$^{1/2}$)]
Gravitomagnetic constant	β [kg$^{1/2}$×s/m$^{3/2}$]
Torsionomagnetic constant	λ [m$^{1/2}$/kg$^{1/2}$]

Next, it is necessary to construct the coupled equations of motion for the treated case (Zakharenko, 2016). It is natural to use the quasi-static approximation because the speed of light is five orders faster than speeds of any acoustic waves. Therefore, the thermodynamic variables are respectively determined as the following partial first derivatives with respect to the real space components x_1, x_2, and x_3: $E_i = -\partial\phi/\partial x_i$, $H_i = -\partial\psi/\partial x_i$, $G_i = -\partial\Phi/\partial x_i$, $T_i = -\partial\Psi/\partial x_i$, where the index i runs from 1 to 3 and x_i are the components of the real space vector. The coupled equations of motion can be written down in the following differential forms: $\partial\sigma_{ij}/\partial x_j = \rho\,\partial^2 U_i/\partial t^2$, $\partial D_i/\partial x_j = 0$, $\partial B_i/\partial x_j = 0$, $\partial Q_i/\partial x_j = 0$, and $\partial K_i/\partial x_j = 0$, where the indices i and j run from 1 to 3, ρ is the mass density listed in Table 1, U_i are the mechanical displacement components, and t is time.

These coupled equations of motion are complicated and their differential form can be replaced by a tensor form. Indeed, for the differential form it is natural to use the solutions in the plane wave form. As a result of the substitution of these solution into the differential form, it is possible to obtain seven coupled equations of motion written in the tensor form. This tensor form of seven homogeneous equations can be naturally rewritten in the following compact form of the modified Green-Christoffel equation (Zakharenko, 2016):

$$\left(\Pi_{IJ} - \delta_{IJ}\rho V_{ph}\right)U_I^0 = 0 \qquad (1)$$

where the indices I and J run from 1 to 7 and the phase velocity is defined by $V_{ph} = \omega/k$ (ω is the angular frequency and k is the wavenumber). Π_{IJ} are the tensor components of the Green-Christoffel equation and δ_{IJ} represents the Kronecker delta-function with the following conditions: $\delta_{IJ} = 1$ for $I = J < 4$, $\delta_{IJ} = 0$ for $I \neq J$, and $\delta_{44} = \delta_{55} = \delta_{66} = \delta_{77} = 0$. U_I^0 are the eigenvector components that must be found.

Tensor form (1) of the coupled equations of motion can be used for modelling of acoustic wave propagation of any type in any propagation direction in any solid with certain crystal symmetry. However, there is an interest in investigations of the transversely isotropic solids of symmetry class 6 *mm*because there is a possibility to obtain solutions of propagation velocities in explicit forms. First of all, it is necessary to choose a right propagation direction in the solid. For this materials, the suitable propagation directions are perfectly described in review by Gulyaev (1998). The propagation direction must be perpendicular to both the sixfold symmetry axis and the surface normal. The chosen propagation direction allow dealing with propagation of SH-SAWs coupled with the electrical, magnetic, gravitational, and torsional potentials. Indeed, in this propagation direction, tensor form (1) representing a set of seven homogeneous equations can split into two independent sets of equations of motion. The first set consisting of five coupled equations is for modelling of the SH-SAW propagation coupled with the aforementioned potentials. The second set of two equations is for the purely mechanical surface Rayleigh wave (Zakharenko, 2005, 2006).

So, the set of five coupled homogeneous equations of motion in the tensor form must be resolved. This means that the suitable eigenvalues and all the corresponding eigenvectors must be found. Some possible eigenvectors were found in (Zakharenko, 2017b). Using the found eigenvalues and eigenvectors, it is possible to obtain a propagation speed for the SH-SAW, the propagation of which must satisfy certain boundary conditions. Pioneer work (Zakharenko, 2016) has obtained the following SH-SAW speed:

$$V_{SHSAW} = V_{emgt}\left[1-\left(\frac{K_{emgt}^2}{1+K_{emgt}^2}\right)^2\right]^{1/2} \quad (2)$$

In expression (2), the velocity V_{emgt} of the shear-horizontal bulk acoustic wave (SH-BAW) can be calculated with the following expression (Zakharenko, 2016):

$$V_{emgt} = \sqrt{\left(1+K_{emgt}^2\right)C/\rho} \quad (3)$$

In definition (3), the material parameters C and ρ are listed in table 1. Also, the velocities defined by (2) and (3) depend on the nondimensional parameter K_{emgt}^2 called the coefficient of the electromagnetogravitotorsionomechanical coupling (CEMGTMC). This coefficient can be calculated with the following formulae (Zakharenko, 2016, 2018e):

$$K_{emgt}^2 = \frac{\Gamma_1}{C\Gamma_2} \quad (4)$$

where

$$\Gamma_1 = e^2(\mu\gamma\eta + 2\beta\lambda\vartheta - \lambda^2\gamma - \beta^2\eta - \vartheta^2\mu) + h^2(\varepsilon\gamma\eta + 2\zeta\xi\vartheta - \vartheta^2\varepsilon - \zeta^2\eta - \xi^2\gamma) + g^2(\varepsilon\mu\eta + 2\alpha\xi\lambda - \lambda^2\varepsilon - \alpha^2\eta - \xi^2\mu) + f^2(\varepsilon\mu\gamma + 2\alpha\beta\zeta - \beta^2\varepsilon - \alpha^2\gamma - \zeta^2\mu) + 2eh(\zeta\beta\eta + \xi\gamma\lambda + \vartheta^2\alpha - \alpha\gamma\eta - \zeta\lambda\vartheta - \xi\beta\vartheta) + 2eg(\alpha\beta\eta + \xi\vartheta\mu + \lambda^2\zeta - \alpha\lambda\vartheta - \zeta\mu\eta - \xi\beta\lambda) + 2ef(\alpha\gamma\lambda + \zeta\vartheta\mu + \beta^2\xi - \alpha\beta\vartheta - \zeta\beta\lambda - \xi\mu\gamma) + 2hg(\varepsilon\lambda\vartheta + \zeta\alpha\eta + \xi^2\beta - \alpha\xi\vartheta - \zeta\lambda\xi - \varepsilon\eta\beta) + 2hf(\varepsilon\beta\vartheta + \xi\alpha\gamma + \zeta^2\lambda - \alpha\zeta\vartheta - \zeta\xi\beta - \varepsilon\lambda\gamma) + 2gf(\varepsilon\beta\lambda + \xi\mu\zeta + \alpha^2\vartheta - \alpha\zeta\lambda - \alpha\beta\xi - \varepsilon\mu\vartheta) \quad (5)$$

$$\Gamma_2 = (\varepsilon\mu - \alpha^2)(\gamma\eta - \vartheta^2) + (\beta\xi - \lambda\zeta)^2 - (\xi^2\mu\gamma + \beta^2\varepsilon\eta + \lambda^2\varepsilon\gamma + \zeta^2\mu\eta) + 2(\gamma\alpha\xi\lambda + \eta\alpha\beta\zeta + \varepsilon\beta\lambda\vartheta + \mu\zeta\xi\vartheta - \alpha\zeta\lambda\vartheta - \alpha\beta\xi\vartheta) \quad (6)$$

All the material parameters present in (5) and (6) are listed in table 1. Also, the reader can find that the following velocities V_{EM}, V_{GT}, $\Lambda_{\zeta\lambda}$ and $\Lambda_{\xi\beta}$ can be used in (5) and (6) instead of the corresponding material parameters:

$$V_{EM} = \frac{1}{\sqrt{\varepsilon\mu}} \quad (7)$$

$$V_{GT} = \frac{1}{\sqrt{\gamma\eta}} \quad (8)$$

$$\Lambda_{\zeta\lambda} = \frac{1}{\sqrt{\zeta\lambda}} \quad (9)$$

$$\Lambda_{\xi\beta} = \frac{1}{\sqrt{\xi\beta}} \quad (10)$$

The velocity V_{EM} (7) represents the speed of the electromagnetic waves that can propagate in the studied solid in the studied propagation direction. Usually, it is slightly slower than the speed of light (C_L) in a vacuum. The velocity V_{GT} (8) stands for the speed of the gravitotorsional waves in the solid that can propagate with the speed comparable with the speed C_L. The extra two speeds $\Lambda_{\zeta\lambda}$ and $\Lambda_{\xi\beta}$ in (9) and (10) can propagate in solids with the speeds thirteen orders faster than the light speed C_L. Therefore, these fast waves called the gravitotorsionoelectromagnetic (GTEM) waves represent an interest in the instant interplanetary (interstellar and even intergalactic) tele-communication (Shkatov and Zamsha, 2015; Zakharenko, 2018b, 2019b).

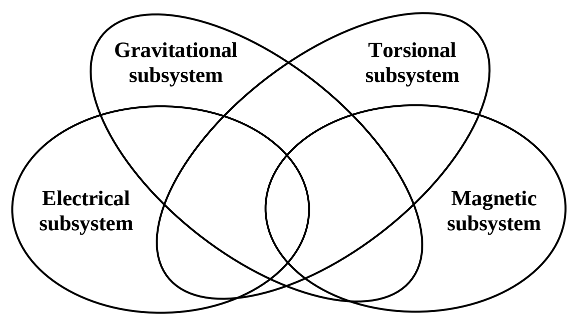

Fig. 2. The schematic demonstration of possible connections among the electrical, magnetic, gravitational, and torsional subsystems in a vacuum.

Also, it is useful to write down formula for calculation of energy that can be transferred by the acoustic wave coupled with the electrical, magnetic, gravitational, and torsional potentials. The total energy W_T can be inscribed as follows:

$$W_T = \Xi(\tau\sigma + ED + HB + GQ + TK)/2 \quad (11)$$

where Ξ is the volume [m^3].

In the parentheses of formula (11), the present five terms manifest the contributions in the total energy of the system from each of the five subsystems, namely from the mechanical, electrical, magnetic, gravitational, and torsional subsystems, respectively. However, each of the thermodynamic functions (mechanical stress σ and inductions D, B, Q, K) depends on all the thermodynamic variables (mechanical strain τ and fields E, H, G, T). This means that each subsystem also takes into account additional contributions from the other sub systems.

Table 2. The physical dimensions of the inductions (D_0, B_0, Q_0, K_0) and the corresponding fields (E_0, H_0, G_0, T_0) in the Maxwell equations for the electromagnetism theory and the Maxwell-like equations for the gravitational theory.

Thermodynamic parameter and symbol	**International dimension**
Electric displacement (electric induction) D_0	C/m^2
Electric field E_0	V/m = N/C
Magnetic displacement (magnetic induction) B_0	Gs = 10^{-4}T
Magnetic field H_0	Oe = $(10^3/4\pi)\times$(A/m)
Gravitational displacement (gravitational induction) Q_0	kg/m^2
Gravitational field G_0	J/(kg×m) = m/s^2
Torsional displacement (torsional induction) K_0	rad/s
Torsional (cogravitational, gravitomagnetic) field T_0	C×Wb/m^3

Table 3. The vacuum parameters borrowed from Yavorsky *et al*. (2006), where the values of the α_0, ϑ_0, ζ_0, ξ_0, β_0, and λ_0 were theoretically evaluated in the first approximation.

Vacuum parameter	**Value**
Electric constant	$\varepsilon_0 = 0.08854187817 \times 10^{-10}$ [F/m]
Magnetic constant	$\mu_0 = 1.25663706144 \times 10^{-6}$ [H/m]
Gravitic constant	$\gamma_0 = 1.498334 \times 10^{10}$ [kg×s^2/m^3]
Torsionic constant	$\eta_0 = 0.0742592 \times 10^{-26}$ [m/kg]
Speed of light	$C_L = (\gamma_0\eta_0)^{-1/2} = (\varepsilon_0\mu_0)^{-1/2} = 2.997924 \times 10^8$ [m/s]
Electromagnetic constant	$\alpha_0 \sim < 10^{-16}$ [s/m]
Gravitotorsionic constant	$\vartheta_0 \sim < 10^{-16}$ [s/m]
Gravitoelectric constant	$\zeta_0 \sim 10^{-8}$ [kg$^{1/2}$×s^2/m$^{5/2}$]
Torsionoelectric constant	$\xi_0 \sim 10^{-45}$ [s/(kg$^{1/2}$×m$^{1/2}$)]
Gravitomagnetic constant	$\beta_0 \sim 10^{-6}$ [kg$^{1/2}$×s/m$^{3/2}$]
Torsionomagnetic constant	$\lambda_0 \sim 10^{-40}$ [m$^{1/2}$/kg$^{1/2}$]

In a vacuum, formula (11) can be reduced to the following form:

$$W_{T0} = \Xi_0(E_0D_0 + H_0B_0 + G_0Q_0 + T_0K_0)/2 \quad (12)$$

where the subscript “0” is used for a vacuum and all the thermodynamic functions and variables are listed in table 2. Indeed, it is well-known that the elastic waves (acoustic waves) cannot propagate in a vacuum. Therefore, there is no mechanical (elastic) subsystem for a vacuum. The interacting subsystems for a vacuum are schematically shown in Figure 2.

However, the other types of waves can propagate in a vacuum. Using the vacuum parameters listed in table 3, it is possible to write down the speeds of the electromagnetic and gravitational phenomena that correspond to the speeds defined by expressions (7), (8), (9), and (10). As a result, the speed of light in a vacuum is

$$C_L = \frac{1}{\sqrt{\varepsilon_0\mu_0}} \quad (13)$$

The speed of the gravitotorsional waves (i.e. gravitational waves in (Abbott *et al*., 2016)) in a vacuum is defined by

$$C_G = \frac{1}{\sqrt{\gamma_0\eta_0}} \quad (14)$$

In a vacuum, the speeds of the GTEM-waves for the instant interplanetary (tele)-communication are expressed as follows:

$$\Lambda_{\zeta\lambda 0} = \frac{1}{\sqrt{\zeta_0\lambda_0}} \quad (15)$$

$$\Lambda_{\xi\beta 0} = \frac{1}{\sqrt{\xi_0\beta_0}} \quad (16)$$

So, the waves propagating in a vacuum with speeds (13), (15), and (16) are relevant to the electromagnetic phenomena. However, the waves propagating in a vacuum with speeds (14), (15), and (16) pertain to the gravitational phenomena. This is true because the waves propagating in a vacuum with speeds (15) and (16) belong to both the electromagnetic and gravitational phenomena.

The speed of light, C_L (13), is present in the following Maxwell equations that can reveal the characteristics of the electromagnetic waves propagating in a vacuum because $D_0 = \varepsilon_0 E_0$ and $B_0 = \mu_0 H_0$:

$$\begin{cases} \mathrm{div}\ \mathbf{D_0} = 0 \\ \mathrm{curl}\ \mathbf{E_0} = -\frac{\partial \mathbf{B_0}}{\partial t} \\ \mathrm{div}\ \mathbf{B_0} = 0 \\ \mathrm{curl}\ \mathbf{H_0} = \frac{\partial \mathbf{D_0}}{\partial t} \end{cases} \quad (17)$$

where **div** stands for divergence, a vector operator in vector calculus that operates on a vector field, producing a scalar field giving the quantity of the vector field's source at each point. The **curl** of a vector field **F** (curl **F**, or ∇ × **F**, or rot **F**) is a vector operator that describes the infinitesimal rotation of a vector field in three-dimensional Euclidean space. The name "curl" was first suggested by Maxwell (1871). However, the concept was apparently first used in the construction of an optical field theory by MacCullagh in 1839 (MacCullagh, 1880).

Using Maxwell's equations (17), the Maxwell-like equations for gravitation can be then written in the following analogous form:

$$\begin{cases} \text{div } \mathbf{Q_0} = 0 \\ \text{curl } \mathbf{G_0} = -\frac{\partial \mathbf{K_0}}{\partial t} \\ \text{div } \mathbf{K_0} = 0 \\ \text{curl } \mathbf{T_0} = \frac{\partial \mathbf{Q_0}}{\partial t} \end{cases} \quad (18)$$

The Maxwell-like equations for gravitation in (18) operate already with the gravitational and torsional inductions (Q_0 and K_0) instead of the electric and magnetic inductions (D_0 and B_0) as well as with the gravitational and torsional fields (G_0 and T_0) instead of the electric and magnetic fields (E_0 and H_0), respectively. In

Table 4. The analogy (Nuriev, 2004) between the electromagnetism and mechanics (gravitation). The vacuum parameters $\{\varepsilon_0, \mu_0, \gamma_0, \eta_0\}$ are listed in Table 3.

Electromagnetism and electric circuits	**Mechanical (gravitational) analogy**
Coulomb's law: $F_q = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2}$ [(C×V)/m] = [N], where r is the distance between the electric charges q_1 and q_2	Newton's law: $F_m = \frac{m_1 m_2}{4\pi\gamma_0 r^2}$ [(kg×m)/s^2] = [N], where r is the distance between the masses m_1 and m_2
Electric field strength: $E = \frac{q}{\varepsilon_0 r^2}$ [V/m]	Gravitational field strength: $G = \frac{m}{\gamma_0 r^2}$ [m/s^2]
Electric induction: $D = \varepsilon_0 E$ [C/m^2]	Gravitational induction: $Q = \gamma_0 G$ [kg/m^2]
Electric induction flux: $N = DS$ [C], where S is the square [m^2]	Gravitational induction flux: $O = QS$ [kg]
Electric current: $I = \frac{dq}{dt}$ [C/s] = [A]	Mechanical current: $j = \frac{dm}{dt}$ [kg/s]
Electrical voltage: U [V]	Mechanical analogy: V^2 [m^2/s^2] is the speed squared
Condenser capacity: $C = \frac{q}{U}$ [C/V] = [F], $C = \frac{\varepsilon_0 S}{d}$ [C/V] = [F], d is the distance	"Mechanical" condenser capacity: $Z = \frac{m}{V^2}$ [(kg×s^2)/m^2], $Z = \frac{\gamma_0 S}{d}$ [(kg×s^2)/m^2]
Attraction force of the capacitor plates: $F_Q = \frac{q^2}{2\varepsilon_0 S}$ [(C×V)/m] = [N]	Attraction force of the mechanical capacitor plates: $F_M = \frac{m^2}{2\gamma_0 S}$ [(kg×m)/s^2] = [N]
Ampere's force law: $F_A = \frac{\mu_0 I_1 I_2 l}{d}$ [(C×V)/m] = [N], where d is the distance between two wires, and l the wire length	Mechanical analogy: $F_{mech} = \frac{\eta_0 j_1 j_2 l}{d}$ [(kg×m)/s^2] = [N]
Magnetic field strength: $H = \frac{I}{4\pi r}$ [A/m]	Torsion field strength: $T = \frac{j}{4\pi r}$ [kg/(s×m)]
Magnetic induction: $B = \mu_0 H$ [(V×s)/m^2] = [T]	Torsion induction: $K = \eta_0 T$ [rad/s]
Magnetic field flux: $\Phi_M = BS$ [V×s] = [Wb] $d\Phi_M = LdI$ [(C×V)/A] = [Wb]	Torsion field flux: $\Phi_T = KS$ [m^2/s] $d\Phi_T = Ydj$ [m^2/s]
Inductance: $L = \frac{U dt}{dI}$ [(V×s)/A] = [H]	Mechanical inductance: $Y = \frac{V^2 dt}{dj}$ [m^2/kg]
Energy: $W = qU$ [C×V] = [J] Capacitor energy: $W_C = CU^2/2$ [J] Inductor energy: $W_L = LI^2/2$ [J]	Energy: $W_M = mV^2/2$ [(kg×m^2)/s^2] = [J]
Ohm's law: $R = U/I$ [V/A] = [Ω]	Mechanical analogy of Ohm's law: $R_{mech} = V^2/j$ [m^2/(kg×s)]
Capacitive reactance: $X_C = 1/\omega C$ = [Ω], where ω is the angular frequency	Reactive resistance of mechanical condenser: $X_Z = 1/\omega Z$ [m^2/(kg×s)]
Inductive reactance: $X_L = \omega L$ [V/A] = [Ω]	Reactive resistance of mechanical inductance: $X_Y = \omega Y$ [m^2/(kg×s)]
Electric power: $P = IU$ [A×V] = [W]	Mechanical power: $P = jV^2$ [(kg×m^2)/s^3] = [W]

(18), inductions $Q_0 = \gamma_0 G_0$ and $K_0 = \eta_0 T_0$ and therefore, there is the wave propagation at speed C_G (14) that can be readily calculated.

To model together both the electromagnetic and gravitational phenomena that can propagate at speeds (13), (14), (15), and (16) in a vacuum, it is necessary to analyze equations (17) and (18). It is obvious that for this purpose, a set of equations must consist of four or even eight equations. These equations must contain the field parameters listed in Table 2 and the vacuum parameters listed in Table 3. So, it is possible to introduce the following functions:

$$F_I(\varepsilon_0, \mu_0, \alpha_0, \gamma_0, \eta_0, \vartheta_0, \zeta_0, \lambda_0, \xi_0, \beta_0, \mathbf{E_0}, \mathbf{D_0}, \mathbf{H_0}, \mathbf{B_0}, \mathbf{G_0}, \mathbf{Q_0}, \mathbf{T_0}, \mathbf{K_0}) = 0 \qquad (19)$$

where the index I can run from 1 to 4 or even from 1 to 8.

It is worth noting that Maxwell has used mechanical analogies to explain the electrical and magnetic phenomena in his theory. Today, the analogies between many electromagnetic and mechanical quantities are widely used in some branches of engineering sciences. It is natural that a large list of the analogies is introduced by Nuriev (2004). Also, Maxwell has derived his equations with the assumption of the existence of aether in the free space. Therefore, it is necessary to discuss some modern evaluations of the aether parameters given in the following section.

Using Table 4, it is possible to make mechanical systems following their analogs in the electrical systems. Analogous electrical and mechanical systems naturally have equations of the same form. There are two analogs that are used to go between the electrical and mechanical systems: 1) electrical quantity to mechanical analog I (force-current) and 2) electrical quantity to mechanical analog II (force-voltage). For instance, the force-current analogy between the mechanical and electrical circuits was touched in (Chen *et al*., 2009). Review (Fouda *et al*., 2015) also touches analogies between some electrical and mechanical quantities because there is a missing link between displacement and momentum.

The results by Atsyukovsky

Atsukovsky has published many books on the world aether discussing its properties. Different achievements in many research arena (including Maxwell's equations discussed in the previous section) were obtained in the framework of the existence of the world aether. However, Einstein did not find a spot for the world aether in his geometric theory of gravitation called the general relativity theory postulated in 1915. As a result, any mention about the existence of aether is avoided in the modern scientific literature, but review papers. However, there is still an interest in studies of the world aether for many modern researchers.

Table 5. The evaluated parameters and physical dimensions of the free space (vacuum, aether) near the planet Earth (Atsyukovsky, 2010).

Parameter and symbol	**Evaluated value and physical dimension**
Pressure, P	$> 1.3 \times 10^{36}$ [N/m^2]
Specific energy, w	$> 1.3 \times 10^{36}$ [J/m^3]
Temperature, T	$< 10^{-44}$ [K]
Speed of first sound, C_A	$> 4.3 \times 10^{23}$ [m/s]
Speed of second sound, C_L	$\sim 3 \times 10^{8}$ [m/s]
Thermal diffusivity, α	$\sim 4 \times 10^{9}$ [m^2/s]
Thermal conductivity, k_T	$\sim 1.2 \times 10^{89}$ [W/(m×K)]
Kinematic viscosity, χ_K	$\sim 4 \times 10^{9}$ [m^{2}s]
Dynamic viscosity, χ_D	$\sim 3.5 \times 10^{-2}$ [kg/(m×s)]
Adiabatic index	1 – 1.4
Heat capacity at constant pressure, C_P	$\sim 1.4 \times 10^{91}$ [m^2/(s^2×K)]
Heat capacity at constant volume, C_V	$\sim 1.0 \times 10^{91}$ [m^2/(s^2×K)]

In his book on aetherodynamics, Atsukovsky (2010) has collected together the evaluated parameters of the free space (aether) near the planet Earth. These parameters are listed in Table 5. The interesting thing in Table 5 is the fifth row, in which Atsukovsky provides the speed of the second sound of the world aether. This speed is equal to the speed of light, $C_L \sim 3 \times 10^8$ [m/s]. Also, the fourth row of table 5 contains the evaluated speed of the first sound of the world aether, $C_A > 4.3 \times 10^{23}$ [m/s]. Atsyukovsky also operates with the other value for the speed of the first sound, $C_A \sim 5.5 \times 10^{21}$ [m/s]. This speed is thirteen orders faster than the speed of light in a vacuum that confirms the evaluation by Le Sage (1761) discussed in the introductory part of this review.

Table 6. The evaluated parameters and physical dimensions of the amer, an element of the aether (Atsyukovsky, 2010).

Parameter and symbol	**Evaluated value and physical dimension**
Mass, m_a	$< 1.5 \times 10^{-114}$ [kg]
Diameter, d_a	$< 4.6 \times 10^{-45}$ [m]
Quantity per volume unit, n_a	$> 5.8 \times 10^{102}$ [m^{-3}]
Average length of free run, λ_a	$< 7.4 \times 10^{-15}$ [m]
Average speed of thermal motion, u_a	$\sim 5.4 \times 10^{23}$ [m/s]

In the frameworks of the aetherodynamical picture of the world by Atsyukovsky (2010) there is an element of the world aether called the amer. The word “amer” means “undividable”, “unmeasurable”. This is true undividable elementary particle. In contrast, the word “atom” means “uncut” and therefore, atoms are dividable particles. Indeed, it is well-known that atoms consist of neutrons, protons, and electrons. Table 6 lists the evaluated parameters of the amer.

It is possible here to mention that Mendeleev has created his table of the chemical elements, in which the aether was included. Like the other outstanding researchers working at the border between the 19th and 20th centuries, Mendeleev (2012) has tried to understand the world aether. However, the aether was soon deleted from Mendeleev’s table of the chemical elements. The absence of the aether in Mendeleev’s table is natural because the amer in Table 6 has very tiny parameters such as the amer mass is $< 1.5 \times 10^{-114}$ [kg] and the amer radius is $< 2.3 \times 10^{-45}$ [m]. These amer parameters are significantly smaller even in comparison with the corresponding parameters for an electron (Yavorsky *et al*., 2006): the electron mass is $\sim 9.1 \times 10^{-31}$ [kg] and the classical electron radius is $\sim 2.8 \times 10^{-15}$ [m]. However, Mendeleev’s table was created for the chemical elements, each of which consists of neutrons, protons, and electrons. For instance, the neutron mass is $\sim 1.67 \times 10^{-27}$ [kg] and a mean square radius of neutron is $\sim 0.8 \times 10^{-15}$ [m]. Indeed, neither electron nor proton is present in Mendeleev’s Table. Therefore, it was not a good idea to include the aether or the amer (an element of the aether) in the table by Mendeleev. Also, Atsyukovsky (2010) has evaluated the density of the free space that is absent in table 5. His value for the density is $\sim 8.85 \times 10^{-12}$ [kg/m^3]. Also, there is the other value for the density, $\sim 9.36 \times 10^{-19}$ [kg/m^3], provided by Maxwell in 1877 in the collected papers on the aether wind (Atsyukovsky, 2011). There is also the known value for the elastic constant of a vacuum: $C_0 = 0.001$ [N/m^2] by Kiang and Tong (2010). This value is thirteen orders smaller than that for a solid. Indeed, with the vacuum elastic constant and the vacuum density, it is possible to evaluate a possible speed of elastic wave (acoustic wave) in a vacuum. However, it is well-known that any acoustic wave cannot propagate in a vacuum. In general, acoustic waves in solids propagate at speeds ~ 2,000 [m/s].

The evaluation by Fedulaev

The other interesting evaluation of the speed of the gravitational phenomena was performed by Fedulaev (2006). He has treated the system of two celestial bodies such as the Sun and the Earth. The earth is orbiting the Sun that is shown in figure 3. The Sun-Earth attraction force F_{SE} that keeps the Earth orbiting the Sun can be calculated with the following well-known formula:

$$F_{SE} = G_N M_S m_E / R_{SE}^2 \quad (20)$$

where G_N is the Newtonian gravitational constant, $G_N = 6.67 \times 10^{-11}$ [N × m^2/kg^2], the mass of the Sun is $M_S \sim 3.6 \times 10^{30}$ [kg] and the mass of the Earth is $m_E \sim 5.98 \times 10^{24}$ [kg]. The average distance between the Sun and the Earth is $R_{SE} \sim 150 \times 10^9$ [m].

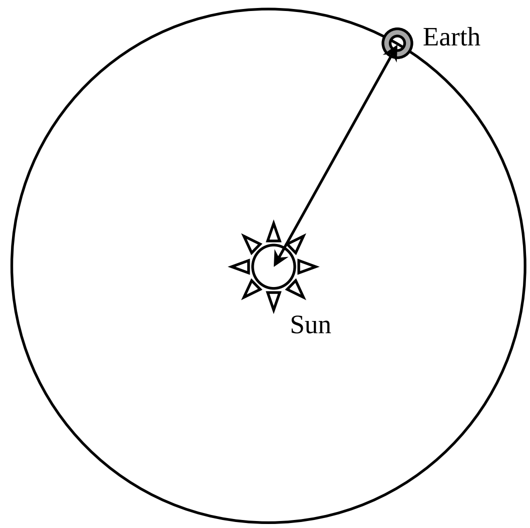

Fig. 3. The interconnection between the Sun and the Earth. The average diameters of the Sun and the Earth are $\sim 139 \times 10^7$ [m] and $\sim 1.27 \times 10^7$ [m], respectively. The average distance between them is $R_{SE} \sim 150 \times 10^9$ [m].

Table 7. The comparison between the Sun-Earth attraction force (F_{SE}) and the pressure force (F_p) acting on the Earth by the solar electromagnetic radiation.

Action force	**Steel cable diameter**
$F_{SE} \sim 3.6 \times 10^{22}$ [N]	$d_{st1} \sim 3.0 \times 10^6$ [m]
$F_p \sim 1.0 \times 10^9$ [N]	$d_{st2} \sim 1.0$ [m]

The value of the force F_{SE} is also well-known (Syunyaev, 1986) and listed in table 7. Fedulaev has stated that this attractive force F_{SE} is able to break a steel cable with the diameter of d_{st1} ~ 3,000 km, see in the second column of table 7. On the other hand, Fedulaev has calculated the repulsion force F_p cause by the solar radiation. It is well-known that the solar radiation can press on any surface. The first experiments on light pressure measurements were carried out by Lebedev more than one century ago (Masalov, 2019; Lebedev, 1963). Fedulaev has calculated that the force F_p (table 7) with which the solar radiation presses on the Earth is ten trillion times less than the gravitational pull of the Earth to the Sun. This repulsive force F_{SE} is able to break a steel cable with the diameter of d_{st2} ~ 1 m.

Next, Fedulaev (2006) has concluded that the speed of the particles responsible for the attractive force must be thirteen orders faster than the speed of light in a vacuum because $F_{SE}/F_p \sim 10^{13}$ and $(d_{st1}/d_{st2})^2 \sim 10^{13}$. Indeed, the speed of the solar electromagnetic radiation in a vacuum is always the same, namely $C_L = 2.997924 \times 10^8$ [m/s]. This can be true in the assumption that one deals here with the massless particles, of which the photons responsible for the repulsion and the faster particles responsible for the attraction are relevant. Fedulaev has also found that his evaluation of the speed of the gravitational phenomena, i.e. $10^{13}C_L$, qualitatively agrees with the first sound speed evaluated by Atsukovsky (2010) in his theory of the aetherodynamics, see in Table 5 of the previous section. Fedulaev has also mention an agreement with the results by Le Sage (1761). The theoretical work by Fatio developed by Le Sage (1761) was shortly discussed in the introductory part of this review. There are also modern books (Ivanov and Savrov, 2004; Edwards, 2002) that relevant to the Le Sage theory of gravitation. It is worth noting that the Le Sage work called the Mechanical Physics (Le Sage, 1818) represents the most systematical description of his theory of the gravitational phenomena. This his work was published by his follower Prévost in 1818.

Fedulaev's point of view on the nature of the attractive forces is close to that described in Hegel's philosophical dissertation (Hegel, 1801, 1972) on orbits of planets. As a result, Fedulaev dedicated his work (Fedulaev, 2006) to the 200th anniversary of the philosophical dissertation by Hegel (1801). Fedulaev (2006) also believes that the propagation of any type of waves in a vacuum looks like it has some features of the shock wave propagating in the other continuous media. Concerning the shockwave studies, the reader can find as many as 39 volumes published from 1993 to 2019 related to the Springer book series on the shockwave and high-pressure phenomena, for instance, see in the book by Davison (2008).

DISCUSSION

So, this review introduced the reader to the various approaches that have led to different evaluations of the speeds of the gravitational phenomena. This is concerned with the possible propagation at speeds many orders faster than the speed of light in a vacuum. The first original explanation of the gravitational theory by Newton (1687) was done in 1690 by Fatio who was a close friend of Newton. The necessity to explain Newton's theory of gravitation lies in the fact that this theory assumes infinitely large speed of the gravitational phenomena. Le Sage (1761, 1818) has developed the ideas of Fatio and found that the speed of the gravitational phenomena must be thirteen orders faster than the speed of light in a vacuum.

Laplace was perfectly familiar with the work by Le Sage. However, in his work Laplace has never mentioned about the achievements by Le Sage. Laplace (2007) has developed his own method for evaluation of the speed of the gravitational phenomena. He has treated the stability of the Solar systemand concluded that the speed of gravitational phenomena must be millions of times faster than the speed of light. Today there is still a great interest in the Le Sage theory of gravitation (Ivanov and Savrov, 2004; Edwards, 2002). As a result, it is natural to combine the evaluations of the speed of the gravitational phenomena in table 8, in which for comparison there are the evaluations by Le Sage and Laplace done several centuries ago and by the modern researchers done in the last and this centuries.

Indeed, the results combined in table 8 support the Le Sage and Fatio ideas that the speed of the gravitational phenomena must be so fast. It is worth noting the Le Sage theory of gravitation was the main theory before Maxwell has criticized this theory. Later, Einstein has created his own theory of the gravitation called the general relativity theory and postulated in 1915 that the speed of light is the maximum possible speed. Indeed, the evaluations in table 8 violate Einstein's postulation. The breakthroughs by Kozyrev (1991) and the results of many his followers in Russia and many other countries represent the solid evidence that there are nonoptic fast signals that can be detected with special tools. Some of his followers have already developed some prototypes of generators and detectors for the instant interstellar communications (Shkatov and Zamsha, 2015). It is expected that the maximum value of the speed (formulae (15) and (16)) of these fast signals must be below ~ 10^{27} m/s (~ $10^{18}C_L$) representing the speed, with which a signal can cross for one second from one boundary of our Universe to the opposite. It is worth noting that the size of our Universe is approximately 100 billion light years, i.e. 100 Gly (Gigalight year). The size of our Galaxy called the Milky Way is ~ 100,000 light years, i.e. six orders smaller than the linear size of our Universe.

The successful experiments by Kozyrev (1991) and his followers are not the single inconvenience for the followers of the Einstein's general relativity theory that violates the postulation on impossibility of propagation at speeds faster that the speed of light. There is also a large class of the solid magnetoelectric materials (Bichurin *et al*., 2019, 2001; Rivera, 2009), for which the electromagnetic constant α characterizing the magnetoelectric effect is successfully measured during the last sixty years. The magnetoelectric materials are suitable candidates for spintronics and there is the following condition of thermodynamic stability for them: $\alpha^2 < \varepsilon\mu$ (Özgür *et al*., 2009; Fiebig, 2005), where ε and μ are the electric and magnetic constants, respectively. For real solids, this condition can be rewritten as $\alpha^2 << \varepsilon\mu$. Using the corresponding speeds instead of the material constants, the thermodynamic stability condition is $V_\alpha >> V_{EM}$, where $V_\alpha = 1/\alpha$ and $V_{EM} = (\varepsilon\mu)^{-1/2}$ stand for the exchange speed and the speed of the electromagnetic wave, respectively. For the solids, the magnetoelectric effect is so small that there is even $V_\alpha >> C_L$. This is an evidence, i.e. $V_\alpha >> C_L$, that the exchange speed can be significantly faster than the speed of the electromagnetic wave propagating in a solid or a vacuum. For instance, $\alpha = 2.67 \times 10^{-12}$ [s/m] for Cr_2O_3 (Bichurin *et al*., 2019; Astrov, 1960) and therefore, $V_\alpha = 3.75 \times 10^{11}$ [m/s] $>> C_L = 2.99782458 \times 10^8$ [m/s].

There are also the experiments by Tajmar *et al*. (2009) concerning the anomalous fiber optic gyroscope signals. They have found that these signals are up to 18 orders of magnitude larger in comparison with the classical frame-dragging spin-coupling predictions. Therefore, their experimental results lie far from the Einstein's general relativity theory. They have concluded without any explanation that they have observed a new phenomenon.

Table 8. The evaluated speeds of the gravitational phenomena that can travel at speeds significantly faster that the speed of light, $C_L = 2.997924 \times 10^8$ [m/s].

Researcher	**Evaluated value [m/s]**	**Year**	**Reference**
Newton	∞	1687	Newton (1687)
Le Sage	$\sim 10^{13} \times C_L$	1761	Le Sage (1761)
Laplace	$\sim 10^{8} \times C_L$	1798	Laplace (2007)
Kozyrev	$\sim 10^{9} \times C_L$	1950s	Kozyrev (1991)
Atsyukovsky	$\sim 10^{15} \times C_L$	2000	Atsyukovsky (2010)
Fedulaev	$\sim 10^{13} \times C_L$	2006	Fedulaev (2006)
Zakharenko	$\sim 10^{13} \times C_L$	2016	Zakharenko (2018b)

Table 9. The frequencies (classification) of the electromagnetic waves in comparison with the classification of the gravitotorsiono electromagnetic (GTEM) waves. In a vacuum, the electromagnetic waves of any frequency (energy) propagate at the same speed (13) and the GTEM-waves propagate at speeds (15) and (16). The visible light is between the NIR and NUV classes.

Electromagnetic waves					**GTEM-waves**
Class	**Legend**	**Frequency [Hz]**	**Wavelength [m]**	**Energy [eV]**	**-**
γ	Gamma rays	30 EHz – 300 EHz	1 pm – 10 pm	124 keV – 1.24 MeV	Classification unknown
HX	Hard X-Rays	3 EHz – 30 EHz	10 pm – 100 pm	12.4 keV – 124 keV	
SX	Soft X-Rays	300 PHz – 3 EHz	100 pm – 1 nm	1.24 keV – 12.4 keV	
SX	Soft X-Rays	30 PHz – 300 PHz	1 nm – 10 nm	124 eV – 1.24 keV	
EUV	Extreme-ultraviolet	3 PHz – 30 PHz	10 nm – 100 nm	12.4 eV – 124 eV	
NUV	Near-ultraviolet	300 THz – 3 PHz	100 nm – 1 μm	1.24 eV – 12.4 eV	
VL	Visible light	429 THz – 750 THz	380 nm – 780 nm	5.32 eV – 9.67 eV	
NIR	Near-infrared	30 THz – 300 THz	1 μm – 10 μm	124 meV – 1.24 eV	
MIR	Mid-infrared	3 THz – 30 THz	10 μm – 100 μm	12.4 meV – 124 meV	
FIR	Far-infrared	300 GHz – 3 THz	100 μm – 1 mm	1.24 meV – 12.4 meV	
EHF	Extremely high frequency (microwaves)	30 GHz – 300 GHz	1 mm – 10 mm	124 μeV – 1.24 meV	
SHF	Super-high frequency (microwaves)	3 GHz – 30 GHz	10 mm – 100 mm	12.4 μeV – 124 μeV	
UHF	Ultrahigh frequency (radio waves)	300 MHz – 3 GHz	100 mm – 1 m	1.24 μeV – 12.4 μeV	
VHF	Very high frequency (radio)	30 MHz – 300 MHz	1 m – 10 m	124 eV – 1.24 μeV	
HF	High frequency (radio)	3 MHz – 30 MHz	10 m – 100 m	12.4 neV – 124 neV	
MF	Medium frequency (radio)	300 kHz – 3 MHz	100 m – 1 km	1.24 neV – 12.4 neV	
LF	Low frequency (radio)	30 kHz – 300 kHz	1 km – 10 km	124 peV – 1.24 neV	
VLF	Very low frequency (radio)	3 kHz – 30 kHz	10 km – 100 km	12.4 peV – 124 peV	
VF	Voice frequency	300 Hz – 3 kHz	100 km – 1 Mm	1.24 peV – 12.4 peV	
ULF	Ultra-low frequency (radio)	300 Hz – 3 kHz	100 km – 1 Mm	1.24 peV – 12.4 peV	
SLF	Super-low frequency (radio)	30 Hz – 300 Hz	1 Mm – 10 Mm	124 feV – 1.24 peV	
ELF	Extremely low frequency (radio)	3 Hz – 30 Hz	10 Mm – 100 Mm	12.4 feV – 124 feV	

It is assumed that their results relate to the gravitational phenomena propagating at speeds (15) and (16) but not to the one propagating at speed (13). Also, Yanchilin (2004) has assumed that the gravitational phenomena can probably propagate instantly due to nonlocal connections among masses. These connections were conserved after the Big Bang.

In his book on understanding of the fifth (torsional) force, Melnik (2010) has stated that many anomalous experimental results can be understood when the torsional phenomena are taken into account. Indeed, studying different phenomena in solids, the gravitational and torsional parts in the total energy can be taken into account as the fourth and fifth terms in expression (11). Melnik has described many experiments, in which the torsional generators were used for the generation of the nonelectromagnetic radiation. It is possible to discuss here one experiment, in which some torsional generator was used.

It is assumed that this experiment relates to the generation of the nonelectromagnetic radiation by a torsional generator, namely the generation of the gravitotorsionoelectromagnetic (GTEM) waves that can propagate at speeds (15) and (16). In this experiment, a large bulk sample solid with a certain structure was positioned close to the GTEM-wave generator. As a result, the generated GTEM-waves must first travel through this bulk sample and then reach a large volume of molten metal or alloy. This large bulk solid with a certain structure plays a role of a filter for the GTEM-waves. This is similar to the utilization of optic filters to get polarized electromagnetic radiation. However, one deals here with the GTEM-radiation that must be certainly polarized as soon as it is passing through this filter. This means that the polarized GTEM-waves can transfer some information about the structure of the filter further to the molten metal. Receiving this information about the sample structure, the molten metal (alloy) can obtain an improved structure after cooling. It is worth noting here that nothing still is known about possible polarizations of the GTEM-waves and little is known about these GTEM-waves, too.

The main characteristics of the electromagnetic radiation are the frequency, wavelength, and polarization. Concerning the polarization of the electromagnetic waves, it is well-known that a dielectric continuum (for instance, a vacuum) can only support the propagation of the transversely polarized electromagnetic waves but the conducting continuum can transfer only the longitudinal component of the waves. The classification of the electromagnetic radiation is given in table 9 in comparison with that for the GTEM-waves. It is now well-known that there are many seemingly unrelated physical phenomena that actually relate to the electromagnetic interactions. These phenomena such as radio waves, light, heat, X-Rays have initially been considered unrelated physical phenomena. It took several centuries to understand that they all relate to the electromagnetic interactions, i.e. the interactions between the electric and magnetic subsystems. It is expected that the next several centuries are needed in order to understand some complex interactions among the electric, magnetic, gravitational, and torsional subsystems causing the GTEM-wave propagation. This will allow a perfect classification of the GTEM-waves to complete table 9. It is possible that a perfect classification will be more complicated in comparison with the one for the electromagnetic radiation.

CONCLUSION

The original theoretical work on gravitation by Newton has stated some problems concerning the propagation speeds of the gravitational phenomena. As a result, many researchers have evaluated the speeds of the gravitational phenomena from the seventeenth century to this century. In the 1950s, astrophysicist Kozyrev has created his own experimental tools to observe true positions of stars distant from the planet Earth on many light years. His work has provoked many researchers from different countries to follow his results. As a result, today there are many technical devices for generation and detection of the fast GTEM-waves propagating at the speeds thirteen orders faster than the speed of light due to some symbiosis between the electromagnetic and gravitational phenomena. Some test signals of the fast GTEM-waves were successfully transferred between some continents on the Earth. However, many investigations to classify the GTEM-waves can be carried out in this century.

This century is actually for the developing of the research arena that symbiotically incorporates both the electromagnetic and gravitational phenomena. This can result in a successful development of the instant interplanetary (interstellar and even intergalactic) communication. For instance, an interplanetary internet can connect planetary colonists with their home planet. It is expected that many-edge development of this studying direction can even help in creation of fast interplanetary spaceships and even starships.

REFERENCES

Abbott, BP., Abbott, R., Abbott, TD., Abernathy, MR., Acernese, F., Ackley, K., Adams, C., Adams, T., Addesso, P., Adhikari, RX. *et al*. 2016. Observation of gravitational waves from a binary black hole merger. Physical Review Letters. 116(6):061102, pp.16.

Armitage, A. 2012. Copernicus and Modern Astronomy. Dover Publications, USA. pp.339.

Astrov, DN. 1960. The magnetoelectric effect in antiferromagnets. Soviet Physics – Journal of Experimental and Theoretical Physics (JETP). 11:708-709.

Atsyukovsky, VA. 2010. Aetherodynamical Picture of the World: A Cycle of Lectures at the Lecture Room of the Polytechnical Museum in 2000-2001. Moscow, Russia. pp.270. In Russian.

Atsyukovsky, VA. 2011. Aethereal wind. 2nd edition. Ed. Atsyukovsky, VA. Energoatomizdat, Moscow, Russia, pp. 500. In Russian.

Auld, BA. 1990. Acoustic fields and waves in solids. Volumes I and II (set of two volumes), 2nd edition, Krieger Publishing Company. pp. 878.

Bichurin, MI., Kornev, IA., Petrov, VM., Tatarenko, AS., Kiliba, YuV. and Srinivasan, G. 2001. Theory of magnetoelectric effects at microwave frequencies in a piezoelectric/magnetostrictive multilayer composite. Physical Review B. 64(9):094409.

Bichurin, MI., Petrov, VM., Petrov, RV. and Tatarenko, AS. 2019. Magnetoelectric Composites. Jenny Stanford Publishing, New York, USA. pp. 296. DOI: https://doi.org/10.1201/9780429488672.

Bleustein, JL. 1968. A new surface wave in piezoelectric materials. Applied Physics Letters. 13(12):412-413.

Chen, MZQ., Papageorgiou, Ch., Scheibe, F., Wang, F-Ch. and Smith, MC. 2009. The missing mechanical circuit element. The IEEE Circuits and Systems Magazine. 9(1):10-26.

Copernicus, N. 1543. De Revolutionibus Orbium Coelestium. Nürnberg, Germany.

Davison, L. 2008. Fundamentals of Shock Wave Propagation in Solids. Part of the Shock Wave and High Pressure Phenomena book series. Eds. Davison L. and Horie Y. Springer, Berlin, Heidelberg, Germany, pp.433. DOI: https://doi.org/10.1007/978-3-540-74569-3

Dieulesaint, E. and Royer, D. 1980. Elastic Waves in Solids: Applications to Signal Processing. J. Wiley, New York, USA, pp.511. Translated by Bastin A. and Motz, M., Chichester [English].

Draper, JW. 1875. History of the Conflict Between Religion and Science. D. Appleton and company, New York, USA. pp. 422.

Durdag, K. 2009. Wireless surface acoustic wave sensors. Sensors and Transducers Journal. 106(7):1-5.

Edwards, MR. 2002. Pushing Gravity: New Perspectives on Le Sage's Theory of Gravitation. Ed. Edwards, MR. Apeiron, Montreal, Canada.

Einstein, A. 1916. Die Grundlage der allgemeinen Relativitätstheorie. Annalen der Physik. 4(49):769-822.

Fedulaev, LE. 2006. Physical Form of Gravitation: Dialectics of Nature. Moscow, Russia, pp. 285. In Russian.

Fiebig, M. 2005. Revival of the magnetoelectric effect. Journal of Physics D: Applied Physics. 38(8):R123-R152.

Fouda, ME., Radwan, AG., Elwakil, AS. and Nawayseh, N. 2015. Review of the missing mechanical element: Memdamper. The IEEE International Conference on Electronics, Circuits and Systems, Cairo, Egypt, Vol. 201-204. DOI: https://doi.org/10.1109/ICECS.2015.7440283

Gulyaev, YuV. 1969. Electroacoustic surface waves in solids. Soviet Physics Journal of Experimental and Theoretical Physics Letters. 9(1):37-38.

Gulyaev, YuV. 1998. Review of shear surface acoustic waves in solids. The IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control. 45(4):935-938.

Heaviside, O. 1893. A gravitational and electromagnetic analogy. The Electrician. 31(Part I):281-282 and 359.

Hegel, GWF. 1801. De Orbitis Planetarum (On Orbits of Planets). Ph.D. thesis, Jena, Germany. Translated from the Latin original by Healan, D. in 2006. Berlin and Yokohama.

Hegel, GWF. 1972. Papers Published in Various Years. Vol. 1. Mysl, Moscow, USSR. pp. 668. In Russian.

Ivanov MA. and Savrov, LA. 2004. The Search for the Mechanism of Gravitation: Collection of Articles. Eds. Ivanov MA. and Savrov, LA. Nizhnii Novgorod, Russia, pp. 304. In Russian.

Jefimenko, OD. 2006. Gravitation and Cogravitation. Developing Newton's Theory of Gravitation to Its Physical and Mathematical Conclusion. Electret Scientific Publishing, Star City, USA. pp. 367.

Kepler, J. 1617. Epitome Astronomiae Copernicanae. Three volumes: the first volume (Books I–III) printed in 1617, the second (Book IV) in 1620, and the third (Books V–VII) in 1621.

Kepler, J. 1619. Harmonices Mundi (The Harmony of the World). Linz, Austria. pp.189.

Kernbach, S., Zamsha, V. and Kravchenko, Yu. 2013. Long and super-long range device-device and operator-device interactions. International Journal of Unconventional Science. 1(1):24-42. In Russian.

Khmelnik, SI. 2017. Gravitomagnetism: Nature's Phenomena, Experiments, Mathematical Models. “MiC” - Mathematics in Computer Comp., Lulu Inc., USA. pp. 257. DOI: http://doi.org/10.5281/zenodo.1403669.

Kiang, J. and Tong, L. 2010. Nonlinear magneto-mechanical finite element analysis of Ni–Mn–Ga single crystals. Smart Materials and Structures. 19(1):015017, pp.17.

Kozyrev, NA. 1958. Causal or asymmetrical mechanics in linear approximation. Pulkovo observatory, GAO AN USSR, Leningrad, USSR. pp. 90. In Russian.

Kozyrev, NA. 1971. On the possibility of experimental investigation of the properties of time. In: Time in Science and Philosophy. Academia, Prague, Czechoslovakia. 111-132.

Kozyrev, NA. 1991. Collected Papers. Leningrad University Publishing, Leningrad, USSR. pp. 448. In Russian.

Kozyrev, NA. and Nasonov, VV. 1980. On some properties of time discovered by astronomical observations. In: Problemy Issledovaniya Vselennoi. Vol. 9. pp.76. In Russian.

Laplace, PS. 1982. Exposition du Systeme du Monde. The fifth book, Nauka Publishers, Leningrad, USSR. pp. 309. In Russian.

Laplace, PS. 2007. The System of the World. The English translation by Pound, J. in 1809, two volumes. Kessinger.

Lavrentiev, MM., Eganova, IA., Lutset, MK. and Fominykh, SF. 1990[a]. On the remote influence of stars on the resistor. Transactions (Doklady) of the USSR Academy of Sciences. 314(2):352. In Russian.

Lavrentiev, MM., Gusev, VA., Eganova, IA., Lutset, MK. and Fominykh, SF. 1990b. On the registration of a true position of the Sun. Transactions (Doklady) of the USSR Academy of Sciences. 315(2):368-370. In Russian.

Lavrentiev, MM., Eganova, IA., Medvedev, VG., Oleinik, VK. and Fominykh, SF. On the scanning of the star sky with Kozyrev's detector. Transactions (Doklady) of the USSR Academy of Sciences. 1992, 323(4):649-652. In Russian.

Le Sage, GL. 1761. Essai de Chymie Mécanique. pp.121.

Le Sage, GL. 1818. Physique Mécanique. In: Prévost, P. Deux traités de physique mécanique, publiés par Pierre Prévost, comme simple éditeur du premier et comme auteur du second. J.J. Paschoud, Genève, Switzerland.

Lebedev, PN. 1963. Combined Papers. Akademiya Nauk USSR, Moscow, USSR, pp.435. In Russian.

MacCullagh, J. 1880. The Collected Works of James MacCullagh. Eds. Jellett JH. and Haughton S. Dublin University Press, Dublin-London, UK.

Masalov, AV. 2019. First Experiments on Measuring Light Pressure I (Pyotr Nikolaevich Lebedev). In: Quantum Photonics: Pioneering Advances and Emerging Applications, Springer Series in Optical Sciences. 217:425-453. DOI: https://doi.org/10.1007/978-3-319-98402-5_12

Maslobrod, S., Maslobrod, E. and Kernbach, S. 2013. Long range interaction within the system “semiconductor generator - matrix – seeds”. The Proceedings of Conference “Bio-Energy-Information Interactions. Ecology and Safety”. 18-19 April, Moscow, Russia.

Maxwell,JC. 1865. A dynamical theory of the electromagnetic field. Philosophical Transactions of the Royal Society of London. 155:459-512.

Maxwell, JC. 1871. Remarks on the mathematical classification of physical quantities. Proceedings of the London Mathematical Society. s1-3:224-233. DOI: https://doi.org/10.1112/plms/s1-3.1.224 .

Melkumyan, A. 2007. Twelve shear surface waves guided by clamped/free boundaries in magneto-electro-elastic materials. International Journal of Solids and Structures. 44(10):3594-3599.

Melnik, IA. 2010. Understanding of Fifth Force. Folium Publishing, Moscow, Russia. pp.180. In Russian.

Mendeleev, DI. 2012. An Attempt of Understanding of World Aether. Kniga po trebovaniyu, Moscow, Russia. pp. 40. In Russian.

Myshkin, NP. 1906. The movement of object placed in the radiant energy flow. Zhyrnal Russkogo Fiziko-Himicheskogo Obshestva. 3:149. In Russian.

Newton, IS. 1687. Philosophiae Naturalis Principia Mathematica (Mathematical Principles of Natural Philosophy). London, England, UK.

Newton, IS. 1989. Mathematical Principles of Natural Philosophy. Nauka Publishers, Moscow, USSR. pp. 689. In Russian.

Nuriev, ZK. 2004. Missing chain of classical mechanics. Science, Culture, Education. Vol.15/16, Gornoaltaisk-Paris. pp.162-166. In Russian.

Özgür, Ü., Alivov, Ya. and Morkoç, H. 2009. Microwave ferrites, part 2: Passive components and electrical tuning.Journal of Materials Science: Materials in Electronics. 20(10):911-952.

Rivera, JP. 2009. A short review of the magnetoelectric effect and related experimental techniques on single phase (multi-) ferroics. The European Physical Journal B. 71(3):299-313.

Shipov, GI. 1998. A Theory of Physical Vacuum. A New Paradigm. ZAO "GART", Moscow, Russia. pp. 312. In Russian.

Shkatov, V. and Zamsha, V. 2015. Torsion Field and Interstellar Communication. Easy Print, China, pp. 30. http://www.iga1.ru/pribor/TorsionField.pdf

Shkatov, V., Zamsha, V., Krinker, M. and Gorokhov E. 2017. The role of the global consciousness in instrumental experiments using subtle fields. International Journal of Unconventional Science. 5(15-16):49-61. In Russian.

Syunyaev, RA. 1986. Physics of Cosmos, Small Encyclopedia. The second edition. Ed. Syunyaev, RA. The Soviet Encyclopedia Publishing, Moscow, USSR. pp.783.

Tajmar, M., Plesescu, F. and Seifert, B. 2009. Anomalous fiber optic gyroscope signals observed above spinning rings at low temperature. Journal of Physics: Conference Series. 150(3):032101. DOI: https://doi.org/10.1088/1742-6596/150/3/032101 .

Veinik, AI. 1991. Thermodynamics of Real Processes. Nauka i Tehnika, Minsk. pp. 576. In Russian.

Veinik, AI. and Komlik, SF. 1992. Complex Determination of Chronophysical Properties of Materials. Nauka i Tehnika, Minsk, Belarus. pp. 95. In Russian.

Yanchilin VL. 2004. Mysteries of Gravity. New Center, Moscow, Russia. pp. 240. In Russian.

Yavorsky, BM., Detlaf AA. and Lebedev, AK. 2006. The Physics Reference Book for Engineers and Students of the Higher Education. (8th edi.). ONICS Publishers, Moscow, Russia. pp. 1054. In Russian.

Zakharenko, AA. 2005. Dispersive Rayleigh type waves in layered systems consisting of piezoelectric crystals bismuth silicate and bismuth germanate. Acta Acustica united with Acustica. 91(4):708-715. DOI: https://doi.org/10.5281/zenodo.1300323

Zakharenko, AA. 2006. On cubic crystal anisotropy for waves with Rayleigh-wave polarization. Nondestructive Testing and Evaluation. 21(2):61-77. DOI: https://doi.org/10.1080/10589750600779704

Zakharenko, AA. 2010. Propagation of Seven New SH-SAWs in Piezoelectromagnetics of Class 6 *mm*. LAP LAMBERT Academic Publishing GmbH & Co. KG, Riga, Latvia. pp. 84. DOI: https://doi.org/10.13140/2.1.4000.8645.

Zakharenko, AA. 2011. Seven New SH-SAWs in Cubic Piezoelectromagnetics. LAP LAMBERT Academic Publishing GmbH & Co. KG, Riga, Latvia. pp. 172. DOI: https://doi.org/10.13140/2.1.2428.0001.

Zakharenko, AA. 2013[a]. Piezoelectromagnetic SH-SAWs: A review. Canadian Journal of Pure and Applied Sciences. 7(1):2227-2240. DOI: https://doi.org/10.5281/zenodo.1300699.

Zakharenko, AA. 2013[b]. New nondispersive SH-SAWs guided by the surface of piezoelectromagnetics. Canadian Journal of Pure and Applied Sciences. 7(3):2557-2570. DOI: https://doi.org/10.5281/zenodo.1300994.

Zakharenko, AA. 2015. A study of new nondispersive SH-SAWs in magnetoelectroelastic medium of symmetry class 6 *mm*. Open Journal of Acoustics. 5(3):95-111. DOI: http://dx.doi.org/10.4236/oja.2015.53009.

Zakharenko, AA. 2016. On piezogravitocogravitoelectromagnetic shear-horizontal acoustic waves. Canadian Journal of Pure and Applied Sciences.10(3):4011-4028. DOI: https://doi.org/10.5281/zenodo.1301184.

Zakharenko, AA. 2017[a]. On new interfacial four potential acoustic SH-wave in dissimilar media pertaining to transversely isotropic class 6 *mm*. Canadian Journal of Pure and Applied Sciences.11(3):4321-4328. DOI: https://doi.org/10.5281/zenodo.1301215.

Zakharenko, AA. 2017[b]. The problem of finding of eigenvectors for 4P-SH-SAW propagation in 6 *mm* media. Canadian Journal of Pure and Applied Sciences. 11(1):4103-4119. DOI: https://doi.org/10.5281/zenodo.1301202

Zakharenko, AA. 2018[a]. On existence of new dispersive four-potential SH-waves in 6 *mm* plates for new communication era based on gravitational phenomena. Canadian Journal of Pure and Applied Sciences.12(3):4585-4591. DOI: http://doi.org/10.5281/zenodo.1471100.

Zakharenko, AA. 2018[b]. On necessity of development of instant interplanetary telecommunication based on some gravitational phenomena for remote medical diagnostics and treatment. Canadian Journal of Pure and Applied Sciences. 12(2):4481-4487. DOI: https://doi.org/10.5281/zenodo.1301289.

Zakharenko, AA. 2018[c]. Acoustic wave propagation in (layered) magnetoelectroelastic (composite) materials and influence of gravitational subsystems. The 1st International Symposium on Mechanics, 9-12 July 2018, Jones session: Mechanics of composite materials, Aberdeen, Scotland, UK. DOI: https://doi.org/10.5281/zenodo.1307174. It is available online at https://mechanics.nscj.co.uk/sessions/Jones.html.

Zakharenko, AA. 2018[d]. Extra two new piezoelectromagnetic SH-SAWs with dramatic dependence on small electromagnetic constant. Journal of King Saud University – Science.30(4):544-548. DOI: https://doi.org/10.1016/j.jksus.2017.05.005.

Zakharenko, AA. 2018[e]. On separation of exchange terms for four-potential acoustic SH-wave case with dependence on gravitational parameters. Hadronic Journal.41(4):349-370. DOI: http://doi.org/10.5281/zenodo.2842082.

Zakharenko, AA. 2019[a]. On discovery of the twelfth and thirteenth new nondispersive SH-SAWs in 6 *mm* magnetoelectroelastics. MDPI Acoustics. 1(4):749-762. DOI: https://doi.org/10.3390/acoustics1040044.

Zakharenko, AA. 2019[b]. Taking into account the gravitational effects for the waves' propagation in continuous media such as a solid and a vacuum. The Papers of Independent Authors. 45:74-81. In Russian, DOI: http://doi.org/10.5281/zenodo.2574555.

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