The Gertsenshtein Effect
In deep space, in the Solar System and on Earth

ABSTRACT

The article describes how the production of a gravitational wave in the Gertsenshtein effect may manifest itself through various phenomena. The basic set up for the Gertsenshtein effect, electromagnetic radiation propagating in a perpendicular magnetic field, is a common occurrence in outer space, which may suggest that the effect is a frequent phenomenon. We discuss how solar radiation propagating through the Earth's magnetic field may result in a natural Gertsenshtein generator and provide evidence of its effect on Earth by considering the geometry of such a wave and correlating it with data on Earth's seismic activity. Finally, we discuss various practical issues regarding the construction of artificial Gertsenshtein generators.

INTRODUCTION

In 1962 the soviet scientist Mikhail Gertsenshtein published an article in which he proved that an electromagnetic wave propagating in a perpendicular magnetic field will generate a coherent gravitational wave. This phenomenon was named the Gertsenshtein effect. Soon after, Gertsenshtein and his co-author Vladislav Pustovoit proposed a way of detecting gravitational waves with the help of an optical interferometer[1]. The first ever discovery of gravitational waves in 2017 at the LIGO interferometer was achieved using the method proposed above. The Nobel prize was awarded for this discovery, awarded, of course, to other people, but this is how things go.

Gertsenshtein did not only describe the effect analytically, but also proposed where this effect can be manifested most distinctly. In his article "Wave Resonance of Light and Gravitational Waves"[2] he proves that stars emit gravitational waves not only as a result of their motion, but also by means of the Gertsenshtein effect, when relativistic gamma-radiation propagates through the magnetic field of the star. He also shows that the spectrum of the gravitational radiation of stars has two comparable maxima: one in the ultra-low frequency range and one in the frequency range of the gamma radiation.

The most complete collection of articles from Gertsenshtein in English can be found at the Journal of Experimental and Theoretical Physics (JETP) site[3].

The Gertsenshtein effect assumes the existence of natural generators of cosmic proportions that emit gravitational radiation, for example stars. It also outlines the principles for constructing artificial Gertsenshtein generators.

The attitude of the scientific community to the possibility of constructing an artificial Gertsenshtein generator gradually changes from sceptical[4], that was later criticised[5], to moderate[6] and not so moderate optimism[7]. Sensonica corporation has developed extremely sensitive detectors of non-ionising radiation, and a few years ago it also succeeded in:

- constructing working samples of Gertsenshtein generators,
- conducting a successful Hertz experiment with a Gertsenshtein emitter and wave detector,
- commencing a study on the influence of Gertsenshtein generator on physical and biological processes.

The corporation has received a patent for all corresponding methods and devices (detectors and emitters of radiation)[8,9] and patent applications have been filed regarding other aspects of the phenomenon[10,11 & 12,13].

DETECTORS OF NON-IONISING RADIATION

As the study of gravitational waves by the academic scientific community is currently just unfolding, we are not ready to take part in any theoretic scientific discussions, we are just concerned with practical issues. We've burned before, so in our conversations with conservative scientific institutes, we take great care when talking about detectors of non-ionising radiation and Gertsenshtein wave generators. However, we are almost convinced that in all of these cases we have to do with gravitational waves, and we have experimental evidence to support it. For example, in Fig.1 we present the signal obtained from our sensor when monitoring the cosmic background non-ionising radiation, together with the registration of gravitational waves by the LIGO + VIRGO complex of laser interferometers.

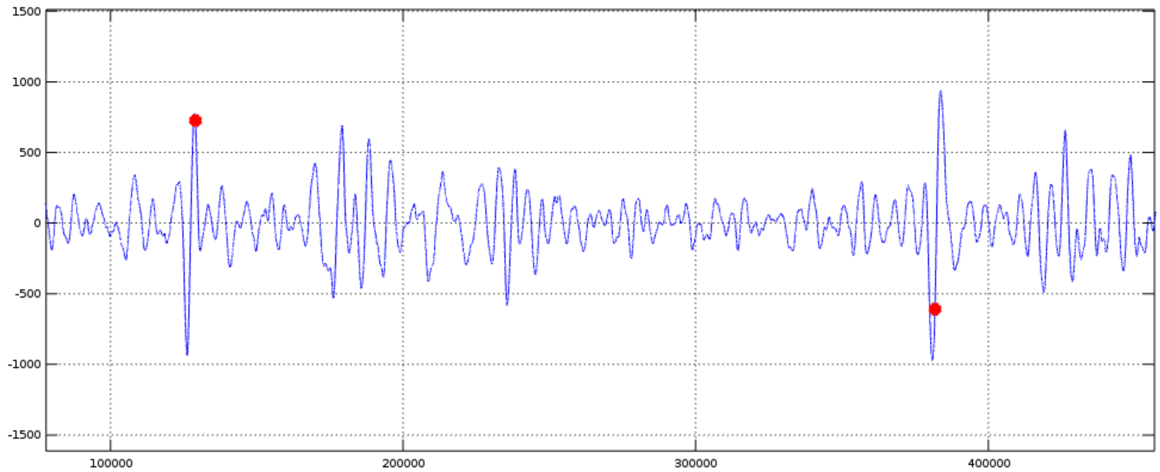

Fig.1

Horizontal axis: time, an interval from 21 to 31 of August 2019.

The figure presents the output signal of our detector (blue line), while the red dots are gravitational events simultaneously registered by LIGO and VIRGO during this time interval (events S190828j and S190828l according to the "*List of Gravitational Wave Observations*"[14]).

We do have further experimental proof that our detectors react to gravitational radiation, but the type of radiation emitted by our Gertsenshtein generators and recorded by our detectors of non-ionising radiation is not critical to us at this point. Our interest lies in the domain of practical application of the devices. When science has a better understanding of gravitational waves, we will then probably have to amend our hypothesis. But our devices are already functioning now; and will not be functioning any worse after clarifying the physical and theoretical details.

THE SUN-EARTH GERTSENSHTEIN GENERATOR

So far, however, we have been unable to confirm experimentally the presence of the Gertsenshtein effect for natural cosmic sources. The sensitivity (and efficiency) of the existing detectors of gravitational waves still raises questions even during registration of signals created by large scale cosmic disasters, like the fusion of black holes. In what follows, we will try to obtain proof of the existence of natural cosmic Gertsenshtein generators without the use of data from our detectors.

According to the principles of the Gertsenshtein effect, during propagation of an electromagnetic wave through a constant perpendicular magnetic field a gravitational wave is created, that is coherent to the original electromagnetic wave. When passing through material objects, this new gravitational wave will cause a change in their geometric dimensions. Existing detectors of gravitational waves operate based on this effect.

The Sun is a strong source of relativistic radiation in the energy range from infrared to gamma quanta. After being emitted this radiation hits the Earth and its magnetic field that extends towards the Sun over a distance of 70 000 km and directed mostly perpendicular to the stream of solar radiation. As a result of the tilt of the Earth's rotational axis and the fact that it does not coincide with the magnetic poles, we observe a modulation of the perpendicular component of this field by the period of the Earth's own rotation and the period of the orbital rotation of the Earth around the Sun. Calculations of the Gertsenshtein effect[6] show that the amplitude of the gravitational waves is proportional to the intensity of the magnetic field. Therefore, the amplitude of the new gravitational wave will be modulated by those frequencies as well.

The model illustrated above describes a natural Gertsenshtein generator, in which the source of electromagnetic radiation is the Sun, while the Earth provides the magnetic field. The gravitational waves produced (multiple waves in fact, since the Sun's radiation is not monochromatic) will be modulated by amplitude with periods that correspond to the period of the Earth's rotation about its own axis, and the orbital period of the Earth moving around the Sun.

IMPACT OF THE SUN-EARTH GERTSENSHTEIN GENERATOR

There are several points of view concerning the possible character and scale of impact that gravitational waves originating from space have on Earth. We will attempt to establish a relationship between the gravitational waves, created by the natural Sun-Earth Gertsenshtein generator, and the seismic events registered on Earth.

The exact direction and magnitude of the Earth's magnetic field is not only a dynamically changing variable, but it also has several definitions[15]. The Earth's magnetic poles can be defined as follows:

1) *Geomagnetic poles*: These are points of intersection of the Earth's surface and the axis of a hypothetical magnetic dipole that approximates the actual magnetic pole of the Earth; the North and South poles are arranged on a single line, that passes through the Earth's centre.
2) *Geographic poles (dip poles)*: These are points on the Earth's surface at which the direction of the magnetic field is exactly vertical to the surface; the South and North poles are defined and migrating over the surface independently of each other.

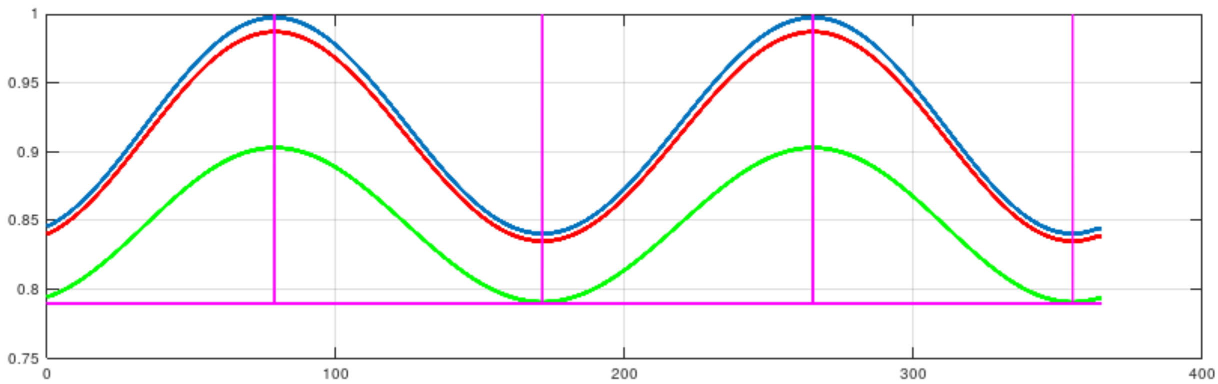

Fig.2

Horizontal axis: days starting from 01.01.2023.
Vertical axis: Relative change of intensity of gravitational wave
Blue line: the intensity of the gravitational wave component parallel to the geomagnetic poles
Red line: the corresponding component parallel to the north geographic pole
Green line: the corresponding component parallel to the south geographic pole
The *Vertical crimson lines*, from left to right, denote the spring equinox, the summer solstice, the autumn equinox and the winter solstice.

The geographic and geomagnetic poles do not coincide, and they are both drifting over the Earth's surface. Currently the geographic poles are moving faster. The position of the poles can be determined, as well as predicted, over several years ahead based on a relatively simple mathematical model. The results of such calculation are given, for example, at the site of the British Geological Survey (BGS)[15]. We got the magnetic poles' coordinates for 2023 and calculated the angle between the radiation from the Sun and the direction of the Earth's magnetic field for the whole year and for every type of pole. Our calculations were based on the JPL NASA Horizons ephemerids[16]. Fig.2 shows the change of the average intensity of gravitational wave over a year.

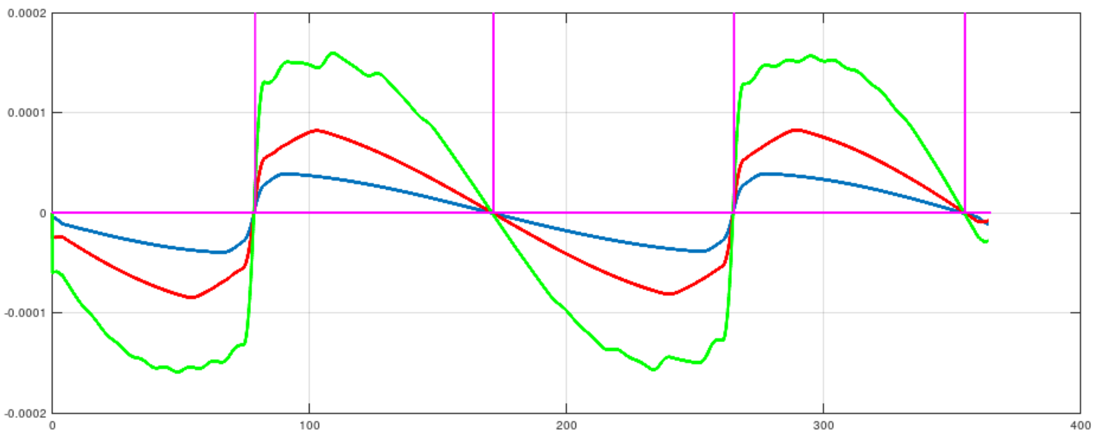

Fig.3.

Rate of amplitude variation of the daily oscillations of the gravitational wave.

Horizontal axis: days starting from 01.01.2023.

Vertical axis: Rate of amplitude variation, the line colours are analogous to the ones in Fig.2.

It is interesting to note that the local minimum around day 55 corresponds to a disastrous (magnitude > 7) earthquake in Turkey on 06.02.2023, that gave rise to a 2-month tail of secondary seismic events.

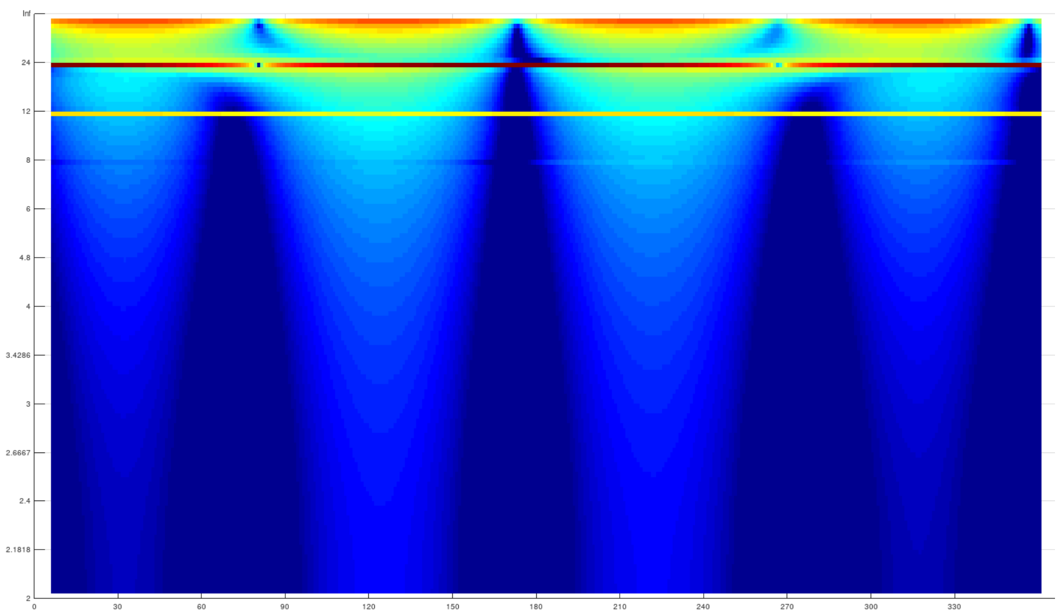

Fig.4.

Amplitude of the gravitational wave in the field of geomagnetic poles

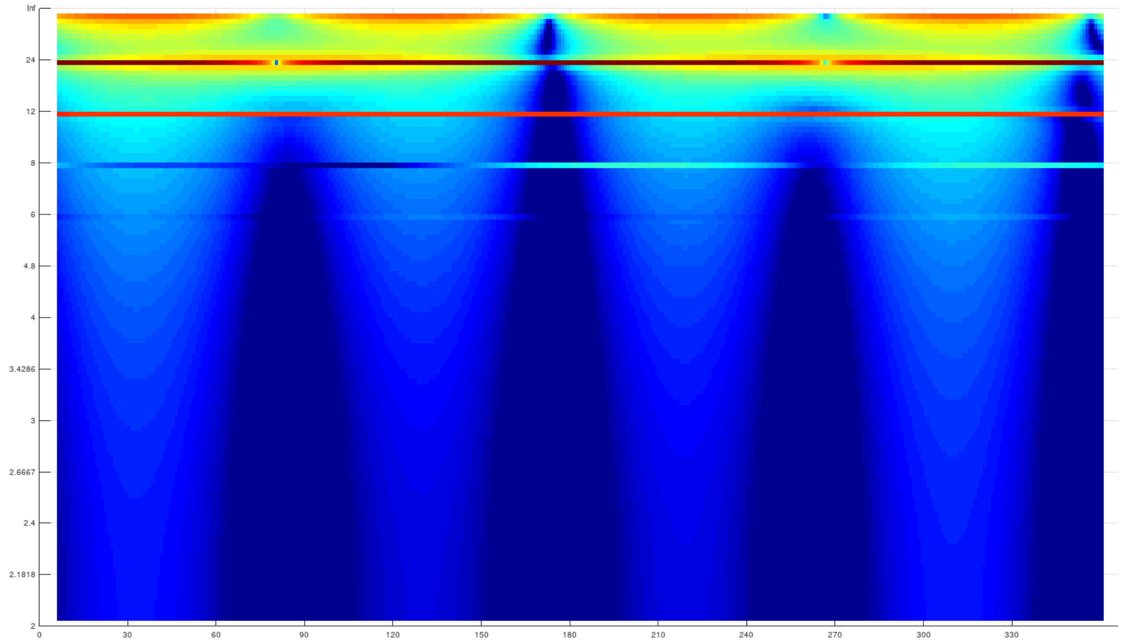

Fig.5.
Amplitude of the gravitational wave in the field of the north geographic magnetic pole

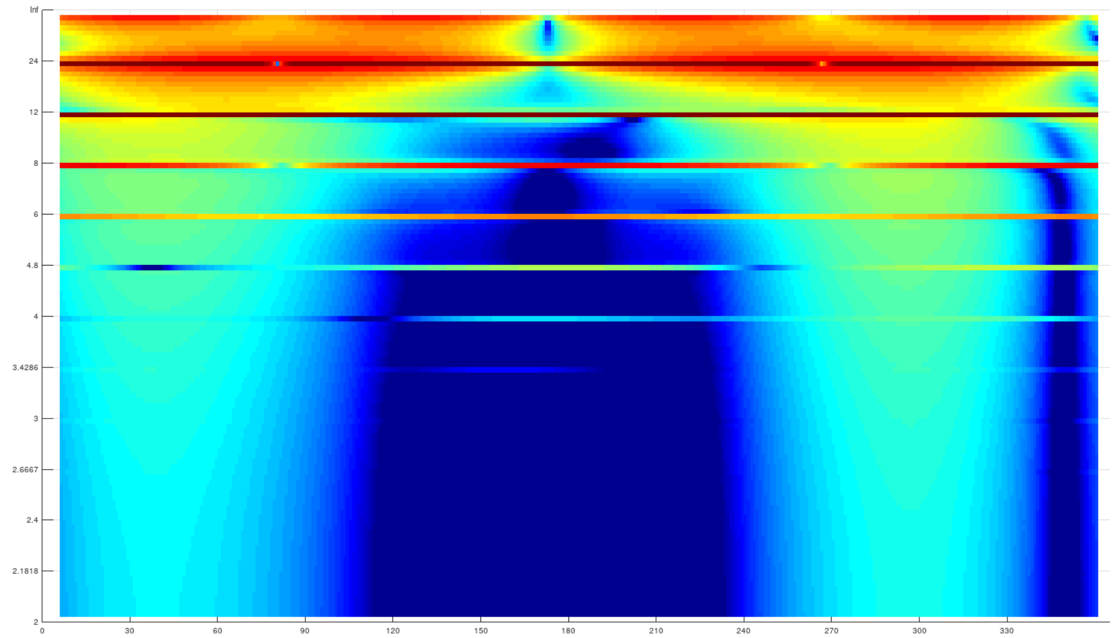

Fig.6
Amplitude of the gravitational wave in the field of the south geographic magnetic pole
Horizontal axis: days starting from 01.01.2023.
Vertical axis: Oscillatory period in hours.
Colour "jet" map: blue, green, yellow, red; blue corresponds to lowest amplitude, red corresponds to highest.

From here onwards we examine the geomagnetic poles together (having one curve, since both poles lie on a single line passing through the Earth's centre) while each geographic pole is examined separately, because it is unclear which components of the magnetic field manifest themselves the most. We can assume that the field formed by the Earth's magnetic dipole (geomagnetic poles) dominates in the remote

magnetosphere, while the field corresponding to the local geographic poles dominates close to the Earth's surface.
Fig.3 shows the rate of amplitude variation of the daily oscillations of the gravitational wave.
Fig.4,5,6 show spectrograms of the relative intensity of gravitational oscillations.

Despite the various differences between the spectra, all fields distinctly show 24-hour cycles with harmonics (of periods 12, 8, 6 hours etc.). In effect, the projection of the gravitational field on the Earth's surface will create a slow changing stationary wave with a main period of 24 hours.
Special zones around the equinoxes (days 79 and 267) and the solstices (day 172 and 355) stand out in all spectrograms, and in geometric terms this is easily understood.

At the equinoxes the Earth's rotational axis is perpendicular to the direction of propagation of solar radiation, which leads to a full replacement of the 24-hour rhythm of the gravitational wave by a 12-hour rhythm, and this in turn results in a significant rearrangement of the low-frequency part of the spectrum and in a disturbance of the stationary wave on and below the Earth's surface.

We can propose a hypothesis, that the gravitational wave, generated by the propagation of the solar radiation through the Earth's magnetosphere has a repercussion on seismic events. In this case we can determine the geographical areas of possible seismic events on Earth around the times of the equinoxes. The gravitational wave is transverse and quadrupole, i.e., maximum disturbances will be observed in the plane perpendicular to the direction of its propagation. Around the equinoxes the maximum amplitude of the gravitational wave will be observed along the meridians that correspond to magnetic poles, because the plane of these meridians formed by the point of the corresponding magnetic pole and the rotational axis of the Earth will indeed be perpendicular to the direction of propagation of the solar radiation. In Spring 2023 the locations of the meridians of the magnetic poles (interpolating the data from the BGS site[15]) are indicated in Table 1.

Table 1. Meridians of the locations of the magnetic poles of the Earth in 2023

Longitude	Pole	Approximate location of the meridian
72.6W	geomagnetic	Columbia, Peru, USA (New-York)
107.3E	geomagnetic	Indonesia, Vietnam, China, Russia (Baikal, island Olkhon)
150E	magnetic, N	Australia, Russia (Kamchatka)
30W	magnetic, N	Mid-Atlantic ridge
135.5E	magnetic, S	Australia, Japan, Russia (Yakutia)
44.5W	magnetic, S	Brazil, North Atlantic

Every magnetic pole together with the Earth's rotational axis, forms a plane that passes through 2 meridians, located at an angle of 180° from each other, which is why in Table 1 three different poles correspond to six meridians.

We also used data from the US Geological Survey, that is available for general access on their internet site[17]. We downloaded a selection of seismic events for the period of 15-25 March 2023 and recalculated the magnitudes of released seismic energy according to the method quoted there in order to obtain the longitude distribution of the total released seismic energy. Fig.7 summarises the results.

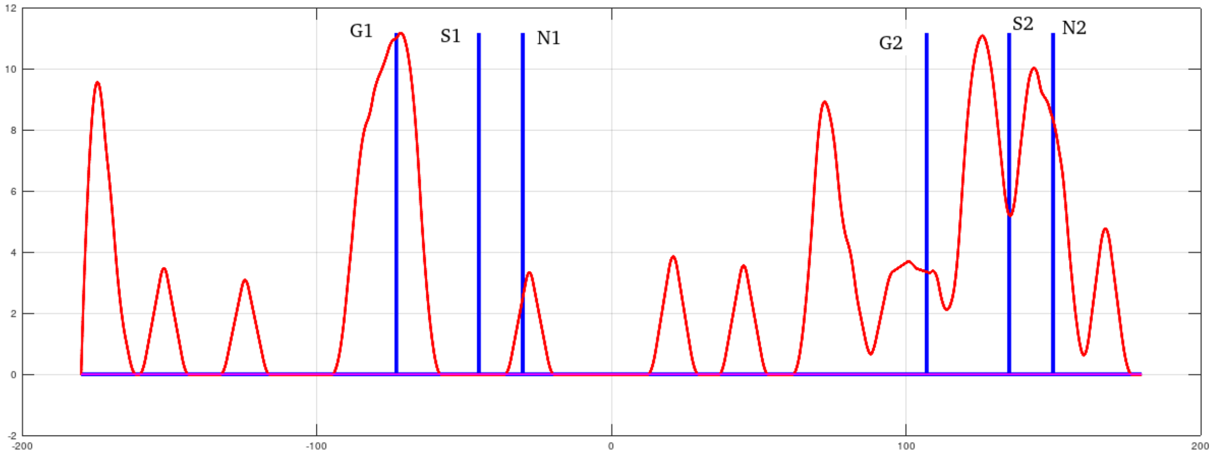

Fig.7

The seismic energy released on Earth during the period 15-25.03.2023 (according to USGS data).
Horizontal axis: longitude, in degrees, positive direction towards East
Letters G, S, N denote the planes of geomagnetic (G1 & G2), South geographic (S1 & S2) and north geographic (N1 & N2) magnetic poles.

Obviously not all maxima of released seismic energy are related to gravitational waves of the Sun-Earth Gertsenshtein generator. On the other hand, meridian G1 demonstrates a clear concurrency with the peak of seismic energy. The meridians S2 and N2 are shifted with respect to a pair of closest maxima, but the distance between maxima is equal to the distance between S2 and N2. We presume that the data (approximated by information from BGS) regarding the location of geographic magnetic poles is not exact. Assuming that the maxima on our graph do correspond to the location of the magnetic poles, it means that they are ahead of their predicted position by more than a year, since according to BGS, the poles should reach those positions only by mid-2024. We have no data concerning the observation of the real position of the magnetic poles in March 2023, but taking into account the nature of their motion, we think that such errors in the model predicting the pole coordinates are indeed possible. The speed and acceleration of migration of the poles, registered over the last 10 years, have never been measured previously, over the whole period of monitoring the Earth's magnetic field with advanced instruments.

The distribution of seismic energy in Fig.7 may not undoubtedly prove our hypothesis regarding the influence of the natural Sun-Earth Gertsenshtein generators on the Earth's seismic activity, but it may at least provide an explanation for the observed phenomena.

ARTIFICIAL GERTSENSHTEIN GENERATORS

Besides natural cosmic Gertsenshtein generators, it is possible to construct artificial generators. We have already mentioned that the views concerning the possibility of constructing such generators have been gradually shifting from sceptical to optimistic. We have also announced previously that corporation Sensonica has been successful in developing and operating several types of Gertsenshtein generators. For some of these instruments we have filed patent applications[9,10 & 11,12].

Fundamentally the generator consists of a powerful source of electromagnetic radiation (laser), that produces a radiation flux that propagates through a chamber of strong perpendicular magnetic field. As the electromagnetic radiation passes through the chamber gravitational radiation is emitted, which is coherent with the electromagnetic radiation. The electromagnetic radiation is subsequently stopped by shielding and only the gravitational wave exits the device. Schematically the process is shown in Fig.8.

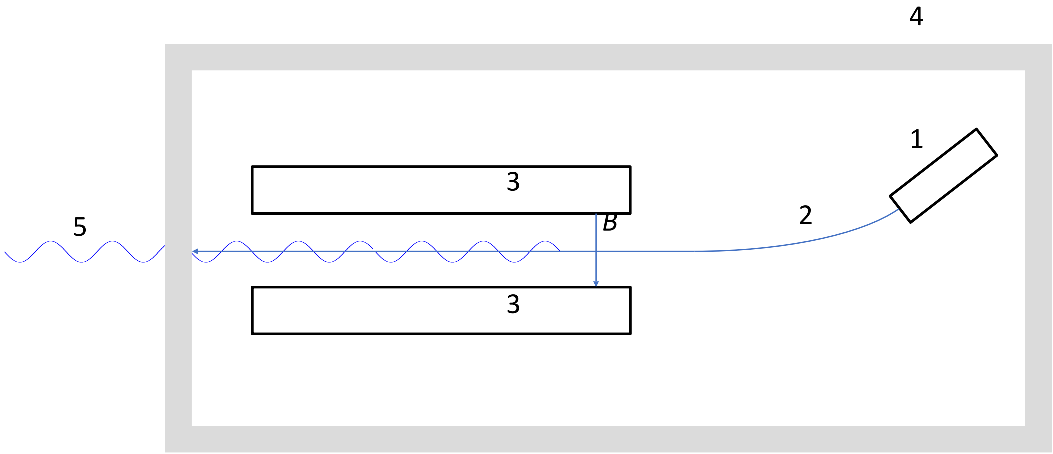

Fig.8
Basic components of a Gertsenshtein generator

1. Laser emitting monochromatic light
2. Light guide directing the light beam towards a magnetic field
3. Magnets creating a constant magnetic field
4. Solid metal shielding for absorbing the original electromagnetic wave
5. Gravitational wave exiting the device

Fig.9 presents the setup of Vega, one of the generators of micro-powerful gravitational radiation constructed by Sensonica corporation. The device is being used for the treatment of a wide range of disorders related to distortions of the cellular aerobic respiration (article 3).

Fig.9

Modern devices nowadays cannot in any way achieve amplitudes or intensities of gravitational waves comparable to those of natural cosmic sources. In fact, the power output of such devices is just on the verge of being detected by the best existing detectors. An estimate of the power of a hypothetical Gertsenshtein generator that uses ultraviolet radiation of 1 MW and magnetic field of flux density equal to 10 Tesla provides a value 50 μW[6].

The equation used for calculating the power output of a Gertsenshtein generator is[6]:

$$Pg/Pw = 5 \times 10^{-9}\,(B/1\ \text{Tesla})^2\,\left(10^{-9}\ \text{Torr}/P\right)^2\,\left(2\,\pi \times 10^{10}\ \text{Hz}/\omega\right)^2$$

where *Pg* is the intensity of the gravitational wave, *Pw* the intensity of the electromagnetic wave, *B* magnetic flux density, *P* is pressure, ω is the frequency of electromagnetic wave.
According to this expression the power output of the Vega generator is no higher than a few pW.

On the other hand, the intensity of the natural Earth-Sun Gertsenshtein generator, that continuously irradiates the Earth, can be very roughly estimated to be around $0.005 \times Pw = 5$ W/m^2. This rough approximation was obtained by regarding the width of the region affected by the magnetic field as being equal to the Earth's radius, with the average magnetic field strength of 0.1 Gauss (10^{-5} T), the pressure in vacuum equal to 10^{-17} Torr and Pw = 1000 W/m^2. It is nevertheless clear though that the intensity of artificial Gertsenshtein generators is smaller than the intensity of natural cosmic generators by several orders of magnitude.

CONCLUSIONS

The transformation of the energy of electromagnetic waves into the energy of gravitational waves by the Gertsenshtein mechanism can apparently be demonstrated in practice for cosmic objects based on the influence they have on seismic events. Artificial Gertsenshtein generators can be developed with the help of modern engineering, but their real intensity is smaller by several orders of magnitude than the natural Gertsenshtein generators.

REFERENCES

1. Gertsenshtein M. E., Pustovoit V. I.
   On the Detection of Low Frequency Gravitational Waves
   Journal of Experimental and Theoretical Physics, 1962, Volume 43, p. 605-607
   http://www.jetp.ras.ru/cgi-bin/dn/r_043_0605.pdf
2. Gertsenshtein M. E.
   Wave Resonance of Light and Gravitational Waves
   Journal of Experimental and Theoretical Physics, 1961, Volume 41, p. 113-114
   http://jetp.ras.ru/cgi-bin/dn/e_014_01_0084.pdf
3. Journal of Experimental and Theoretical Physics
   http://jetp.ras.ru/cgi-bin/e/index?a=s&auid=362454
4. Eardley D. et al.
   High Frequency Gravitational Waves
   JASON Program Office, JASON Report JSR-08-506
   https://irp.fas.org/agency/dod/jason/gravwaves.pdf
5. *JASON Report on High-Frequency Gravitational Waves*
   https://studylib.net/doc/9706744/jason-report-on-high-frequency-gravitational
6. Stephenson G. V.
   Analysis of the Demonstration of the Gertsenshtein Effect
   AIP Conference Proceedings Volume 746, p. 1264–1270 (2005)
   https://doi.org/10.1063/1.1867254
7. Pais S. C.
   High Frequency Gravitational Wave Generator
   United States Patent Application Publication: US 2018 / 0229864 A1
   https://patentimages.storage.googleapis.com/a5/7b/8e/c4e27782082a8f/US20180229864A1.pdf
8. Margaritova O., Khodkin A.
   Radiation Detection Apparatus and Method
   United States Patent Application Publication: US 2019 / 0154849 A1
   https://www.freepatentsonline.com/20190154849.pdf
9. Margaritova O., Khodkin A.
   Radiation Detection Apparatus and Method
   European Patent Application: EP 3 486 688 A1
   https://www.freepatentsonline.com/EP3486688A1.pdf
10. Margaritova O., Khodkin A.
    Apparatus, System and Method to Controllably Influence at Least One of a Rate of a Chemical Reaction, a Biological Process and/or Phase Transition Processes
    United States Patent Application Publication: US 2021 / 0124084 A1
    https://www.freepatentsonline.com/20210124084.pdf
11. Margaritova O., Khodkin A.
    Apparatus, System and Method to Controllably Influence at Least One of a Rate of a Chemical Reaction, a Biological Process and/or Phase Transition Processes
    European Patent Application: EP 3 859 406 A1
    https://www.freepatentsonline.com/EP3859406A1.pdf

12. Margaritova O., Khodkin A.
Information Exchange Using Gravitational Waves
United States Patent Application Publication: US 2020 / 0371269 A1
https://www.freepatentsonline.com/20200371269.pdf
13. Margaritova O., Khodkin A.
Information Exchange Using Gravitational Waves
European Patent Application: EP 3 742 204 A1
https://www.freepatentsonline.com/EP3742204A1.pdf
14. *List of gravitational wave observations*
https://en.wikipedia.org/wiki/List_of_gravitational_wave_observations
15. *Magnetic Poles*
British Geological Survey
https://geomag.bgs.ac.uk/education/poles.html
16. NASA Jet Propulsion Laboratory: Horizons System
https://ssd.jpl.nasa.gov/horizons/app.html
17. United States Geographical Survey site
https://earthquake.usgs.gov/