A New Detector for Perturbations in Gravitational Field

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The paper presents design, principles of operation, and examples of registrations carried out by original device developed and constructed by V. N. Smirnov. The device manifested the possibility to register very weak gravitational perturbations of non-seismic kind both from celestial bodies and from the internal processed in the terrestrial globe.

Given all hypotheses of the possible, do choice for such one which doesn't limit your further thinking on the studied phenomenon.

J. C. Maxwell

1 Introduction

At present day, we have many working properly gravitational wave detectors such as LIGO (USA), GEO-600 (Great Britain and Germany), VIRGO (Italy), TAMA-300 (Japan), miniGRAIL (the Netherlands) and so on. The physical principles of measurement, on a basis of which all the detectors work, lie in the theory of deviation of two particles in the field of a falling gravitational wave meant as a wave of the space metric (so called deformation gravitational waves [1, 2]). The first of such devices was a solid-body (resonant) detector — a 1.500 kg aluminum pig, which is approximated by two particles connected by an elastic force (spring). It was constructed and armed in the end of 1960's by Joseph Weber, the pioneer of these measurements [3–5]. Later there were constructed also free-mass gravitational detectors, built on two mirrors, distantly located from each other and equipped by a laser range-finder to measure the distance between them. Once a gravitational wave falls onto both solid-body or free-mass detector, the detector should have smallest deformation that could be registered as piezo-effect in a solid-body detector or the change of the distance between the mirrors in a free-mass detector [1]. For instance, LIGO (USA) is a free-mass detector, while miniGRAIL (the Netherlands) is a solid-body detector built on a 65-cm metallic sphere, cooled down to liquid Helium. (A spherical solid-body detector is especially good, because it easily registers the direction of the falling gravitational wave that manifests the source of the gravitational radiation.) A device similar to miniGrail will soon be launched at Saõ-Paolo, Brasil. Moreover, it is projected a "big Grail" which mass expects to be 110 tons.

As supposed, the sources of gravitational radiation should be the explosions of super-novae, stellar binaries, pulsars, and the other phenomena in the core of which lies the same process: two masses, which rotate round the common centre of inertia, loose the energy of gravitational interaction with time so shorten the distance between them; the lost energy of gravitational interaction exceeds into space with gravitational radiation [1]. In the same time, we may expect the sources of gravitational radiation existing in not only the far cosmos, but also in the solar system and even in the Earth. The nearest cosmic source of gravitational waves should be the system Earth-Moon. Besides, even motion of tectonic masses should generate gravitational radiation. Timely registering gravitational radiation produced by such tectonic masses, we could reach a good possibility for the prediction of earthquakes.

Here we represent a device, which could be considered as a gravitational wave detector of a new kind, which is a resonant-dynamic system. The core of such a detector is a rotating body (made from metal or ceramics) in the state of negative acceleration. Besides the advantage of the whole system is that is gives a possibility for easy registration of the direction of the gravitation wave moved through it.

2 The dynamical scheme of the device

Fig. 1 shows the dynamical scheme of the device, where the rotating body is a 200 g cylindrical pig made from brass and shaped as a cup (it is marked by number 1). The rotor is fixed up on the axis of a micro electrical motor of direct current (number 2). In the continuation of the axis 3 of the motor a thick disc made from aluminum (number 4) is located; the other side of the disc is painted by a light-absorbing black color ink, except of the small reflecting sector 5. There over the disc, an azimuth circle 6 is located, it is for orientation of the device to the azimuth coordinates (they can further be processed into the geographical coordinates of the sources of a registered signal, or the celestial coordinates of it if it is located in the cosmos). The azimuth circle has a optical pair consisting of semiconductor laser as emitter and photodiode as receiver 7. A laser beam, reflected by the sector 5, acts onto the photodiode. The electrical motor 2 is fixed on the rectangular magnetic platform 8, which is suspended by the strong counter-field 0.3 Tesla of the stationary fixed magnet 9. There between the magnetic platforms an inductive detector 10 is located.

We consider the functional dependencies between the elements of this device. The rotor 1 turns into rotation by the

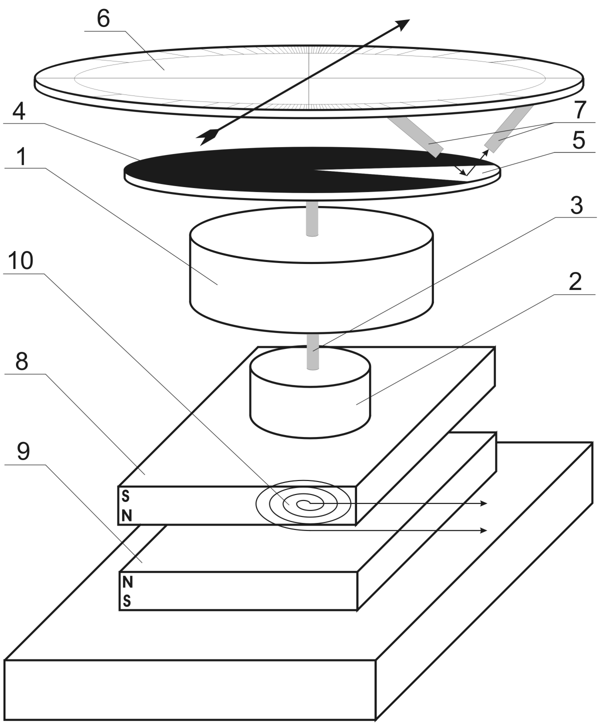

Fig. 1: Dynamical scheme of the device.

electric motor to 4.000 rpm; the disc 4 rotates synchronically with the rotor. Once the reflected laser beam falls onto the photodiode, it produces an electric current. The pulse signal, produced by the photodiode, goes into the control electronic block which produces a rectangular pulse of voltage with the regulated duration in the scale from 1.5 to 4.0 μsec. Next time these impulses go into the input of the motor driver. If the output of the driver had a stable voltage with the polarity $(+,-)$, the inverts to $(-,+)$ in the moment when the electric pulse acts. For this moment the motor's rotation is under action of a negative acceleration: the rotation is braking for a short time. During the braking a reverse pulse current is inducted in the motor circuit, that is a "braking current" appears a form of which is under permanent control on the screen of an control oscilloscope.

Fig. 2 shows the block diagram of the control block. There are: the rectangular magnetic platform 1, in common with the rotor and the motor 3 located on it; the stationary fixed magnetic platform 2; the inductive detector 4; selective amplifier 5 working in the range from 10 Hz to 20 kHz; plotter 6; the source of the power for the electrical motor (number 7); the driver 8; the electronic block for processing of the electric pulse coming out from the photodiode (number 9); the inductive detector of the pulse current (number 10); the indicator of the angular speed of the rotor (number 11); oscilloscope 12.

At the end of braking pulse finishes (if to be absolutely exact — on falling edge of pulse) the electrical motor rotating with inertia re-starts, so a positive acceleration appears in

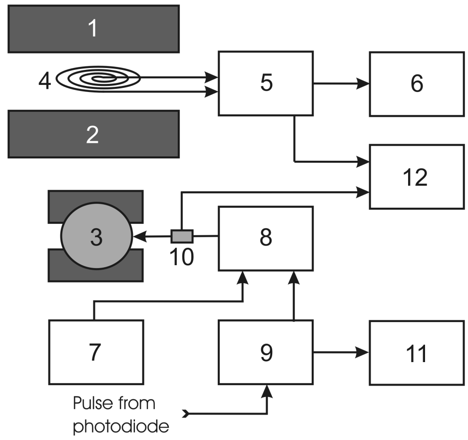

Fig. 2: Diagram of the control block.

the system. The starting pulse is due to the strong starting currents in the power supply circuit. According to Ampere's law, the occurred starting current leads to a mechanical impact experienced by the electrical motor armature (it is the necessary condition for the work of the whole device as a detector of gravitational perturbation). During the rotor's rotation, the whole spectrum of the low frequent oscillations produced by this mechanical impact are transferred to the mechanical platform 1, which induces electromotive force on the detector 4. This signal is transferred to the selective amplifier 5, wherein a corresponding harmonic characterizing the rotor's state is selected. This harmonic, converted into analogous signal, is transferred to the plotter 6.

3 The peculiarities of the experiment

The impulsive mechanical impact experienced by the motor armature is actually applied to the centre of the fixation of the rotor at the axis of electrical motor. The rotor, having a form of cylindrical resonator, reach excitation with low frequency due to this impact. In order to increase the excitation effect, a brass bush seal was set up on the motor's axis: the contact surface between the axis and the rotor became bigger than before that. As a result in the rotor a standing sonar wave occurs which has periodically excited, while all the time between the excitations it dissipates energy. The rotor, as a low frequent resonator, has its own resonant frequency, which was measured with special equipment by the method of the regulated frequent excitation and laser diagnostics. (The necessity to know the resonator frequency of the rotor proceeded from the requirement to choose the frequency of its rotation and also the frequency of its excitation.

Effect produced in the rotor due to a gravitational perturbation consist of the change of the period of its rotation that leads to the change in the initially parameters of the whole system: the shift of the operating point on frequency response function of selective amplifier and also the signal's amplitude changed at the output of the selective amplifier. Besides the

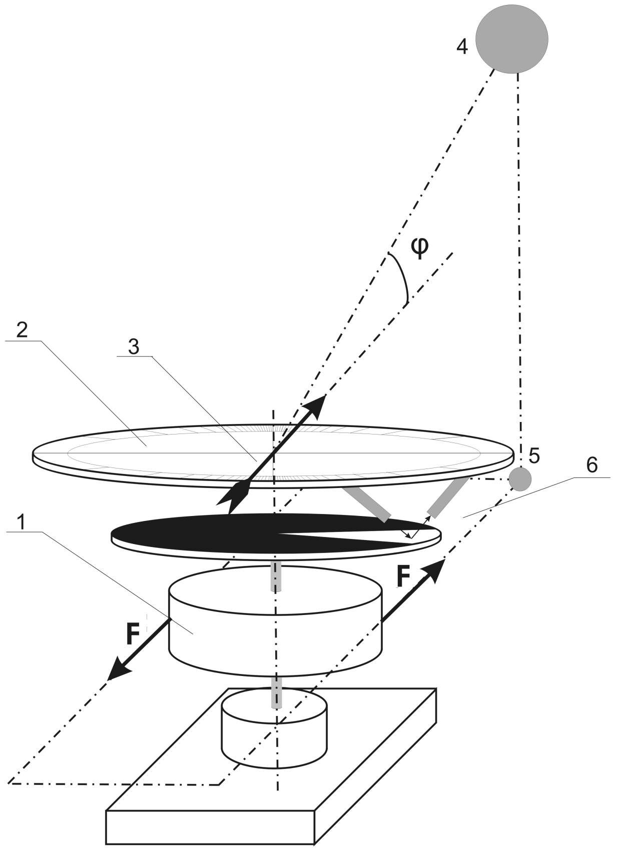

Fig. 3: Diagram of the device orientation at the supposed source of gravitational perturbation.

change of the angular speed of the rotation, due to the momentum conservation law, produces a reaction in the magnetic platform. Because the magnetic has rectangular form, the magnetic field between the platforms 1 and 2 (see Fig. 2) is non-uniform so the derivative of the density of the magnetic flow is substantial. All these lead to the fast change in the level of the signal's amplitude, and are defining the sensitivity of the whole device.

Plotter registered such a summarized change of the signal's amplitude.

Thus the sensitivity of the device is determined by the following parameters: (1) the choice for the required resonant frequency of the rotor; (2) the choice of the angular speed of its rotation; (3) the duration of the braking pulse; (4) the choice for the information sensor which gives information about the rotor; (5) the factor of the orientation of the device at the supposed source of gravitational perturbation.

The vector of the device orientation is the direction of the impulsive braking force F or, that is the same, the negative acceleration vector applied to the rotor. In the moment of braking there a pair of forces F appears, which are applied to the rotor. The plane where the forces act is the antennae parameter of the system. Fig. 3 represent a fragment of the device, where 1 is the rotor, 2 is the azimuth circle, 3 are the indicators of direction, where the angular scale has the origin of count (zero degree) pre-defined to the Southern pole. If we suppose that the source of gravitational perturbation (it is pictured by gray circle, 4) is a cosmic object, the device should be oriented to the projection of this source onto the horizontal plane (this projection is marked by number 5, and pictured by small gray circle). The plane 6 is that for the acting forces of braking.

4 Experimental results

Here are typical experimental results we got on the device over a years of investigations.

The fact that such a device works as an antenna permits to turn it so that it will be directed in exact at the selected space objects in the sky or the earthy sources located at different geographical coordinates.

First, we were looking for the gravitational field perturbations due to the tectonic processes that could be meant the predecessors of earthquakes. Using the geographic map of the tectonic breaks, we set up an experiment on the orientation of the device to such breaks. Despite the fact that exact measurement of such directions is possible by a system of a few devices (or in that case where the device is located in area of a tectonic brake), the measurement of the azimuth direction by our device was as precise as $\pm 2^{\circ}$. The azimuthal directions were counted with respect to the South pole. All measurement represented on the experimental diagrams (Fig. 4–9) are given with Moscow time, because the measurement were done at Moscow, Russia. The period of the rotation of the gyro changed in the range from 75 μsec to 200 μsec during all the measurements produced on: the rises and sets of the planets of the solar system (including the Moon) and also those of the Sun; the moments when the full moon and new moon occurs; the solar and lunar eclipses; the perihelion and aphelion of the Earth, etc. In some experiments (Fig. 6) extremely high gravitational perturbations were registered, during which the period of the rotation of the gyro was changed till 400 μsec and even more (the duration of such extremely high perturbations was 5–10 minutes on the average). Further we found a correlation of the registered signals to the earthquakes. The correlation showed: the perturbations of the earthy gravitational field, registered by our device, predesecced the earthquakes in the range from 3 to 15 days in the geographic areas whereto the device was directed (Fig. 4–6).

Examples of records in Fig. 7–8 present transit of Venus through the disc of the Sun (Fig. 7) and solar eclipse at Moscow, which occur at November 03, 2005.

Aside for such single signals as presented in Fig. 4–8, our device registered also periodic signals. The periodic signals were registered twice a year, in October and May, that are two points in the chord of the orbit of the Earth which connects the directions to Taurus and Virgo. The time interval between

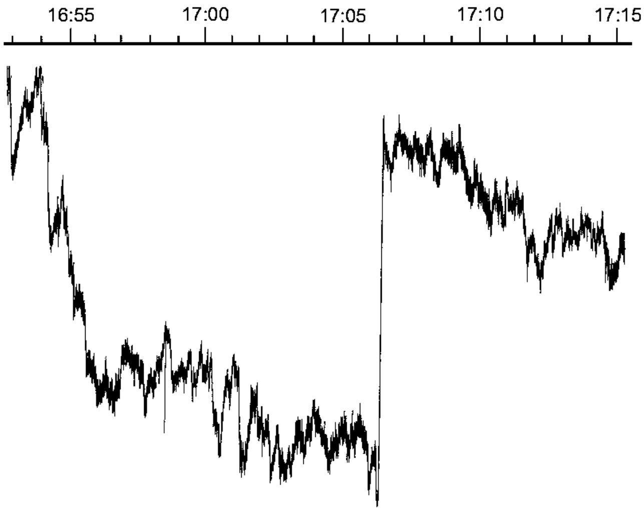

Fig. 4: June 30, 2005. The azimuth of the signal is ∼53° to East. The predecessing signal of the earthquake in the Indian Ocean near Sumatra Island, Indonesia, July 05, 2005.

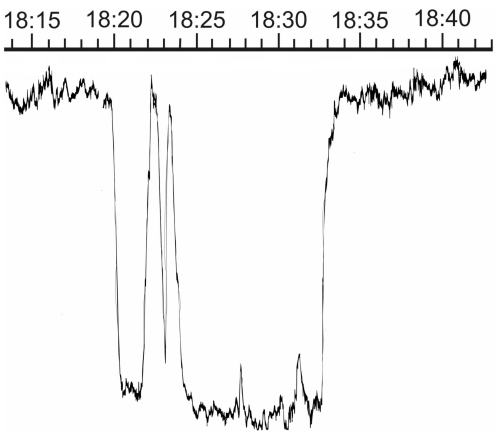

Fig. 5: March 29, 2006. The azimuth of the signal is ∼9° to East: the predecessor of the earthquake in the Western Iran, which occurred on April 02, 2006.

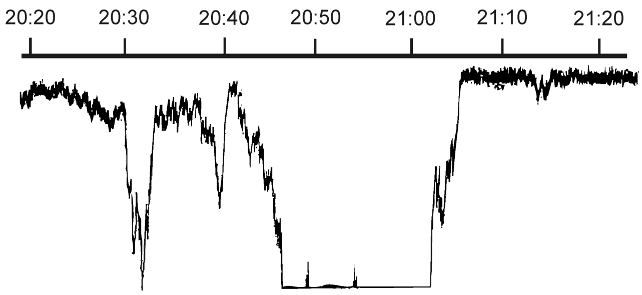

Fig. 6: May 05, 2007. A high altitude gravitational perturbation. The azimuth of the signal is 122° to West. The central states of the USA became under action of 74 destructing tornados two days later, on May 08, 2007.

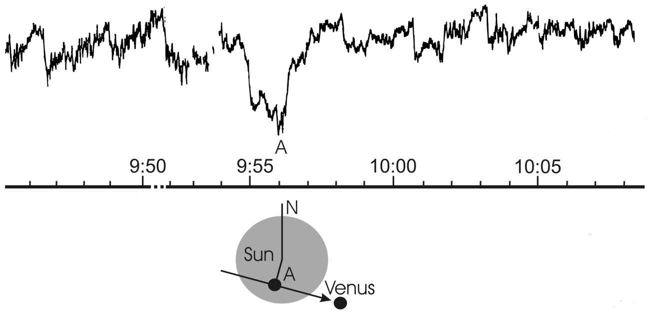

Fig. 7: June 08, 2004. Transit of Venus through the disc of the Sun, $09^{h}51^{min}$.

Fig. 8: November 03, 2005. The solar eclipse at Moscow city, Russia. The eclipse phase is ∼0.18.

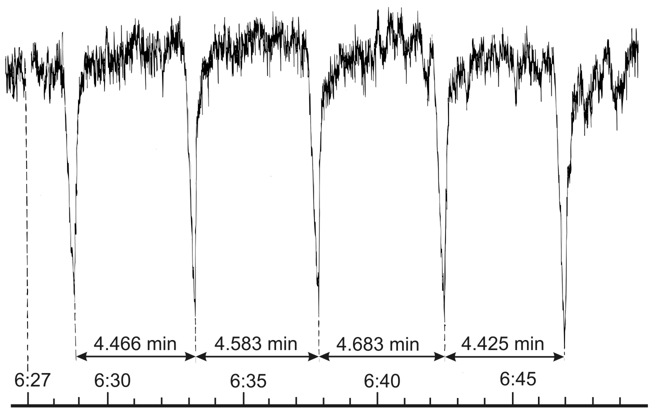

Fig. 9: May 31, 2003. Periodical signals.

the signals growing with the motion of the Earth along its orbit during 5 days then deceased. A fragment of the graph is represented in Fig. 9.

It should be noted that when Joseph Weber claimed about a gravitational wave signal registered with his solid-body detector [3–5], he pointed out that fact that the solely registered signal came from Taurus.

5 Conclusion

The core of the device is a rotating body (in our case it is a rotating brass resonator), which sensitivity to gravitational radiation lies in its excitation expected in the field of a falling gravitational wave. Despite the physical state of the gyro-resonator corresponds, in main part, to the wave-guide solid-body gyros, its internal construction and the principles of work are substantially different from those [6].

The device manifested the possibility to register gravitational perturbations of non-seismic kind from the internal processed in the terrestrial globe, and locate the terrestrial coordinates of the sources of the perturbations.

An auxiliary confirmation of such a principle for the registration of gravitational perturbation is that fact that one of the gyros CMG-3 working on board of the International Space Station "experienced an unusual high vibration" on March 28, 2005 (it was registered by the space station commander Leroy Chiao and the astronaut Salizhan Sharipov [7]), in the same time when a huge earthquake occurred near Nias Island (in the shelf of Indian Ocean, close to Sumatra, Indonesia).

This device is a really working instrument to be used for the aforementioned tasks. In the same time, a lack of attention to it brakes the continuation of the experiments till the stop of the whole research program in the near future.

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