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Possibility to construct a gravitational wave detector by utilizing the electrogravitic property of dielectric materials

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Abstract

Astronomers tried to detect gravitational waves, which are generated by the movement of massive astronomical bodies. However, it is very difficult to detect gravitational waves by using a massive transducer such as a Weber detector. According to the theory by Boyko Ivanov, the gravitational field can be induced by an external electric field. By studying Ivanov's theory, the author has obtained the result that a gravitational wave detector consisting of a dielectric material, which has a higher sensitivity and a smaller size compared with the conventional gravitational detector, can be constructed. To verify the theoretical analysis, the author attempted to detect gravitational waves from the Crab Nebula by using a piezoelectric transducer and obtained a candidate detection.

Keywords

Gravitational wave detector; Electrogravity; Dielectric material; Pulsar; Piezoelectric transducer; Wigner distribution.

INTRODUCTION

Astronomers have tried to detect gravitational waves generated by the movement of massive astronomical bodies. However these waves are very weak to be detected by conventional gravitational wave detectors such as the Weber detector, which consists of a heavy aluminum cylinder suspended by a cable. T. T. Brown, who discovered the Biefeld-Brown effect, also conducted the research on rock electricity and he found that rocks possessed a property that he referred to as a natural electrical polarization[1]. It is the phenomenon that electricity is generated from rocks, and he concluded that it was spontaneous, everlasting and affected only by diurnal cycles, which is based on observations taken for entire years in various parts of the United States. Exploratory work with various semi-conducting material has revealed that massive high-K dielectrics, being heavy semi-conducting materials with high dielectric constant, produce the greatest self-potential. Solid dieliectrics such as barium titanate, lead zirconate titanate and certain natural rocks (granite, basalt, etc.) were found to produce this electrical self-potential. Brown concluded that the dielectric materials underwent changes influenced by the motion and orientation of the Earth with respect to the Sun and the Moon, and the universe, which leads to the conclusion that the rocks can be charged by the gravitational waves arriving from the universe. This is a reciprocal phenomenon of the Biefeld-Brown effect that is an impressed electric field to the dielectric material, which generates a gravitational field[2]. According to the Einstein theory of relativity, small gravitational perturbations generated by the movement of massive astronomical bodies propagate as waves at the speed of light. Perturbations of space-time metric induced by the movement of celestial bodies can be given by[3]

$$\bar{h}_{\mu\nu}(r,t) \approx \frac{4G}{r}\int \frac{T^{\mu\nu}(x',y',z',t-r/c)}{c^4}dx'dy'dz' \qquad (1)$$

where G is the gravitational constant, c is the light speed, $T^{\mu\nu}$ is an energy-momentum tensor and r is the distance from the origin. From which, the amplitude of a gravitational wave at the frequency of ω can be estimated as:

$$h \approx \frac{2G}{r}M\omega^2R^2\varepsilon \qquad (2)$$

where h is the amplitude of a gravitational wave, R is the size of the source, M is the mass of the source, and ε is the factor to describe the asymmetry of the source.

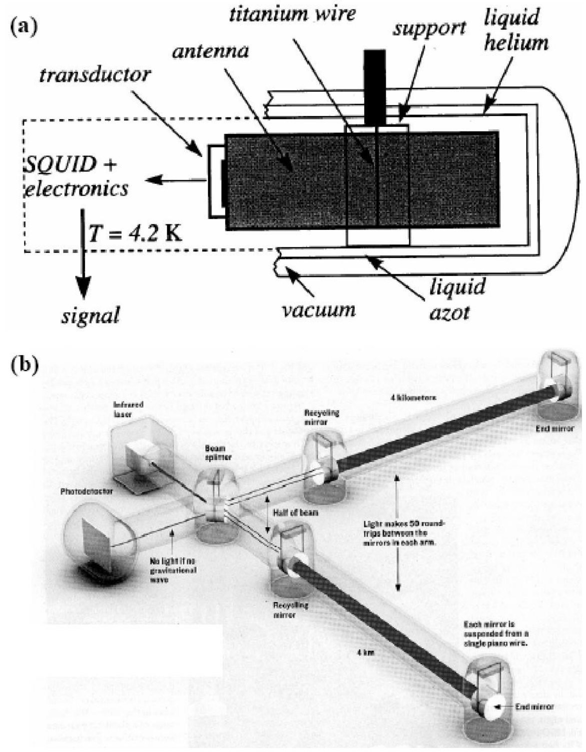

Figure 1 : (a) Schematic diagram of the Weber detector and (b) the laser interferometer gravitational wave observatory (LIGO)

At the lower frequency region, two types of gravitational detectors as shown in Figure 1, the Weber detector (a), which consists of a heavy aluminum cylinder suspended by a cable[4] and the laser interferometer gravitational wave detector (b), which consists of two long perpendicular arms with lasers and mirrors[5].

However these gravitational detectors need an enormous size from the quantum limit of the detector[6] given by:

$$h = \sqrt{\frac{\hbar}{M_0 \omega L^2}} \qquad (3)$$

where $\hbar$ is a Plank's constant divided by 2π, M_0 is a mass of the detector and L is its length.

According to this formula, the quantum limit for the gravitational detector, which has a length of 1.0m and the weight of 1500kg, becomes as shown in Figure 2 (b), and it can be seen that the gravitational wave detector is required to have an enormous size for the detection of gravitational waves from binary stars, which is estimated to have the order of $h \approx 10^{-26}$ from Figure 2 (a). To overcome the problem of quantum limit of the detector, HFGW detectors were proposed by many researchers to detect high frequency gravitational waves instead of lower frequencies[7].

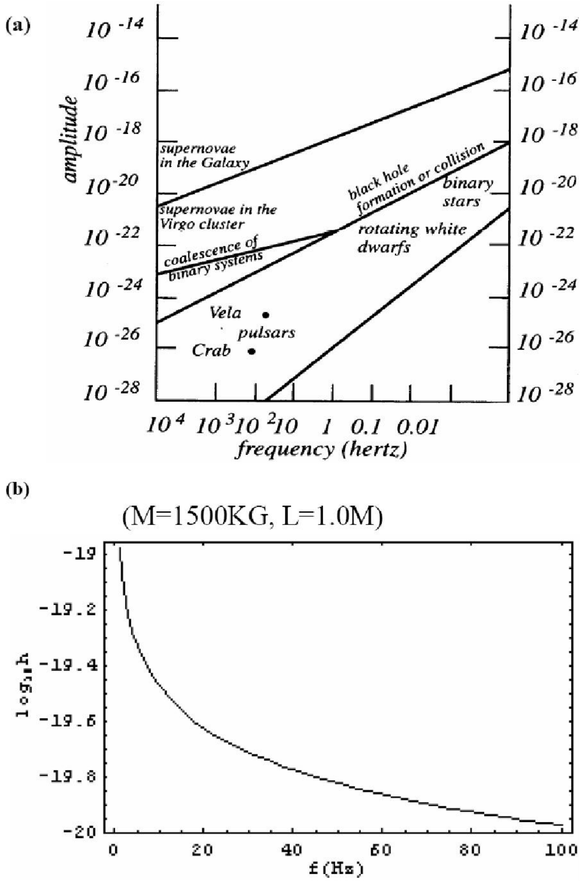

Figure 2 : (a) Estimates of amplitudes of gravitational waves as a function of frequency for various astrophysical processes and (b) the quantum limit of the gravitational detector

However, there is another possibility to overcome the quantum limit problem, which is the method utilizing the rock electricity discovered by T. T. Brown.

For the explanation of Biefeld-Brown effect, B. V. Ivanov of the Institute for Nuclear Research and Nuclear Energy in Bulgaria wrote papers on the field of electrogravitics from Weyl-Majumdar-Papapetrou solutions of the general relativity theory in 2004[8-10]. By studying Ivanov's theory, it can be considered that the gravitational field applied the dielectric material can generate the electric field as observed by T. T. Brown. Thus the gravitational wave detector, which has a higher sensitivity and a smaller size compared with the conventional gravitational detector can be constructed. In this article, the author presents the theoretical analysis of the rock electricity discovered by T. T. Brown and an experimental result obtained by him to try to detect gravitational waves from the Crab nebula by using a piezoelectric transducer.

THEORETICAL ANALYSIS

From Weyl-Majumdar-Papapetrou solutions of the general relativity theory, the equation for the gravitational field induced by static electric can be given by:

$$\mathbf{g}_i = \mathbf{c}^2 \hat{\mathbf{f}}^{-1} \left(\frac{\mathbf{B}'}{2} \sqrt{\frac{\kappa\varepsilon}{8\pi}} \overline{\phi}_i + \frac{\kappa\varepsilon}{8\pi} \overline{\phi\phi_i} \right) \quad (4)$$

where ϕ is a gravitational potential, $\hat{\mathbf{f}} = \mathbf{A} + \mathbf{B}\phi + \phi^2$, B' and ε are constants, and $\kappa = 8\pi G / c^4$.

From which, it is shown that the particle that stays in equilibrium when they are charged satisfies:

$$|\mathbf{e}| = \sqrt{4\pi\varepsilon_0 \mathbf{G}\mathbf{m}} \quad (5)$$

where m is the mass, e is its charge and ε_0 is the permittivity in a free space[8,9].

The differential equation for the atom under a gravitational field ϕ in an oscillating electric field becomes:

$$\mathbf{m}\ddot{\mathbf{x}}^k + \mathbf{m}\partial_k \phi + \mathbf{m}\omega_0^2 \mathbf{x}^k = \mathbf{e}\mathbf{E} \quad (6)$$

where ω_0 is a resonance frequency given by $\omega_0 = \sqrt{4\pi \mathbf{N}\mathbf{e}^2 / \mathbf{m}(\chi - 1)}$ (χ: dielectric constant)[11]. For the atom inside a dielectric material, we can suppose that $x^k \approx 0$, then Eq.(6) can be simplified as $m\partial_k \phi \approx eE$ if ω_0 is relatively small.

From Eq.(5), an electric field, which is generated by the gravitational waves inside the dielectric material with high dielectric constant, becomes:

$$\mathbf{E} \approx \frac{1}{\sqrt{4\pi\varepsilon_0 \mathbf{G}}} \mathbf{g} \quad (7)$$

where g = $\partial_k \phi$.

From which, it is possible to estimate the amplitude of gravitational waves from the electric field generated inside the dielectric material.

We consider a plane wave with an angular frequency ω propagating along the z axis, which is described by $\phi = \phi_0 \exp[i(\omega t - k_z z)]$, where ϕ is the gravitational scalar potential and k_z is the wave number of the gravitational wave (= $\omega \cos \theta / c$).

By introducing Eq.(7) into the equation, g = $-\partial\phi / \partial z = k\phi_0$, we have:

$$\phi_0 \approx \sqrt{4\pi\varepsilon_0 \mathbf{G}} \cdot \mathbf{E}/\mathbf{k}_z = 8.6 \times 10^{-11} \mathbf{E}/\mathbf{k}_z \quad (8)$$

From the formula h = $2\phi_0 / c^2$, the amplitude of a gravitational wave can be estimated from the amplitude of the electric potential $\overline{\psi}_0$ (= Ed) generated inside the dielectric material shown as:

$$\mathbf{h} \approx 9.13 \times 10^{-20} \frac{\overline{\psi}_0}{\mathbf{f} \cdot \mathbf{d}} \quad (9)$$

at the angle of $\theta = 0$, where d is a length of dielectric material and f is a frequency of the gravitational wave. From Eq.(9), the directivity of the detector has a cosine pattern as shown in Figure 3.

EXPERIMENTAL RESULT FOR THE DETECTION OF GRAVITATIONAL WAVES

Solid dieliectrics such as barium titanate, lead zirconate titanate and certain natural rocks (granite, basalt, etc.) are found to produce this electrical self-potential. The experiment to detect the gravitational wave was conducted for the pulsar in the Crab nebula (at the center of the Crab Nebula there is a magnetized neutron star that spins very rapidly, completing one full revolution every 33 milliseconds), which is the most conspicuous and well-known gaseous remnant of a supernova in our galaxy. This experiment was conducted in a shielded room at Yokosuka, Japan (located at 35.224494N, 139.728096E) to avoid the external electromagnetic interference by using the transducer made of a barium titanate with high piezoelectric sensitivity, $d_{33} = 302 \times 10^{-12}$ (m / V) and $\chi = 1400$, which was developed for a sonar array. The transducer consists of six circular plate ceramics with the thickness of 13mm, the total thickness of the piezoelectric material is 78mm. At the base of the transducer as shown in Figure 4 (a), there was a rubber mount to shield vibrations. The time to conduct the experiment was at 0800 (UT) on March.5, 2006 near the meridian passage of the constellation Taurus, in which the Crab nebula is located, when the directivity of the transducer became maximum for the Crab Nebula. The output signal of the transducer was amplified

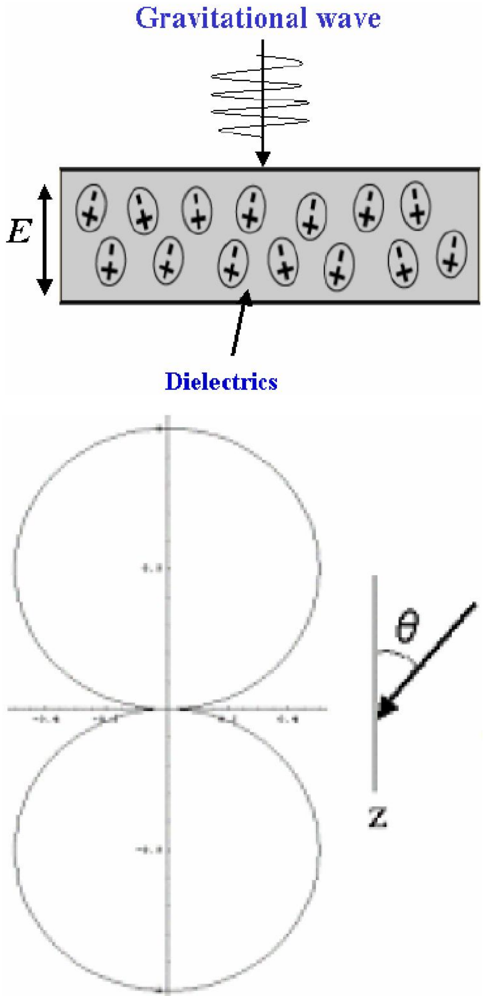

Figure 3 : Directivity pattern of the dielectric material

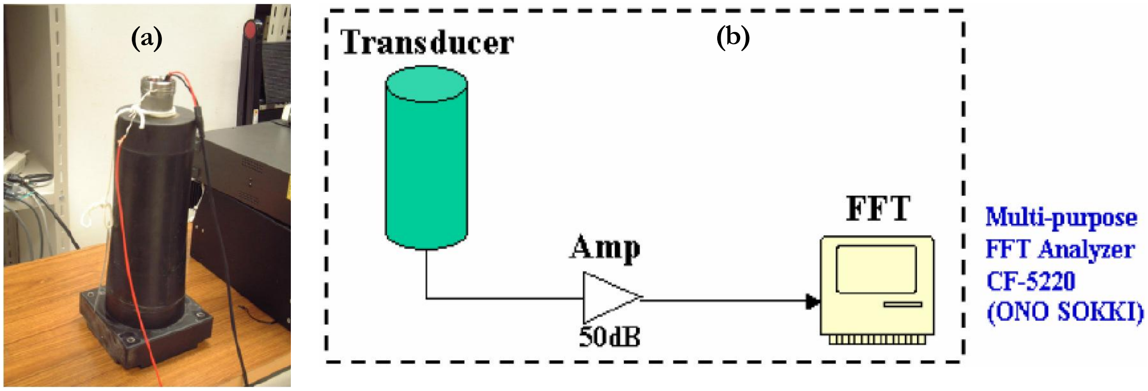

Figure 4 : (a) Photo of the transducer and (b) experimental set-up conducted for the detection of gravitational waves

with the gain of 50 dB and it was supplied to the multi-purpose FFT analyzer as shown in Figure 4 (b).

Because the signal was very faint that could not be recognized by the FFT analysis, the output signal from the transducer was analyzed by using an instantaneous spectrum analysis method that can attain high resolution to improve the signal/noise ratio, known as the Wigner distribution[12], defined by:

$$W_s(f,t)=\int_{-\infty}^{+\infty} s(t+\tau/2)s^*(t-\tau/2)e^{-i2\pi f\tau}d\tau \qquad (10)$$

where *s*(*t*) is a output signal, *s**(*t*) is a conjugate of *s*(*t*), and *f* is a frequency of the signal.

An example of the analyzed result by the Wigner distribution is shown in Figure 5.

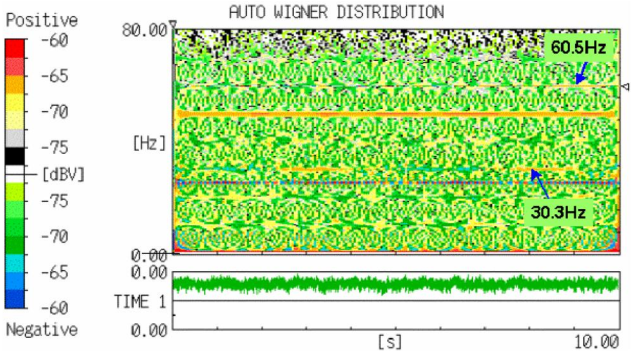

Figure 5 : Wigner distribution analysis result of the transducer output

In this figure, two lines of signals were observed besides artifacts at 50Hz induced by the power supply. In this figure, the vertical line shows the frequency in Hz and the horizontal line shows the time in seconds. As the electrical supply frequency used for the experiment was 50Hz, it was concluded that detected signals were originated from other source except for the power supply.

Eq.(9) was used for the estimation of the amplitude of gravitational waves. By substituting the length of the transducer, *d* = 78mm in Eq.(9), we have:

$$h \approx 1.17\times10^{-18}\,\overline{\psi}_0/f \qquad (11)$$

Frequencies of detected signals and electric potentials measured are shown in TABLE 1. From Eq.(11), the amplitude of the gravitational wave, h can be estimated. The astronomical observation has shown that a magnetized neutron star spins very rapidly, completing one full revolution every 33 milliseconds, with the frequency of 30.3Hz, which coincides with the experimental result.

The signal at 60.5Hz was considered to be the second harmonics related to the revolution of the neutron star. Amplitudes of gravitational waves obtained from the experiment also coincide the theoretical estimation as shown in Figure 6.

TABLE 1 : Frequencies of the signal detected, electric potentials measured at the output of the transducer and estimated amplitudes of gravitational waves from the Crab pulsar

No	Frequency	$\overline{\psi}_0$	*h*
1	30.3Hz	-80.2dBV	1.19×10^{-26}
2	60.5Hz	-89.2dBV	2.12×10^{-27}

Hence it is considered that they correspond to the rotational frequency of the pulsar in the Crab nebula and it can be seen that there is a possibility to detect gravitational waves from celestial bodies by utilizing the electrogravitic effect of dielectric materials.

As the signal from the pulsar composed of two frequen-

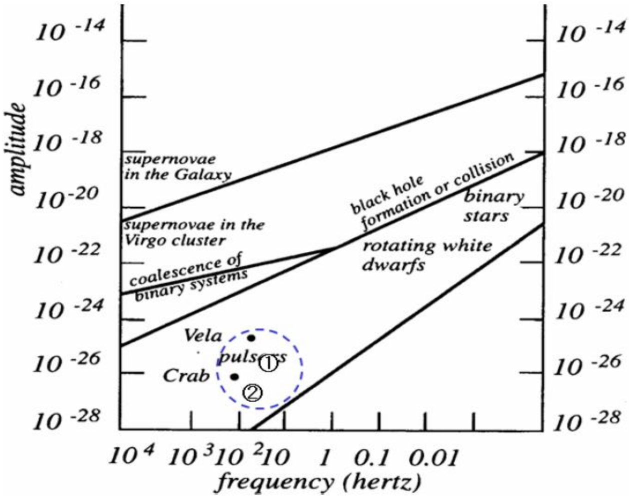

Figure 6 : Experimental data compared with the theoretical analysis (Data: ① and ② inside the circle)

cies, 30Hz and 60Hz, we may consider that the shape of the Crab pulsar is not a spherical but rather an oval shape and the rotation axis is shifted from the symmetrical axis. The pulsars are generally believed to be rapidly rotating neutron stars and the optical emission of the Crab pulsar is actually in the form of 30 Hz flashes. But certain of the pulsars might actually be electrogravitic oscillators. According to Gary Osborn[13], the electrical and gravitational fields appear to be coupled in dynamic solutions, then one consequence of the coupling is that a dense magnetized sphere has a specific resonant frequency that decreases to about 0.4 Hz as the radius shrinks to the Schwarzschild radius. Thus the 30Hz signal is modulated with a 5 sec period, which frequency is 0.2Hz is considered to be related to this specific resonance of this coupling effect.

CONCLUSIONS

In this article, the possibility to detect the gravitational waves by using the dielectric material is studied from the standpoint of Ivanov's theory for the explanation of the Biefeld-Brown effect. From the theoretical analysis, it is seen that the electric field can be induced by the gravitational field for the dielectric material with high dielectric constant. By the experiment conducted for the Crab Nebula, two spectrums, which amplitudes are $h = 1.19 \times 10^{-26}$ at $30.3Hz$ and $h = 2.12 \times 10^{-27}$ at $60.5Hz$, were detected. As the magnetized neutron star completes one full revolution every 33 miliseconds, it is considered that detected signals are related to the revolution of the star. It can be also seen that the strengths of them are almost equal to the theoretical estimation. From this result, it is considered that the gravitational wave detector a consisting of dielectric material, which has a higher sensitivity and a smaller size compared with the conventional gravitational detector, can be constructed by utilizing the electrogravitic effect of dielectric materials, that was originally found by T.T.Brown for the investigation on rock electricity. He also studied the application of the Biefeld-Brown effect for the space propulsion system and this result suggest the possibility to construct a propulsion system according to the Ivanov's theory by utilizing dielectric materials.

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