**V. B. Braginskiĭ, A. V. Gusev, V. P. Mitrofanov, V. N. Rudenko, and V. N. Yakimov.** *Searches for low-frequency bursts of gravitational radiation.* Practically all the Weber and laser antennas for the detection of gravitational radiation that are working or being constructed, are designed for the frequency range $\Delta\omega/2\pi \sim 0.5-10$ kHz. This range probably contains only sources of exotic frequency, which means that they must be very distant from the antennas on the ground (examples include the asymmetric explosion of a supernova with the conversion of $\sim M_\odot c^2$ into gravitational radiation, which is unlikely to be observed at a rate of more than once per month in the 300 nearest galaxies). The remoteness of the sources leads to the prediction that the amplitude $h$ of variations in the metric due to such phenomena must be small: an optimistic estimate obtained for this region is $h \simeq 10^{-20}-10^{-19}$. Bursts of higher duration $\tau_{gr}$ and lower mean frequency $\omega_{gr} \approx 2\pi/\tau_{gr}$ should have greater $h$. For example, in the range 0.1–0.01 Hz, one would expect[1] $h \simeq 10^{-17}-10^{-16}$. We note that sources of such bursts could be present also in our Galaxy.

The purpose of this paper is to consider an alternative program of searches for gravitational radiation in the low frequency range.[2] It relies on the following basic facts:

1. Sadovskiĭ *et al.*[3] have recently discovered a block structure in rocks in the Earth's crust; the linear dimensions of these blocks are $l \simeq 5\times10^6-7\times10^6$ cm.

2. Even minor seismic disturbances, recorded in seismically quiet regions, are produced by sources localized outside these regions.[4]

One or more such blocks can be used as natural gravitational antennas, with an array of low-frequency seismographs mounted upon them for the detection of displacement (acceleration).

We reproduce a few typical estimates for such an arrangement. If we suppose that the seismograph period is $\tau_0 \approx \tau_{gr} \approx 2\pi/\omega_{gr} \approx 30$ s and $h \approx 2\cdot10^{-17}$, $l \approx 7\cdot10^6$ cm, the response for $t \lesssim \tau_{gr}/2$ turns out to be

$$\Delta l_{gr} \approx \frac{1}{2} hl \approx 7\cdot10^{-11}\,\text{cm}. \tag{1}$$

Since the spectral density of displacements in the range $\tau_0 \approx 30-40$ s is[5] $S \simeq 7\cdot10^{-13}$ cm$^2$/Hz, the variation in the seismograph oscillation amplitude in the time $\sim \tau_0/2$ is approximately

$$\Delta l_{\text{seis}} \approx \sqrt{S\frac{\omega Q}{2\pi}}\sqrt{\frac{\tau_0}{\tau^*}} \approx 2\cdot10^{-7}\,\text{cm}. \tag{2}$$

Comparison of the quantities $\Delta l_{gr}$ and $\Delta l_{\text{seis}}$ shows that, for $h \simeq 2\times10^{-17}$, the response should be lower than the background by roughly 3.5 orders of magnitude. These two quantities together determine the lower limit of the dynamic range of the seismograph. Very moderate conditions must be satisfied if the response is to exceed the natural thermal-fluctuation level of the seismograph in $\tau \approx \tau_0/2$

$$\Delta l_T \approx \sqrt{\frac{kT\tau_0}{4M\omega Q}}. \tag{3}$$

For example, for $T = 300$ K and $M = 3000$ g, the $Q$-factor should be $Q \gtrsim 10^5$.

This experimental scheme has one further important feature. The energy flux density $\tilde{I}$ for $\omega_{gr}\tau_{gr} \approx 2\pi$ is simply related to $h$:

$$\tilde{I} \approx \frac{c^5\omega_{gr}h^2}{16G}, \tag{4}$$

where $c$ is the velocity of light and $G$ is the gravitational constant. For existing programs of searches for high-frequency bursts, the figure $h \simeq 2\times10^{-17}$ corresponds to $\tilde{I} \approx 2.5\cdot10^4$ erg/cm$^2$. In our program, $h \simeq 2\times10^{-17}$ and $\omega_{gr} \approx 0.2$ rad/s correspond to $\tilde{I} \approx 2.5\cdot10^3$ erg/cm$^2$. If this source were to be located at the center of our Galaxy, this would require the conversion of about $10^{-5}M_\odot c^2$ per burst, i.e., a figure lower by a factor of $10^5$ as compared with the high-frequency burst.

The successful implementation of this program will depend on whether the signal (1) can be separated, at least in principle, from the largely pulsed noise background (2). This can be assured by exploiting the specific properties of gravitational-wave disturbances.

It is well-known that the bulk excitation of a continuous medium by gravitation waves is equivalent in the long-wave approximation to a surface excitation.[6] In the simplest one-dimensional model of a block, the measured deformation $W$ is described by the equation

$$\begin{aligned} &W_{tt} + 2\delta W_t \approx v_s^2 W_{xx},\\ &W(-l,\ t) = n_1(t) - \frac{1}{2}h(t),\\ &W(l,\ t) = n_2(t) - \frac{1}{2}h(t), \end{aligned} \tag{5}$$

where $\delta$ is the damping efficiency, $v_s$ is the velocity of sound and $n_i(t)$ $(i = 1, 2)$ are fluctuational deformations due to the pulsed noise. The characteristic feature of the gravitational-wave effect is that the amplitudes are in phase and are equal for sources on both boundaries ($x = -l,l$). When this is taken into account, the result is a lower pulsed noise background (probability of false alarm) by the factor

$$q = \frac{\Delta a}{A}\frac{\Delta t}{T_0}\Delta\varphi < 10^{-3}, \tag{6}$$

where $\Delta a$, $\Delta t$, $\Delta\varphi$ are the experimental uncertainties in amplitude, time, and phase difference, $A$ is the maximum possible amplitude of a noise pulse, and $T_0$ is the mean time interval. The above factors are sufficient for the effective suppression of the pulsed noise background. The limiting values of $\Delta a$, $\Delta t$, $\Delta\varphi$ in (6) are restricted by the intensity of the white Gaussian noise, $\Delta a/A \approx \Delta t/\tau_0 \approx \Delta\varphi \approx \rho^{-1}$, where

$\rho$ is the signal-to-noise ratio. We then have $q \lesssim (\tau_0 / T_0)\rho^{-3}$ and for (6) to remain valid, it is sufficient to have $\rho \gtrsim 10$ which is satisfied with considerable margin for the thermal fluctuations of a block. The algorithm for differentiating between a gravitational burst and a noise pulse relies on an analysis of anticoincidences between even and odd modes of the block. Transition to the two-dimensional model (measuring instrumentation distributed over the perimeter of the block surface) produces only a modification of the structure of the seismic-antenna system which becomes a four point array (in place of the instrument pair in the one-dimensional model).

Our method differs fundamentally from the proposal of Weber and Dyson[6,7] who suggested the use of the Earth as a detector of the continuous radiation from pulsars within a very narrow frequency band, known in advance.

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