is produced and

$$\gamma_{max} = \sqrt{3}\omega = 0.87\omega_0\left(\frac{v_E}{c}\ \frac{\omega_{Li}}{\omega_0}\right)^{2/3} = (2-4)\cdot 10^7\ \text{sec}^{-1}.$$

The frequency turns out to be underestimated by several times in comparison with the observed one.

Such a difference is apparently due to the fact that the employed theory does not take into account the influence of the inhomogeneity of the plasma layer.

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[1] V.P. Silin, A Survey of Phen. in Ionized Gases, Vienna, 1961, p. 205; FIAN Preprint No. 138, 1967.
[2] D.F. DuBois and M.V. Goldman, Phys. Rev. Lett. 14, 544 (1965).
[3] G.M. Batanov and V.S. Silin, ZhETF Pis. Red. 14, 445 (1971) [JETP Lett. 14, 303 (1971)].
[4] R.A. Stern and N. Tzoar, Phys. Rev. Lett. 17, 903 (1966).
[5] N.E. Andreev, A.Yu. Kirii, and V.P. Silin, Zh. Eksp. Teor. Fiz. 57, 1024 (1969) [Sov. Phys.-JETP 30, 559 (1970)].
[6] L.M. Gorbunov, ibid. 55, 2298 (1968) [28, 1220 (1969)].

SEARCH FOR GRAVITATIONAL RADIATION OF EXTRATERRESTRIAL ORIGIN

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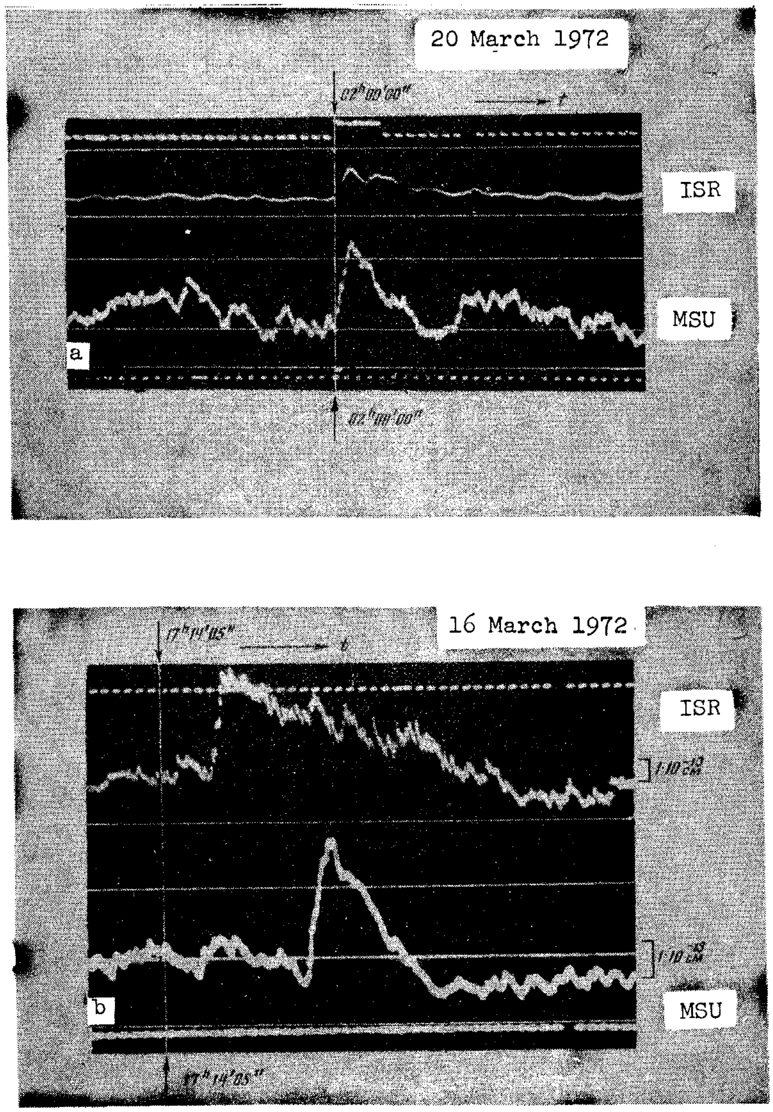
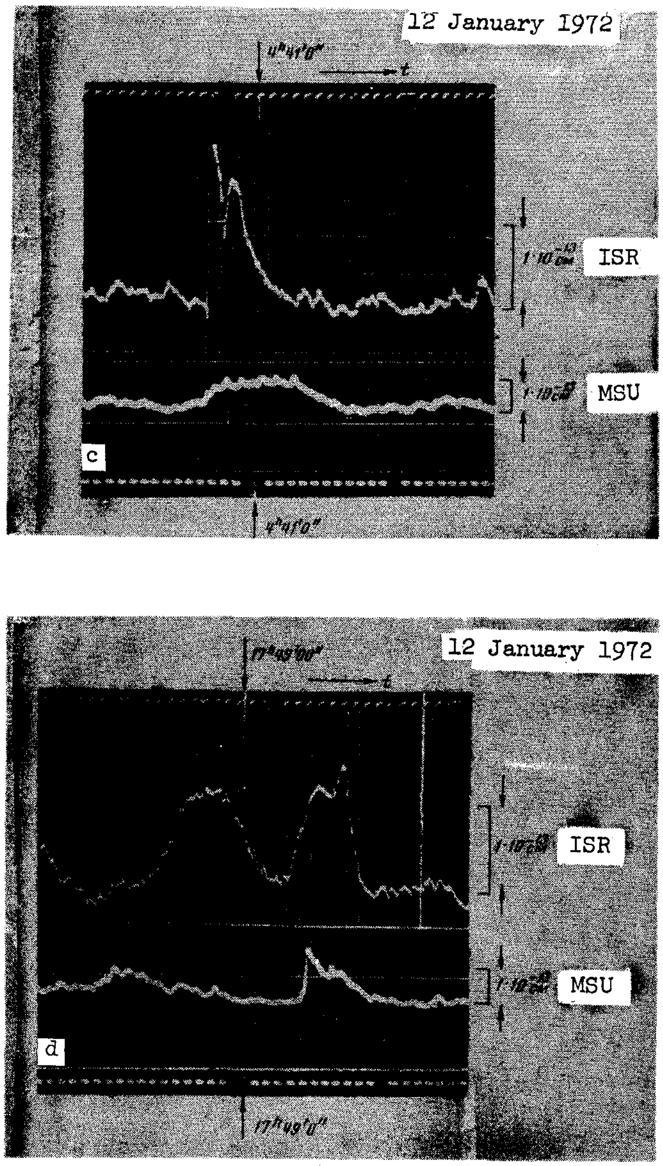
I. We present here the results of the first series of measurements performed with two gravitational antennas, with the aim of observing simultaneous responses produced by gravitational radiation from extraterrestrial sources against the background of Brownian oscillations. The antennas had the same parameters as those of J. Weber [1] ($m = 1.3 \times 10^6$ g, $f_{quad} = 1640$ Hz, $Q = 10^5$, relaxation time $\tau^* = 20$ sec) were placed in evacuated chambers ($p < 1 \times 10^{-4}$ Torr) located 20 km apart. The anti-seismic insulation of the antennas was the same as in [1]. Unlike in [1], the small quadrupole vibrations of the antennas were measured with modulated capacitive displacement pickups, whereas in [1] piezoelectric pickups were used to record stresses. The capacitive pickup transformed a vibration amplitude of $\sim 4.5 \times 10^{-14}$ cm (corresponding to the rms amplitude σ_{Brown} of the Brownian oscillations) into a radio-frequency signal of amplitude $\sim 4 \times 10^{-7}$ V. The construction of the pickup and the system for the absolute ponderomotive calibration of the antenna are described in detail in [2]. We note that in Weber's experiments the Brownian fluctuations corresponded to a piezoelectric-pickup signal level of 5×10^{-10} V [1]. The amplitude of the vibrations are photographed on film with an oscillograph (film speed 0.6 mm/sec, beam spot diameter less than 0.2 mm). This made it possible, without using an electronic coincidence circuit, to discern on the film changes in the oscillation amplitude with a resolution time not worse than 0.3 sec. The recording apparatus for each of the antennas was located at the antenna itself, unlike in [1]. The plots were synchronized with the aid of the time-service radio signals, and with chronometers in the intervals between the hourly radio signals.



a - Imitation of gravitational signal: response to simultaneous artificial excitation of the antennas by a short resonant pulse of duration ∿1 sec; b - bursts with similar front slope, but with a shift ∿(7 - 8) sec.

II. The reduction of 20 days' simultaneous recording yielded the following results:

1. The pickup was sensitive enough to measure changes of 2×10^{-14} cm in the amplitude of the quadrupole mode within a time $\tau = 2$ sec, corresponding to an rms fluctuation drift of the Brownian-oscillation amplitude $\delta x_0 = \sigma_{Brown} \sqrt{2\hat{\tau}/\tau^*} \simeq \sigma_{Brown}/2$ (for details see [3]). For prolonged sections of the plots (on the order of 300 τ^*), we verified the validity of two hypotheses: a) does the measured absolute rms value of the oscillation amplitude correspond to the



c, d - Bursts coinciding within 1 sec, but significantly different in shape and in rise time. The scale of the figure was determined from electronic calibration; the difference in the vertical scales on the films obtained at the Moscow State University (MSU) and the Space Research Institute (SRI) is due to the difference in gain between the electronic apparatus; one time marker corresponds to 1 sec.

calculated σ_{Brown}, and b) does the oscillation amplitude have a Rayleigh distribution with a variance calculated beforehand from the known f_{quad}, m, and T. No statistically significant discrepancy between the experimental results and the predictions corresponding to these hypotheses were observed (the F criterion and the K(λ) criterion were applied).

2. In both antennas we observed relative rare bursts of oscillations of patently non-thermal origin (exceeding in frequency the statistical predictions). The statistics of these bursts are characterized by the following data: a) an abrupt change of the amplitude δx_0 by an amount $3\sigma_{Brown}$ within a time $\hat{\tau}$ = 2 sec occurs on the average 100 times daily, and by an amount $5\sigma_{Brown}$ about 20 times daily; b) the level $3\sigma_{Brown}$ is exceeded (with a rise time from 0 to 20 sec) on the average 100 times daily, while the $5\sigma_{Brown}$ level is exceeded 40 times daily; the statistically expected values are 100 times daily for the $3\sigma_{Brown}$ level and once every 10 days for $5\sigma_{Brown}$.

3. By using different methods of reducing the photographs (including the photograph superposition method used by Weber [1], but without an electronic threshold device), we were unable to observe bursts that coincided within 0.5 sec.

We noted approximately 30 suspicious places corresponding to the appearance of bursts ($\delta x_0 > 2\sigma_{Brown}$) with a time delay within ∿10 sec; several cases satisfied a "coincidence accurate to 1 sec." The great differences in the structure of the bursts (shape, rise time) do not allow us to regard these cases as a response to a signal from one and the same source (see Fig. 1). The difference between the slopes of the fronts exceeded the permissible confidence limits.

We note that Weber [1] observed in the first runs 1 - 2 coincidence per week, and in the last ones 1 - 2 daily, with accuracy 0.2 sec, and the magnitude of the bursts was equal to or exceeded the $3\sigma_{Brown}$ level. If we assume that the duration of the expected bursts of gravitational radiation is approximately 2 sec, then the observable flux density would be 1×10^7 erg/sec-cm^2, and if the bursts were longer, 5 - 10 sec, then the observed flux density would be $(5 - 2) \times 10^6$ erg/sec-cm^2. It is easy to estimate that the attained sensitivity level is worse, by 1.5 orders of magnitude, than the potential sensitivity of antennas having the same f_{quad}, Q, and m (see [3] for details). This is due, on the one hand, to the relatively high level of non-thermal bursts, and to the insufficient resolution of the small displacements as a result of the electronic noise ($\delta x_0 = 2 \times 10^{-14}$ cm).

The decrease in the number of coincidences following the introduction of delay in one of the channels, and the anisotropy of the distribution of the coincidences in sidereal time, are significant arguments in favor of the correlated bursts in Weber's experiments. The absence of coinciding bursts above the $3\sigma_{Brown}$ level in our experimental scheme does not contradict the astrophysical estimates [7].

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[1] J. Weber, Phys. Rev. Lett. 22, 1320 (1969); 24, 276 (1970); 25, 180 (1970); Nuovo Cimento Letters 4, 653 (1970).
[2] V.B. Braginskii, V.P. Mitrofanov, V.N. Rudenko, and A.A. Khorev, Prib. Tekh. Eksp. No. 4, 245 (1971).
[3] V.B. Braginskii and V.N. Rudenko, Usp. Fiz. Nauk 100, 395 (1970) [Sov. Phys.-Usp. 13, 165 (1970)]; V.B. Braginskii, Fizicheskie eksperimenty s probnymi telami (Physical Experiments with Test Bodies), Nauka, 1970.
[4] M.E. Gertsenshtein, ZhETF Pis. Red. 14, 611 (1971) [JETP Lett. 14, 427 (1971)].

[5] R.A. Adamyants, A.D. Alekseev, and N.I. Kolosnitsyn, ibid. 15, 277 (1972) [15, 194 (1972)].
[6] I.I. Kalinnikov and S.M. Kolesnikov, Astronomicheskii tsirkulyar (Astronomical Circular), No. 619 (1971).
[7] V.B. Braginskii, Ya.B. Zel'dovich, and V.N. Rudenko, ZhETF Pis. Red. 10, 437 (1969) [JETP Lett. 10, 280 (1969)].

CHANNELING OF POSITRONS OF 1 GeV ENERGY

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The channeling of positrons of ∿28 MeV energy in a silicon crystal along the [110] axis was observed by Walker [1]. We show in the present paper that the effect of channeling of positrons in a crystal exists also at 1 GeV. The channeling of positrons at high energies was never observed before, owing to the difficulty of generating high-energy positron beams with small divergences [2, 3].

In our experiment a beam of positrons with energy 1 GeV and divergence $\leq 2 \times 10^{-4}$ rad was directed on a single-crysjal silicon target mounted in a goniometer. The goniometer has made it possible to rotate the crystal in the vacuum chamber of the accelerator about all three axis, with a reading accuracy 5×10^{-5} rad. The silicon crystal was in the form of a plate 0.64 mm. The normal to the plane of the plate made an angle ∿1° with the [110] axis. The crystal was oriented relative to the beam by a method analogous to that described in [4] in such a way that the [110] crystal axis was directed along the beam axis, and the [001] axis was oriented along the goniometer axis that was perpendicular to the beam direction.

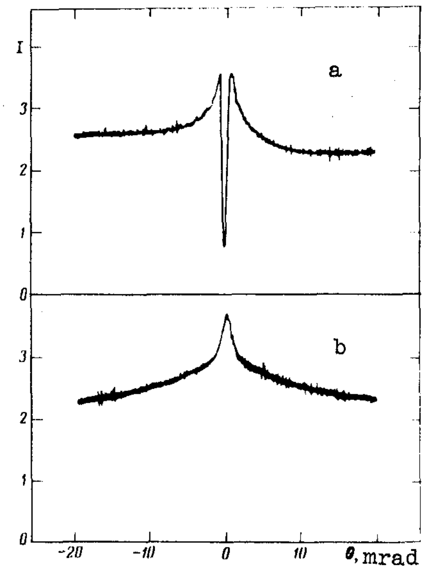

Fig. 1. Bremsstrahlung energy flux vs. angle between the direction of the beam and the silicon [110] crystal axis: a - positrons, b - electrons.

After it interacted with the crystal, the positron beam was reflected with a magnet. The photon beam was registered with a Gauss-quantometer [5] placed behind the crystal. The quantometer registered the energy flux of the bremsstrahlung γ quanta in the direction of the primary positrons, within a solid angle $4\pi \times 10^{-4}$ sr. The results of the measurements performed on the positron beam are shown in Fig. 1a. Figure 1b shows, for comparison, a curve obtained with an electron beam having parameters identical with those of the positron beam. The abscissas are the angles of rotation of the crystal about the [001] axis in milliradians, and the ordinates are the quantum-meter currents in relative units, proportional to the γ-quantum energy flux. It is seen from Fig. 1a that when the positron beam makes an angle smaller than a certain critical value with the crystal axis, the flux of the γ quantum energy decreases sharply.

Figure 2 shows the spectra of the positrons incident on the crystal (1), scattered by the crystal when the beam angle is parallel to the [110] axis of the crystal (2), and