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A joint scientific session of the Division of General Physics and Astronomy and the Division of Nuclear Physics, USSR Academy of Sciences, was held on March 26 and 27, 1980 at the Academy's P. N. Lebedev Physics Institute. The following papers were presented:

March 26

1. *V. B. Braginskiĭ*, Quantum aspects of gravitation antennas.
2. *I. M. Belousova, L. F. Vitushkin, I. P. Ivanov, N. I. Kolosnitsyn, A. A. Pomanskiĭ, V. I. Sintsov, and V. P. Chebotaev*, Design of a laser-interferometer gravity-wave experiment.
3. *L. P. Grishchuk*, The problem of relic gravitational radiation.

March 27

4. *A. V. Tutukov* and A. G. Masevich, The evolution of massive close binary stars.
5. *É. V. Ergma* and A. D. Kudryashov, Thermonuclear bursts on neutron stars.

Below we publish summaries of four of these papers.

V. B. Braginskiĭ. *Quantum aspects of gravitation antennas.* The ground-based and satellite gravitation antennas being developed in 18 laboratories in various countries are intended for use in detecting bursts of gravitational radiation from astrophysical "catastrophes" that take place outside of our Galaxy. The ground-based antennas are designed to detect bursts in the frequency range $\omega_{gr} \approx 2\pi(1\cdot10^{3}-1\cdot10^{4})$ rad·sec^{-1}, and the satellite antennas for bursts in the range $\omega_{gr} \approx 2\pi(1\cdot10^{-2}-1\cdot10^{-3})$ rad·sec^{-1}. Gravitational-radiation bursts are conveniently characterized in terms of the dimensionless disturbance amplitude of the metric h, which is related to the Riemann curvature tensor: $R_{j0k0} \cong \ddot{h}^{TT}_{jk}/2$. It is known (see, for example, Ref. 1) that the difference between the accelerations F/m in the field of a gravity wave for two test masses separated by a distance l is approximately equal to $c^2 l_j R_{j0k0}$, while the displacement amplitude of the same masses due to the wave is $\Delta l_j \approx (1/2)h^{TT}_{jk} lk$ if the masses are free (i.e., not coupled by rigidity). The astrophysical predictions (see, for example, Refs. 2 and 3) for the first of the two ranges are: near the earth, h may range from $2\cdot10^{-19}$ to $1\cdot10^{-21}$, the duration of a burst $\tau_{gr} \approx 2\pi/\omega_{gr}$, and 1 yr^{-1}–10 yr^{-1} for the frequency of occurrence of such bursts. In the second range, it is expected that h may reach $1\cdot10^{-15}$ to $1\cdot10^{-20}$, $\tau_{gr} \approx 2\pi/\omega_{gr}$, and that the repetition frequency of the bursts may exceed $1/\tau_{gr}$ at $h < 1\cdot10^{-17}$. The ground antennas being designed are of two types: "free" masses separated by $l \approx 1\cdot10^{5}$ cm together with a Michelson-type multipath laser interferometer, and Weber-type mechanical resonant antennas (massive metallic or dielectric cylinders, $l \approx 1\cdot10^{2}$ cm) with small-oscillation sensors, based on the use of cryogenic electronics (cryonics) (see, for example, the reviews of Refs. 4, 5). The natural vibration frequency of the "free" masses is $\omega_M \ll \omega_{gr}$, and the resonant vibrational frequency of the cylinders is $\omega_M \approx \omega_{gr}$. The "response" of the free masses to a gravity-wave burst is a change in the distances between them, $\Delta l \approx hl/2$, and the vibration amplitude of the mechanical resonator changes by approximately the same amount. In the satellite gravitation antennas (two satellites or the earth and a satellite as test masses), it is proposed that Doppler methods be used to measure the variations of the relative velocities caused by the wave: if $l > c\tau_{gr}$, then $\Delta v/c \approx h$ (see the reviews of Refs. 4, 5, and Ref. 6). The small h values that is necessary to detect and the (apparently technical) difficulties that arose in execution of various programs produced a series of papers devoted to clarification of the question as to what are the quantum limits of sensitivity of the various gravitation-antenna types, assuming that thermal, seismic, and other noises have been eliminated. Below we present the basic results of this analysis:

1. For laser antennas with "free" masses, the smallest observable value $h_{min} \approx (1/l)\sqrt{\hbar\tau_{gr}/m}$, where $\hbar$ is Planck's constant and the registration time is assumed equal to τ_{gr}. If $\tau_{gr} = 10^{-3}$ sec, $m = 10^{5}$ g, and $l = 10^{5}$ cm, we have $h_{min} \approx 1\cdot10^{-22}$.[7-9]

2. For Weber-type resonant mechanical antennas with continuous registration of the coordinates, $h_{min} \approx (1/l)\sqrt{\hbar/m\omega_M}$. In this registration mode, the antenna is at all times in a coherent quantum state. At $m = 10^{4}$ g, $\omega_m = 4\times10^{4}$ rad·sec^{-1}, and $l = 1\cdot10^{2}$ cm, we have $h_{min} \approx 1\cdot10^{-20}$. However, if, for example, only one of the noncommuting quadrature components of the coordinate is measured (the antenna is in a supercoherent quantum state), it is possible in principle to measure arbitrarily

small $h_{\odot}$[10–13]

3. In satellite antennas, the smallest observable $h \approx \Delta v/c$ must obviously exceed the relative frequency instability $\Delta\omega/\omega$ of the self-excited master oscillator in the Doppler system. An instability level $\Delta\omega/\omega \approx 3 \cdot 10^{-16}$ of a self-excited oscillator of microwave frequency has already been attained for times of 10^2–10^3 sec.[14] A specific quantum instability limit on the self-excited oscillator frequencies exists: $\Delta\omega/\omega = \sqrt{\hbar/YV\tau}$, where V is the cavity volume, Y is Young's modulus, and τ is the averaging time.[15,16] If $Y = 4 \cdot 10^{12}$ dyn $\cdot$ cm^{-2}, $V = 10^2$ cm^3, and $\tau = 10^2$ sec, then $\Delta\omega/\omega \approx 1 \cdot 10^{-22}$. First of all, therefore, there is a great deal of room for stability improvement of self-excited frequency generators and, secondly, there is no fundamental prohibition preventing reaching the sensitivity that corresponds to the lower limit $h \approx 10^{-20}$ for longwave bursts of gravitational radiation.

In summarizing the above, it is appropriate to stress that the analytic work done by various authors on the quantum features of gravitation antennas, which determine their sensitivity, has placed no obstacles in the way of experimentors attempting to detect bursts of gravitational radiation at the level predicted by the astrophysicists.

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