RECORDING THE GRAVITATIONAL EMISSION OF DOUBLE STARS OF THE GALAXY

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It is proposed that a system of close double stars in our galaxy can be employed as a source of gravitational emission for solving the problem of gravitational waves experimentally.

THE system of close double stars of the type W UMa in our galaxy is an extremely powerful source of gravitational emission. A previous estimate [1] based on the energy pseudotensor yields a value of 10^{38} erg/sec which is only five orders of magnitude smaller than the light emission of the galaxy. The flux density within the solar system is $\sim 10^{-7}$ erg/sec-cm^2. The spectrum of the emission is in the range of periods of 0.1—0.5 days.

Let us consider the possibility of registering the emission. As the receiver we take a torsional frictionless pendulum [1)] with a natural frequency ω_0 within the range of the emission spectrum. When in equilibrium, let the pendulum be oriented along the x axis of an orthogonal geodesic coordinate system. Then the equation of motion in the plane of oscillation xy of the pendulum at a distance l from the axis of revolution can be written as follows [3]:

$$\ddot{y} + \omega_0^2 y = -c^2 l \sum_i R_{2010}(\mathbf{r}_i, \mathbf{n}_i) \sin(2\Omega_i t + \varphi_i). \qquad (1)$$

The summation includes a component of the Riemann tensor connected with the radiation field of the i-th star, Ω_i is the angular frequency, and $\mathbf{r}_i$ and $\mathbf{n}_i$ are vectors characterizing respectively the position of the star and the orientation of the plane of the orbit in space. In the right-hand side of the equation one can use the Riemann tensor calculated in a system of coordinates that are stationary with respect to the center of mass of the radiating star, since for small velocities it changes little on going over to a system connected with the center of mass of the detector. [3]

The data on the W UMa system of stars [1] are statistical in nature and a concrete result can therefore be obtained by the following method. With the aid of (1) we find y^2 and then average it over the distribution of stars in space, over all possible orientations of the receiver and orbits, and over the distribution of frequencies and phases. The final result for $t \gg T_0$ is of the form

$$(\overline{y^2})^{1/2} \approx 10^{-19} l T_0^{-2/3} \sqrt{f(2T_0)t} \ \text{[cm]}. \qquad (2)$$

Here $f(\tau)$ is the probability density of the distribution of W UMa stars with respect to the periods of revolution τ, T_0 is the period of the natural oscillations of the pendulum, t is the time of observation (t and T_0 are expressed in days and l in centimeters). We note that in deriving Eq. (2) we did not make use of the pseudotensor of the energy of the gravitational field, and Eq. (2) is thus free of the shortcomings connected with this concept. Following the work of Weber [3] and Braginskiĭ, [4] one can replace $[R_{i0j0}(\omega)]^2$ referring to the geodesic system of coordinates, by a quantity proportional to the spectral flux density $P(\omega)$ of the gravitational emission in the coordinate system of the radiating source, and thereby express the mean-square deviation of y in terms of $P(\omega)$. The expression equivalent to (2) is of the form

$$(\overline{y^2})^{1/2} \approx l\sqrt{GP(\omega)t/c^3} \ \text{[cm]}, \qquad (3)$$

where G is the gravitational constant and c the speed of light (cgs units). The spectral flux density $P(\omega)$ can be determined from data cited in [1]. We shall give a numerical estimate of $(\overline{y^2})^{1/2}$ of the pendulum whose period (T_0 = 0.15 days) corresponds to the maximum of the spectral density P(T). Taking $l = 10^3$ cm, the time of observation $t = 10^2$ days, and allowing for the fact that f(0.3) = 2.2 [1] we obtain from (2)

$$(\overline{y^2})^{1/2} \approx 5 \cdot 10^{-15} \text{ cm}.$$

As noted by Braginskiĭ, [4] with the aid of present-day experimental techniques it is apparently possible even now to measure periodic displacements of about 10^{-14}—10^{-15} cm. It is thus possible to hope to

[1)] V. B. Braginskii proposed an experimental setup[2] with exceptionally small intrinsic friction so that attenuation can be neglected for arbitrary practically acceptable time intervals.

check experimentally the considered effect, and consequently to solve the fundamental problem: do gravitational waves exist ?

In the case of an affirmative answer, gravitational experiments can serve as a source of additional astrophysical information, particularly about neighboring double stars whose double nature cannot be determined optically. With resonance tuning to the source

$$\overline{(y^2)}^{1/2} \approx 0.25lt\sqrt{\pi GP / c^3} \text{ [cm]}.$$

Let us estimate this quantity for the close stars i Boo and WZ Sge. In the vicinity of the earth both stars give rise to radiation fluxes with a density $P \approx 10^{-11}$ erg/sec-cm^2 (in the coordinate system of the radiating source). Taking $l = 10^3$ cm, and $t = 10^2$ days, we find $\overline{(y^2)}^{1/2} = 6 \times 10^{-16}$ cm. The emission of the first star (T = 0.134 day) is within the "gravitational noise" spectrum of the galaxy, which will build up the oscillations of the pendulum by an order of magnitude more strongly during 100 days than the emission of the star i Boo, and cannot thus be detected at that time.

The emission of the other star (T = 40.5 min) is far outside the limits of the noise spectrum, and therefore the possibility of registering it is determined only by the sensitivity of the shift detector. Estimates indicate that one should first plan an experiment for registering gravitational emission with the continuous spectrum. As can be seen from Eqs. (2) and (3), a characteristic sign of emission reception will be an increase of the oscillation amplitude $\sim\sqrt{t}$.

In setting up the experiment under terrestrial conditions, it is essential to allow for the modulation of the emission due to the rotation of the earth. This effect will lead to a small decrease of the quantities indicated above.

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