Возможность регистрации гравитационных волн от галактических тесных двойных массивных звездных систем

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The possibility of detecting the gravitational waves (GW) from close binary massive star systems (CMSS) was considered. Galactic CMSSs can compete with the most powerful supermassive black holes (SMBH) in terms of registration of GWs on the Earth's surface. Under certain conditions, they can significantly exceed those of SMBHs.

Using the example of W49N, we have shown that such a system can emit GWs, the flux density of which on Earth is comparable to the flux density from the promising extragalactic source OJ 287.

In order to obtain identical GW flux densities on the Earth's surface from OJ287 and W49N, it is enough to have massive stars in W49N.

Thus, galactic CMSSs can be of great interest in terms of registering GWs. The registration of GWs from sources for long periods of time ranging below nanohertz to a few tens of microhertz is more preferable for International Pulsar Timing Array detectors.

The maser source W49N is one of the most distant in the Galaxy (~11 kpc). It has an extremely wide range of radial velocities of features (±150 km/s), high luminosity of masers and a flux density variability range from hours to tens of years.

If we assume the existence in the W49N system of the CMSS of $60\ M_{\odot}$ and an orbital period of 0.6 yr, then we can determine the circular orbit of the companions that have a separation of components of about 1.5 au.

Such a CMSS will emit GWs and giant water maser flares may be indicators of massive stars being in the CMSS phase.

The radiated power of GWs will be:

$$\frac{dE}{dt} = \frac{32G^4M_1^2M_2^2(M_1+M_2)[1+(73/24)e^2+(37/96)e^4]}{5c^5a^5(1-e^2)^{7/2}} \quad (1)$$

where M_1 and M_2 are the masses of the companions, e is the eccentricity of the orbit, c is the speed of light and a is the semimajor axis of the orbit.

The flux density of GWs on the Earth's surface (R_{W49N} = 11 kpc) is

$$S^{\mathrm{Earth}}_{\mathrm{W49N}} = \frac{(\mathrm{d}E/\mathrm{d}t)(\mathrm{W49N})}{4\pi R^2_{\mathrm{W49N}}} \approx 1.1 \times 10^{-15}\ \mathrm{erg\,s^{-1}\,cm^{-2}}$$

For comparison, the power of GWs emitted by the most promising GW source, the supermassive black hole OJ287, calculated by equation (1) with e = 0, is the value $dE/dt_{(OJ287)} \approx 3.6\times10^{47}$ erg/s at the accepted values of the system parameters.

The flux of GWs on the Earth's surface from the OJ 287 source will be $S^{Earth}_{OJ287} \approx 7.2 \times 10^{-10}$ erg/s cm^2.

When stars merge, the energy of the gravitational interaction is released: $E_{merge} \approx 3.8 \times 10^{50}$ erg.

The registration of GWs from sources for long periods of time ranging below nanohertz to a few tens of microhertz is more preferable for International Pulsar Timing Array (IPTA) detectors.

Ref.: Volvach et. al., MNRAS 496, L147–L151 (2020).
Volvach et. al., A&A 648, A27 (2021).