

### The Binary Pulsar PSR 1913+16

J. H. Taylor and R. A. Hulse of the University of Massachusetts have detected a new radio pulsar which is a member of a binary system (*IAU Circular* 2704). The position coordinates of the pulsar are:  $\alpha(1950.0) = 19^{\text{h}}13^{\text{m}}13^{\text{s}} \pm 24^{\text{s}}$ ;  $\delta(1950.0) = +16^{\circ}00' \pm 24''$ . The dispersion measure and the average flux have been estimated to be  $167 \pm 5 \text{ pc cm}^{-3}$  and  $5 \times 10^{-29} \text{ W m}^{-2} \text{ Hz}^{-1}$  respectively. The apparent period of the pulsar varies between 58.967ms and 59.045ms depending on the component of velocity of the pulsar along the line of sight of the observer. Taylor and Hulse have used their measurements of the variation of the apparent period of the pulsar with time to compute the following parameters of the binary system; period of the orbit,  $27907 \pm 30^{\text{s}}$  (0.3230 day); radial velocity semi-amplitude, 198  $\text{km sec}^{-1}$ ; eccentricity of the orbit, 0.61; projected semi-major axis, 690,000 km and mass function,  $0.13 M_{\odot}$ .

For the above object, P. Margon, A. Davidson, K. Mason and P. Sanford have put an upper limit of  $10^{-10} \text{ ergs sec}^{-1}$  on the pulsating X-ray flux between  $1 \text{ \AA} - 3 \text{ \AA}$  (*IAU Circular* 2712). W. Liller (*IAU Circular* 2714) has examined the plates of the region taken between 1891 and 1963 and does not find evidence of any kind of variable object brighter than 11th magnitude.

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Seven years have elapsed since the discovery of the first pulsar. More than 150 pulsars have been discovered during that period. However, it is a curious fact that none of the pulsars is a member of a binary system. Several theories have been proposed to explain this fact. One of these is that, if the progenitor of a pulsar is originally a member of a binary system, the explosion will always disrupt the system. However, this does not seem to be the commonest case since the exploding star in a close binary system is usually the less massive component, as a consequence of the mass transfer preceding the explosion; in this case, the explosion is generally incapable of disrupting the system. Shvartsman (*Sov. Astr.*, **15**, 342, 1971) suggested that a neutron star in a binary system can appear as a pulsar only for a comparatively short time. Stellar wind from the companion will suppress the ejection of material from the neutron star so that the neutron star will cease to be a pulsar and become an X-ray source. Another theory has recently been proposed by Bisnovatyi-Kogan and Komberg (*Sov. Astr.*, **18**, 217, 1974). They suggest that the magnetic field of a neutron star in a binary system will decay due to the mass transfer from the primary. They give evidence that the magnetic field of the neutron stars in the X-ray binaries is at most two orders of magnitude less than in pulsars.

It is indeed very interesting that at the very moment when a lot of attention is being given to X-ray binaries, i.e., binaries with compact component, the first binary pulsar (PSR 1913+163) is discovered.

Flannery and van den Heuvel (preprint) have proposed two evolutionary scenarios for this system. In the first scenario, it is suggested that the exploded star is a white dwarf which is a member of a cataclysmic variable type binary with mass very near to the Chandrasekhar limit. As is well known, the period of such binary systems is usually only of the order of a few hours. Mass transfer from the companion will push the white dwarf above the Chandrasekhar limit and thus an explosion is expected. This is the mechanism suggested by Whelan and Iben (*Ap. J.*, **186**, 1007, 1973) for Type I supernova. The explosion should be asymmetric in order to explain the very short binary period of the resulting binary pulsar. In this scenario, the companion of the pulsar is thus expected to be a low mass main-sequence star ( $> 1 M_{\odot}$ ). The apsidal

motion of the system is predicted to have a period of a few months. In the second scenario, the authors point out that, as suggested by van den Heuvel and De Loore (*Astr. & Ap.*, **25**, 387, 1973), massive X-ray binaries like Cen X-3 and Cyg X-1 may evolve into very short period binary systems as a consequence of the mass transfer from the primary. At the end of the mass transfer, the system consists of a helium star (originally the helium core of the primary) and a compact object. Systems like Cyg X-3 (X-ray binary with period of a few hours) might be a result of such an evolution. The helium star will eventually explode as a Type II supernova and leave behind a neutron star as a remnant. PSR 1913+16 is proposed to be a result of such an evolution. The system will then consist of a young neutron star (the pulsar) and an old compact object (either a black hole or a neutron star). Since in this case the amount of mass ejected by the explosion is most likely larger than one half of the total mass, it is required that the explosion should be highly asymmetric, i.e. the exploded star acquires a kick velocity in a favourable direction due to some internal forces, in order to maintain the system in a close orbit. The fact that binary pulsar is very rare implies that the kick velocity is in general large to maintain the system remaining bound.

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### Is the Gravitational Constant, G, Changing with Time?

Recent analysis of astronomical data by P. M. Muller (from Jet Propulsion Laboratory, Pasadena California and School of Physics, The University, Newcastle upon Tyne, U.K.) answers the above question in the affirmative. Muller obtains the following value for  $\dot{G}/G$ :

$$\dot{G}/G = -4.5 \pm 2 \times 10^{-11} \text{ year}^{-1}.$$

Thus G is very slowly decreasing with time.