EFFECT OF INSTANTANEOUS MASS EJECTION ON ORBITAL ELEMENTS OF CIRCULAR BINARIES

R. MITALAS

Dept. of Astronomy, University of Western Ontario, London, Canada

Abstract. All attempts to fit the binary pulsar PSR 1913 + 16 into an evolutionary scenario consider the effect of an instantaneous mass ejection on the orbital elements of a circular binary.

In an explosion which does not affect the companion and does not change the linear velocity of the remnant, the original mass ratio of the binary is related to the final mass ratio by

$$\frac{m_1}{m_2} = \left(\frac{qm_1}{m_2}\right)(1 + e) + e,$$

where qm_1 is the mass remaining after the explosion of m_1, m_2 is the mass of the companion, and e is the final eccentricity. There is an upper limit to the value of q, and a minimum to the fraction of mass carried away by the explosion,

$$q_{\max} = \frac{1}{1 + e}; \qquad f_{\min} = \frac{e}{1 + e}.$$

The total mass, period, semi-major axis and mass function of the original circular binary are simply related to the total mass, period, semi-major axis and mass function of the present binary. From the mass limits of pulsars, bounds can be set on the original mass of the exploding star,

$$M_p (1 + e) < m_1 < M_p \frac{(1 + e)}{(1 - e)}$$

where M_p is the pulsar mass, and the right side inequality is valid only if the primary explodes. A lower limit on the original mass ratio is set, $(m_1/m_2) \geqslant e$.

An asymmetric, instantaneous explosion where both the mass and velocity of each component of the binary are altered also has an analytic solution. If the radial velocity increments of the remnants $q_1 m_1$ and $q_2 m_2$ due to the explosion are $f_1 v$ and $f_2 v$ where v is the relative velocity, and $f_3 v$ is the velocity increment of the exploding star m_1 in the direction opposite to its orbital velocity, then the total masses before and after the explosion are related by

$$(m_1 + m_2) = (q_1 m_1 + q_2 m_2)\left[\frac{1 \pm e\sqrt{R}}{D}\right]$$

where $R = 1 - \dfrac{1 - e^2}{e^2} \dfrac{(f_1 + f_2)^2}{(1 - f_3)^2}$ and $D = (f_1 + f_2)^2 + (1 - f_3)^2$.

The permitted values of $(f_1 + f_2)$, f_3 are limited, since R must be positive. For applications to the binary pulsar, limitation to $(q_1 m_1 + q_2 m_2)/(m_1 + m_2) \leqslant 1$ limits the allowed values of parameters further.

P. Eggleton et al. (eds.), Structure and Evolution of Close Binary Systems, 81–82.

https://doi.org/10.1017/S0074180900011876 Published online by Cambridge University Press

The period, semi-major axis and mass function of the original circular binary are simply related to the period, semi-major axis and mass function of the present binary. It is noteworthy that the ratio of the semi-major axes is independent of f_3 when $(f_1 + f_2) = 0$. The maximum increase of the ratio of semi-major axes is $1/(1-e)$. A full account will appear in a forthcoming publication.

Note Added in Proof. It has been pointed out to the author by Dr E. H. Geyer that the first equation is the same as the one found in Borsche, D.: 1962, *Z. Astrophys.* **56**, 181.