Bull. Astr. Soc. India (2000) **28**, 275-276

Radio emission from Cyg X-3

Krishna M. V. Apparao

Department of physics, University of Mumbai, India

Abstract. The acceleration of high energy particles by a shock produced by the passage of the secondary object in the binary system, through the wind of the primary, is considered and is shown to be adequate to account for the quiescent radio emission from Cyg X-3. A mechanism for inducing large radio flares is outlined.

1. Introduction

The x-ray source Cyg X-3 is a binary system with a wolf-rayet star (5 $M_\odot$) primary and a Black hole (7 $M_\odot$) secondary (Schmutz et al., 1996); the binary period is 4.8 hrs. The system emits radio radiation at a quiescent level (0.1) Jy and also has flares (1 to 20 Jy; Waltman et al., 1995). Based on the nature of the radio spectrum, Seaquist and Gregory (1977), suggested that the radio radiation is due to synchrotron emission from high energy electrons immersed in the stellar wind. A reservoir of high energy electrons exists, which is supplied with energy at a rate $E_T = 6 \times 10^{34}$ ergs s^{-1}. We give below the process which supplies the electrons.

2. Quiescent radio emission

The velocity of the blackhole in its orbital motion is 7.4×10^7 cm s^{-1} and it moves through the wind of the Wolf-Rayet star. This velocity is supersonic and a shock is formed. High energy particles are accelerated at the shock and the rate at which they are produced is given by (zdizrsky 1986) :

$$E_r = \rho_s \, 2\pi \, r_s \, v_s^3 \eta \qquad \text{ergs s}^{-1}$$

where ρ_s is the density at the shock, v_s is the velocity of the shock and r_s is its radius. η is the efficiency of acceleration which is taken as ~1 (Zdiarsky 1986). The particles accelerated are helium nuclei which are the main constituent of the Wolf-Rayet wind. The mass loss of the Wolf-Rayet star is taken as 4×10^{-5} $M_\odot$ Yr^{-1}, and use of the binary parameters gives $\rho_s = 4 \times 10^{11}$ gm cm^{-3}, $r_s = 1.1 \times 10^{11}$ cm, $v_s = 1.24 \times 10^8$ cm s^{-1}. Using these values the rate of injection $E_i = 2.4 \times 10^{36}$ ergs s^{-1}.

The high energy helium nuclei interact with the ambient gas and produce high energy electrons by nuclear interactions. The fraction of energy transferred to the high energy electrons is ~ 0.15, and the mean free path for nuclear interaction of helium nuclei, using expressions given by Stephens(1997), is 32 gm cm^{-2}. The amount of matter traversed by the high energy helium nuclei is ~8 gm cm^{-2}, giving the injection energy for the high energy electrons to be $E_i(e) = 5 \times 10^{34}$ ergs s^{-1}. This is adequate to account for the injection energy required as given by Seaquist and Gregory (1977). Thus the quiescent radio emission from Cyg X-3 can be accounted for by the high energy electrons obtained from the high energy particles acccelerated by the shock produced by the secondary object in its orbital motion through the wind of the primary.

3. Flare emission

The flare emission in Cyg X-3 occurs by a sudden acceleration of high energy particles due to a sudden large accretion of matter onto the black hole. The size of the Wolf-Rayet star of the mass given is such that it just fits its Roche lobe. Thus normally the surface of the star could be just below the Roche lobe. Due to the large mass loss from the Wolf-Rayet star, the orbit of the binary shrinks and consequently the size of the Roche lobe also shrinks. Thus the Roche lobe "eats" into the surface of the star, creating an equilibrium surface. A Raleigh-Taylor instability at the equilibrium surface may occur, resulting in a sudden mass transfer onto the black hole. This sudden accretion onto the black hole results, in analogy with the picture suggested in the case of radio galaxies, in the creation of jets of high energy particles. Continuing the analogy with the radio galaxies, the high energy particles lead to the observed flare emission. The quantitative aspects of this picture of flare emission will be given elsewhere.

References

Schmutz W., Gabelle T. R., Schild H., 1996, A&A, 311, L25.

Seaquist R., Gregory C., 1977, Ap. Lett., 18, 65.

Stephens S. A., 1977, Astr. Part. Phys., 6, 29.

Zdiarsky A. A., 1986, ApJ., 305, 45.