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Shocks in binary systems with high density winds or envelopes

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Several Binary Systems with Wolf-Rayet stars (WR) or Be stars exist. The WR stars give out strong winds and the Be stars have dense gas envelopes. In close binaries the companion star passes through the gas at supersonic speeds, resulting in a shock. The post-shock gas has a high temperature and gives out radiation. Also the shock accelerates high energy particles which in turn lead to radiation. We apply these considerations to Cyg X–3, a binary with a WR star and LSI +61° 303 which has a Be star.

Cyg X–3

Cyg X–3 is a binary system with a WR star and a companion which is a Black Hole (BH). The binary period is 4.8 hrs. The infrared radiation observed from Cyg X–3 is modulated with the binary period. The modulated K-band flux is F_k^m=1.7 (+/–0.04)×10^{21} ergs s^{-1} Hz^{-1}. In addition flares with a maximum increase by a factor of 20 and duration of a few hundred seconds are observed. Using the masses of the stars M_1=5M and M_2=7M, the velocity of BH is 7.4×10^7 cm s^{-1}. The velocity of the wind is about 1000 km s^{-1}, giving a relative velocity v_r=1.2×10^8 cm s^{-1}. The mass loss of WR star is M=4×10^{-5}M Yr^{-1}, giving a number density n_0=7×10^{21} cm^{-3} at the BH. The post shock temperature is calculated to be T_S=4.7×10^7 °K. The post-shock structure is given by Hollenbach and Mckee (1979). Using this and the above values for the parameters, the K-band flux from the post-shock gas is calculated as F_k=2.2×10^{21} ° ergs $s^{-1}Hz^{-1}$, which agrees with the modulated flux. The shock is transparent (Apparao, 1997) for infrared radiation as seen from the front due to the high temperature. It is opaque as seen from the back due to the denser gas and lower temperature. Thus the radiation is observed as the BH in its binary motion, moves towards the observer and is blocked as the BH recedes, leading to the observed modulation. The wind from the WR has clumps with density enhancements upto a factor of six. The shock encountering these clumps are shown (Apparao, 1997) to give the observed infrared flares.

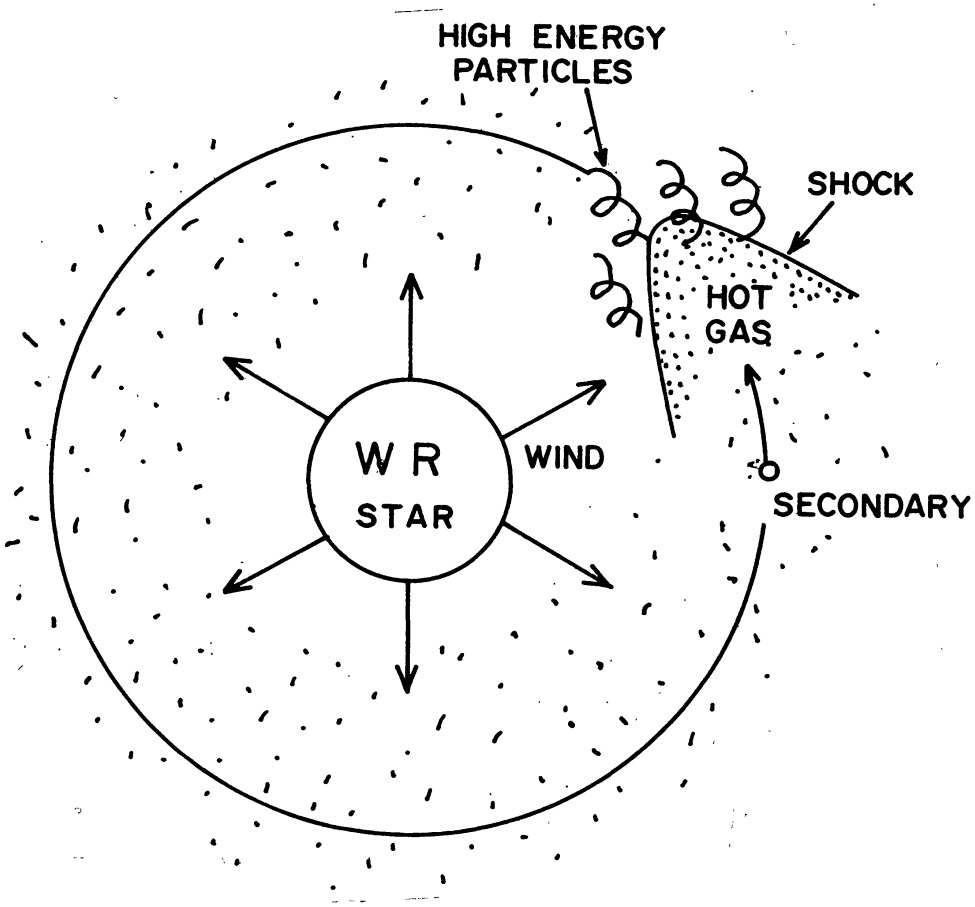

Figure 1. The Cyg X–3 binary system consists of a Wolf-Rayet star and a Black hole as the secondary. The secondary passes through the dense wind of the WR star at supersonic speed and produces a shock. The post shock attains a high temperature, which gives out radiation. The shock also gives high energy particles. See text for applications.

LSI +61° 303

This object is an X-ray emitting binary system with a period of 26.5 days consisting a Be star and a neutron star. The orbit has an eccentricity and the neutron star passes though the Be star gas envelope at periastron. The infrared emission from this object shows modulation with the binary period, the maximum emission occurring at about a phase of 0.8. The K-band flux corresponding to the modulation is $2.6(+/-0.1) \times 10^{21}$ ergs s^{-1} Hz^{-1}. Calculations similar to that of Cyg X–3 above, gives a K-band flux of 3.5 10^{21} ergs s^{-1} Hz^{-1} which explains the observations. The modulation occurs as in the case of Cyg X–3, due to the transparency of the shock to infrared radiation as seen from the front and opaqueness as seen from the back. The infrared maximum occurs at the descending node of the secondary as observed.

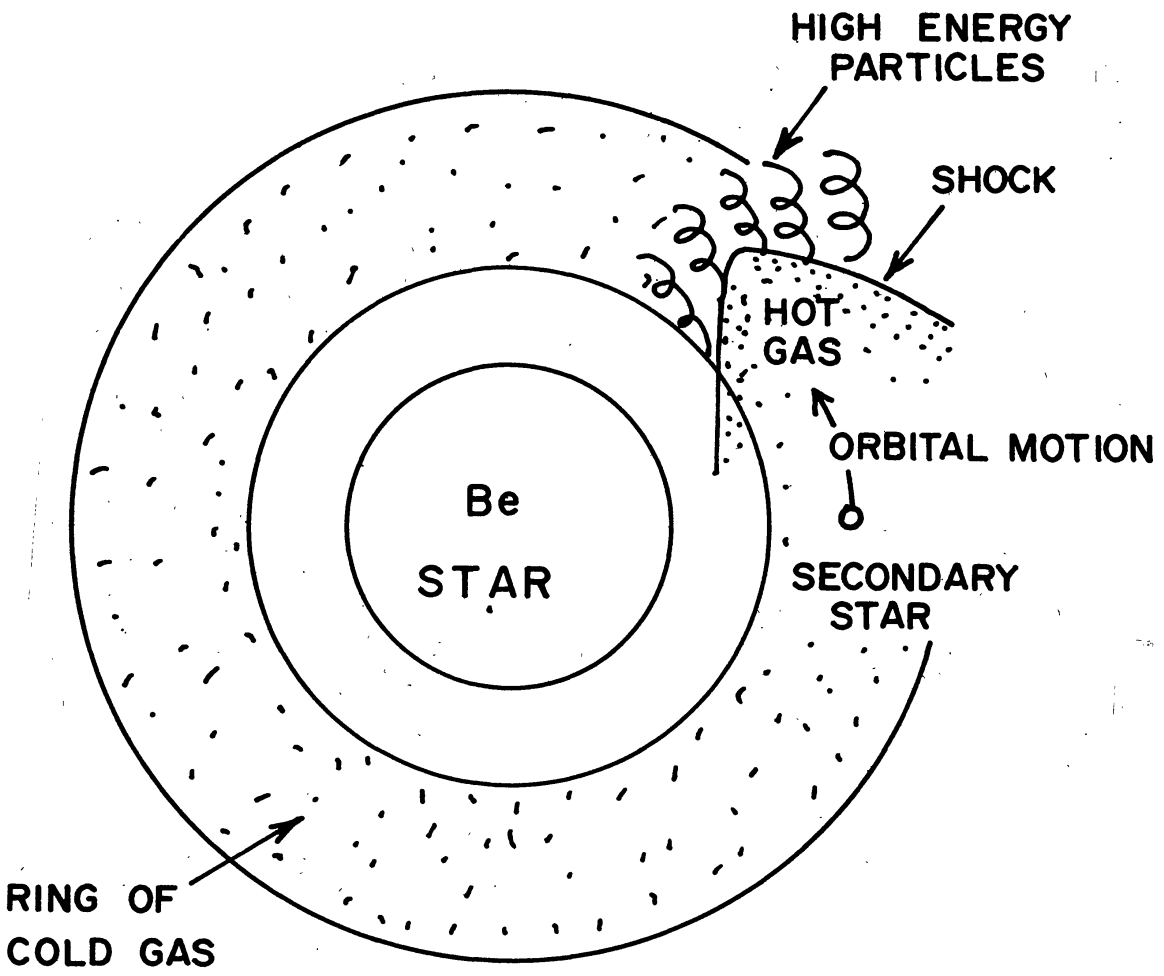

Figure 2. The binary system LSI +61°303 contains a Be star and a neutron star. The binary motion of the neutron star through the gas envelope of the Be star produces a shock. The post shock gas is hot and gives radiation. Also the shock accelerates relativistic particles. See text for applications.

Radio Radiation

The acceleration of high energy particles by the shock and the radiation from them for Cyg X–3 and LSI +61° 303 have been calculated and presented elsewhere.

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