JETS FROM SYMBIOTIC STARS

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ABSTRACT. R Aquarii is the closest symbiotic variable that shows extended emission with multiple jet components. A number of other symbiotics also show jet activity and this phenomenon may be common, particularly among D-type symbiotics.

R Aquarii may be the prototype of jet activity in symbiotic stars. Extended UV, radio, optical and X-ray observations are described in Kafatos, Michalitsianos and Hollis (1986) and Cassatella et. al. (1987). The emission from the jet of R Aqr is variable and the high excitation lines such as He II, N V and C IV have been increasing in intensity in the recent past, surpassing the emission of those lines from the compact H II region surrounding the binary star system. The jet is also a weak X-ray emitter (Cassatella et al. 1987) and it may well be that both X-ray and UV line emission of the jet components comes from component A and possibly B (Kafatos, Michalitsianos and Hollis 1986). The nature of the alligned radio-optical features that comprise the R Aqr jet indicates that directional mass outflow is taking place. The most likely mechanism of ejection is radiation pressure on grains formed in the outer, cool regions of a spatially thick accretion disk that forms around the hot secondary star. The inner regions of this disk are hot, with $T \gtrsim 10^5$ K and emit high energy radiation. The plane of the orbit of the two stars is, however, along the line of sight and the cone of radiation that escapes from the disk cannot be seen directly but goes out perpendicular to the disk and ionizes the gas parcels which form the jet components. This model explains the predominance of high excitation lines in the jet, the secular increase of UV line emission, the semi-periodic variability of the UV line emission from the jet and is consistent with the large amount of dust being present in R Aqr and maybe even with the eclipses of R Aqr itself by a cooler object in the late 70's. R Aqr is a D-type symbiotic (dust-type) in contrast to the

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S-type (stellar-type) which show strong, hot star, stellar continuum. Recent observations of R Aqr with the Hat Creek interferometer (Hollis et al. 1986) indicate that the jet also emits in SiO masing line, v = 1, J = 2 - 1. This emission does not arise in the Mira primary but must come from an extended region south of the binary, most likely a cool jet component. Finally, optical observations of R Aqr resulting in slit spectra (Solf and Ulrich 1985) indicate that the expansion velocities of the gas components in the R Aqr nebula are low, $\sim$ 50 km s^{-1}, consistent with ejection from low escape velocity regions.

Other symbiotic stars show jet emission or extended nebular emission such as: CH Cyg (Taylor, Seaquist and Mattei 1986); AG Peg (Hjellming 1985). Extended emission has been detected from V1016 Cyg (Hjellming and Bignell 1982); RX Pup (Hollis et al. 1987). CH Cyg and AG Peg are S-type symbiotics whereas V1016 Cyg and RX Pup are D-type symbiotics. CH Cyg is the only symbiotic where high velocity ejection ($\gtrsim$ 1000 km s^{-1}) is present, although this interpretation depends on a somewhat controversial identification of distinct jet features. The sizes of these jets or extended emissions are all about a few x 10^{15} cm, the largest one being the size of the jet structure in R Aqr where a distance of the outermost component B from the central source is 10^{16} cm. Luminosities seem to be well below the Eddington limit for all symbiotics where jet or extended emission has been detected and mass outflow rates are generally around 10^{-7} $M_\odot$ yr^{-1}. These results are in agreement with the results for R Aqr indicating that dust may be responsible for the ejection mechanism in most symbiotics. Further studies of symbiotic jets would provide important clues for the important topic of astrophysical jets.

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