INTERACTING STELLAR WINDS IN A BINARY SYSTEM

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It is now known that strong stellar winds develop in stars mostly at the red and blue sides of the HR diagram. However, although the mass loss rates observed in O and M stars are comparable, the corresponding wind velocities are vastly different. It would thus be of great interest to find a binary system, containing both a cool and a hot star each with its own wind, and observe the resultant interaction. For a long time, α Sco (M1.5 Iab + B2.5 V) was the only known example (Kudritzki and Reimers 1978, van der Hucht *et al.* 1980). The situation in this case is best illustrated by a VLA map made by Gibson (1979) who finds that a shock develops at the surface of interaction of the two winds. In this paper I shall describe another binary system in which two stellar winds are interacting with dramatic effects.

HM Sge is a new emission-line star unique in many aspects. It brightened by 6 visual magnitudes in 1976 (Dokuchaeva 1976) and has remained in maximum light since (Ciatti *et al.* 1978). After the brightening, an emission line spectrum emerged, suggesting the presence of a circumstellar nebula. Ultraviolet observations of HM Sge show that it has an extremely rich UV emission line spectrum (Bogges *et al.* 1980). Infrared observations by Davidson *et al.* 1978) found the object to be heavily reddened with most of the energy emitted in the infrared. The 9.7μm silicate feature was also detected, characteristic of a mass-losing M star. The 2.3μm CO absorption feature was

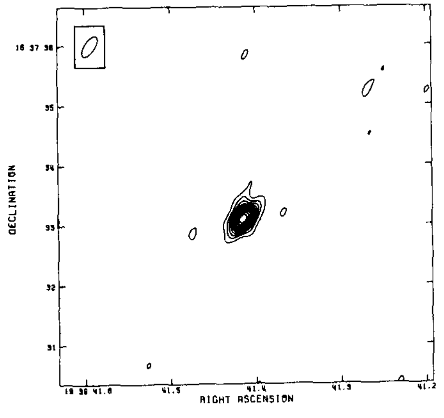

Fig. 1 λ2cm VLA map of HM Sge

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found by Puetter *et al.* (1978) providing evidence for the actual presence of an M giant. Several velocity components (from 35-1700 km s^{-1}) have been found in the optical spectrum, indicating a complex system (Wallerstein 1979).

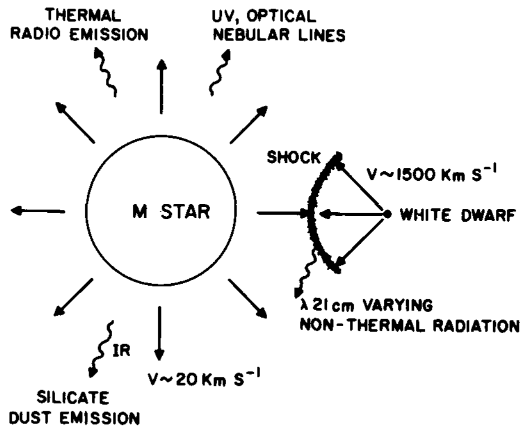

Fig. 2 A schematic model of HM Sge

Strong thermal radio continuum radiation is emitted by HM Sge (Feldman 1977, Purton *et al.* 1980), presumably arising from the circumstellar nebula. VLA observations by Purton, Kwok and Feldman (1980) show that the nebula is resolved at λ2cm with an angular size of 0.2" (see figure 1). Assuming a distance of 1 kpc, this corresponds to a physical size of 3×10^{15}cm. The radio spectrum is optically thick up to $\nu = 15$ GHz, with a spectral index of $\sim$+1. λ21cm continuum observations by Spoelstra, Matthews and Kwok (1980) found erratic variability on a time scale of at least as short as a few hours, suggesting that the emission mechanism at this wavelength is non-thermal. Such rapid "flickering" implies that the emission cannot arise from the same emission region as the thermal radio source, but is caused by a more energetic phenomenon confined to a smaller region.

The optical outburst of HM Sge in 1976 has been suggested by Paczyński and Rudak (1980) to be the result of the onset on nuclear burning on the surface of an unseen while dwarf companion accreting mass from the red giant primary. In fact, the accretion is not necessarily via a Roche lobe: the compact companion can simply be accreting mass from the M-giant wind. The large quantity of UV photons released from the nuclear burning will lead to the ionization of the M-giant circumstellar envelope, emission of optical and UV nebular lines and thermal radio emission. Since nuclear burning can easily raise the white dwarf luminosity above the Eddington limit, part of the hydrogen atmosphere will be ejected by radiation pressure in the form of a high-speed wind. This could give rise to the $v = 1500$ km s^{-1} Wolf-Rayet feature observed in the optical spectrum. The collision of this fast wind with the M-giant wind will inevitably produce a shock, accompanied by the acceleration of particles and synchrotron radiation (see figure 2).

The above model is similar to that of a classical nova and the similarity is further strenghtened by the recently observed continued brightening of the thermal radio component (Purton, Kwok and Feldman 1980). Figure 3 shows the spectra of HM Sge in 1977 and 1980. The observed flux densities have increased approximately twofold while the spectral shape is not significantly changed. It is known that in a classical nova, the radio flux density can continue to rise long after the nova has passed its visual maximum (Hjellming *et al.* 1979). In HM Sge, there has been no optical decline and the radio brightening occurs on a much longer time scale (years instead of months). The radio brightening is probably due to a significant input of mass from the fast wind.

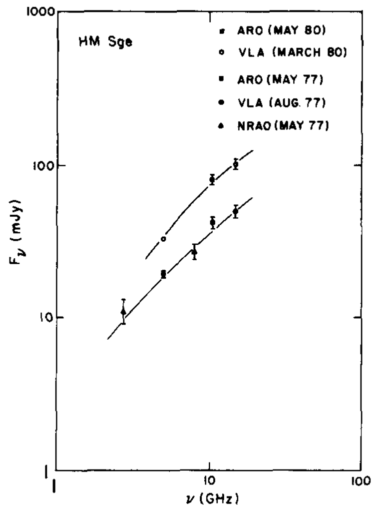

Fig. 3 Radio spectrum of HM Sge

If HM Sge can be considered as an example of a slow nova, then the analysis above suggests that slow novae may be intermediate objects between symbiotic stars and novae. Most symbiotic stars do not have radio emission, implying that the circumstellar nebula is small and a strong stellar wind is absent. On the other hand, classical novae probably have small binary separations to allow direct accretion and the fast wind is the major contributor to the envelope mass. The presence of a stellar wind from the M giant component of a slow nova system permits limited accretion by the compact companion, which results in optical outbursts similar, but not identical to, that of novae. Further work on these three classes of objects is needed to clarify their inter-relationships.

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DISCUSSION

WILLSON: The observations and the picture you sketch resemble the system V 1016 Cyg as well. Do you know of any comparable radio observations of V 1016 Cyg?

KWOK: There exists many similarities between V 1016 Cyg and HM Sge in the optical, infrared, radio parts of the spectrum, as well as in the optical history. However, radio data go back several years do not show any significant increase in the flux from the termal free-free emission. It is possible that there was a radio brightening soon after the visual brightening, but no radio data existed at that time.

NUSSBAUMER: It is true that it a first glance HM Sge. and V 1016 Cyg have about the same spectrum. A closer look however reveals not only quantitative but also qualitative differences. Thus a model which may be appropriate for HM Sge is not necessarily the right one for V 1016 Cyg.

RUMPL: In your model, is the shock hot enough to emit X-rays, and if so, have they been observed for HM Sge?

KWOK: Since the wind from the white dwarf seems to be quite energetic, it is reasonable to expect X-ray emission. We have attempted to obtain observing time on the HEAO-B satellite. It is possible that there are proposals from other groups as well.

VIOTTI: Regarding the X-ray observation of Symbiotic Stars in a recent letter C.M. Anderson wrote to Fredjung and me:" Joe Cassinelli and I have received Einstein Observatory IPC data of several symbiotics with some startling results, i.e. nothing of what we expected, on the basis of optical spectrum, were sure things; viceversa we observed strong X-rays from what was thought to be a poor candidate.

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