INFRARED OBSERVATIONS OF HDE 226868/CYG X-1 AND HDE 245770/A0535+26

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ABSTRACT: We know from Copernicus ultraviolet observations that all O-type stars are losing mass by stellar wind. The ionized expanding circumstellar envelope formed by the stellar wind is emitting through free-free and bound-free radiation processes. This radiation is detectable at the infrared wavelengths where the stellar continuum is negligible. The measurement of the IR excess (defined as the difference between the total flux and the stellar continuum at a given wavelength) and the knowledge of the terminal velocity of the envelope, allow us to derive for OB stars the mass loss rate. From the analysis of our IR observations of two O stars, HDE 226868 and HDE 245770, identified as optical counterpart of X-ray sources, we give an estimate of their mass loss rate. The IR observations were carried out with the Jungfraujoch 76 cm telescope using a GE bolometer with a focal plane chopping system and with the Merate 132 cm telescope using an InSb detector.

HDE 226868/CYG X-1

The O9.7IIab star HDE 226868 is known to be the optical counterpart of the X-ray source 3U 1956+35. Our IR observations in the J,H,K,L and M bands were obtained in May 1976 and September 1976. During these periods no significant variations were observed.

Figure 1 displays the unreddened optical-infrared energy distribution of HDE 226868. We used a colour excess $E_{B-V} = 1.08$. The adopted U, B and V magnitudes are mean values obtained by Bregman et al. (1973) and Liutyi et al. (1975).

We compared the observed spectral points with a blackbody distribution at the same effective temperature of an O9.7 supergiant star (T_{eff} = 32,000°K). Looking at the figure, we see that J,H,K and L fluxes lie on the blackbody curve, while the magnitude corresponding to 5μ (M-band), is 4σ above the stellar continuum. This evidence of an IR excess at 5μ is in agreement with a mass loss rate greater than 10^{-6} $M_{\odot}$ y^{-1}. The decrease of the statistical error at 5μ, and the IR observations at

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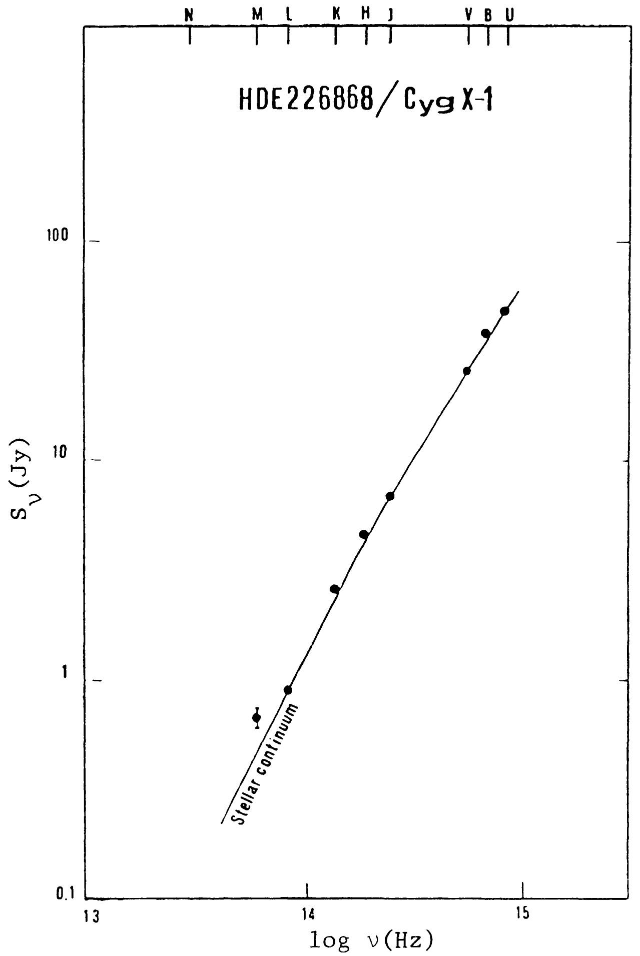

Figure 1. The optical and near IR energy distribution of HDE 226868.

longer wavelengths (10μ) would allow us to derive a better value of $\dot{M}$ for HDE 226868.

HDE 245770/A0535+36

This star, recently classified by Giangrande et al. (1977) as O9.7IIe, has been suggested as the possible optical counterpart of the transient X-ray source A0535+26. A model proposed by Rappaport et al. (1976) consists in a long-period orbit neutron star (>17^d) around the OBe star with a variable stellar wind. The presence of a stellar wind is suggested by the broadening of the Hα emission line (~300 km s^{-1}) observed by Soderblom (1976).

In order to derive the mass loss rate from HDE 245770, observations were carried out in the J,H,K and L photometric bands on Nov.-Dec. 1976

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and March 1977. In the same period the star was observed in U,B,V by Giangrande et al. (1978). No variations were found in optical and IR wavelengths.

Figure 2 shows the unreddened ($E_{B-V} = 0.80$) energy distribution for HDE 245770. By comparison we also show (crosses in figure) the narrow-band spectrophotometric observations of Wade and Oke (1977). The stellar continuum is represented by a blackbody with an effective temperature of 32,000°K. The IR excess (filled squares) shows a distribution of the type $S_\nu \propto \nu^\alpha$ with a spectral index $\alpha \sim 0.6$ which is consistent with a thermal free-free + bound-free emission from a circumstellar envelope with an electron density $n_e \propto r^{-2}$. Taking as a model an expanding

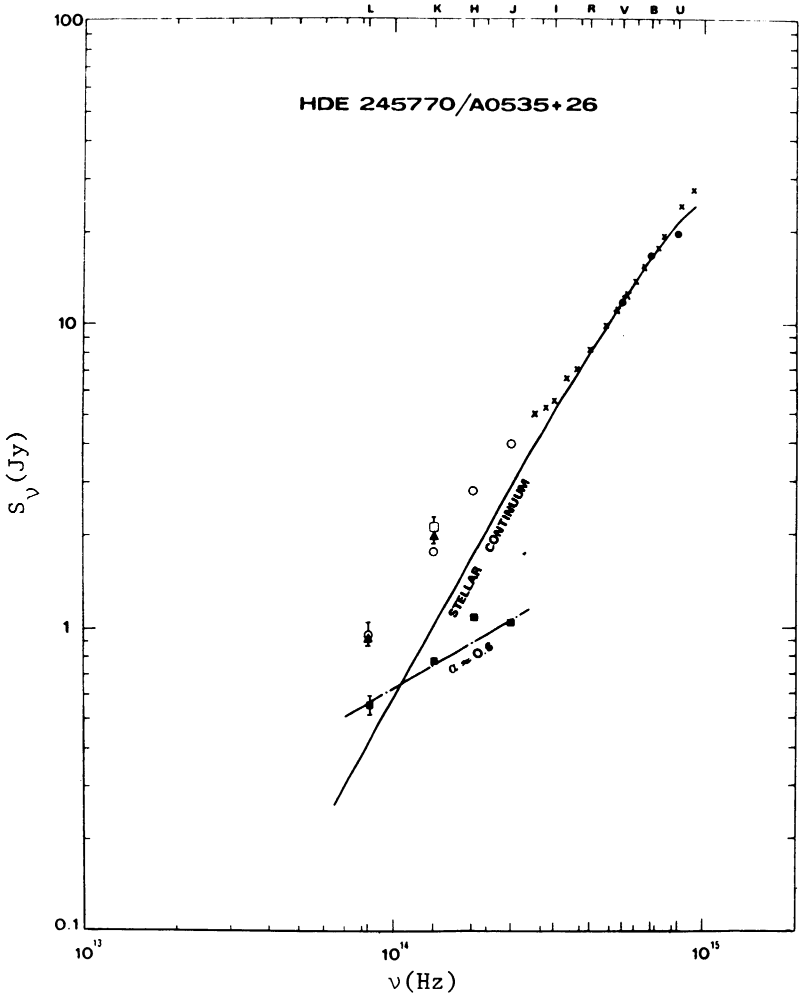

Figure 2. The optical and near IR energy distribution of HDE 245770; o: JHKL observations on 1976 Dec. 11, 13; □: K observations on 1976 Nov. 16; ▲: KL observations on 1977 March 16.

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spherical envelope with a constant velocity described by Wright and Barlow (1975) and Panagia and Felli (1975), we can estimate the value of $\dot{M}$ from the observed IR excess.

Adopting for HDE 245770 a distance D ~ 1.8 kpc, an envelope temperature $T_e = 20{,}000°K$, and the measured IR excess at 3.6μ $S_\nu = 0.56 \pm 0.04$ Jy, we obtain a ratio $\dot{M}/v_{exp} \cong 1.7 \times 10^{-8}\ M_\odot\ y^{-1}/km\ s^{-1}$. For a $v_{exp} \cong 300\ km\ s^{-1}$ we derive for the mass loss $\dot{M} \cong 5 \times 10^{-6}\ M_\odot\ y^{-1}$. This value of $\dot{M}$ could be overestimated because of the breakdown of the simple uniform-flow model.

Finally, from the evolutionary tracks computed by Chiosi et al. (1978) for a massive star with mass loss, we derive the mass of HDE 245770. Adopting a luminosity of $L^* = 2.9 \times 10^5\ L_\odot$ and the above mass loss rate we obtain M ~ 35-40 $M_\odot$.

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DISCUSSION FOLLOWING PERSI et al.

Cowley: Because A0535+26 is a transient X-ray source, it would be especially interesting to redetermine the mass loss rate from the IR data at a time when the X-rays are strong, as it may be an indication of an enhanced mass flow.

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