INFRARED OBSERVATIONS AND MASS LOSS OF THE BINARY SYSTEM V861 SCO

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1. INTRODUCTION

V 861 Sco (HD 152667) is a well known single line binary[1,2]. The proposed association with a variable X-ray source[3,4] has triggered renewed interest in the system. Recent optical, infrared and ultraviolet observations[5 - 12] have provided a better knowledge of its characteristics. A first estimate of the mass loss was given by Hutchings[13].

Here we report on a series of photometric observations in the infrared (from 1.25 to 4.8 μ) taken at various orbital phases which improve and extend previous measurements by Tanzi et al.[12]

The results give evidence of a phase modulated infrared excess which can be interpreted in terms of a non isotropic mass flow in the system or, alternately, of a contribution from a colder secondary component.

2. OBSERVATIONS

Observations of V 861 Sco in the infrared filters J (λ_{eff} = 1.25 μ), H (λ_{eff}= 1.65 μ), K (λ_{eff}= 2.2 μ), L (λ_{eff}= 3.6 μ) and M (λ_{eff}= 4.8 μ) have been made in February and June 1979 with a InSb photometer[16] attached to the 1 m telescope of the European Southern Observatory, La Silla, Chile.

Reduction to magnitudes in the ESO infrared photometric system[17] has been performed by means of several observations of reference stars during each night. Correction for atmosheric extinction has been obtained by means of mean extinction coefficients (Wamsteker, private communication). Small deviations from the adopted values have been occasionally observed and have been treated as fluctuations and combined quadratically with the statistical uncertainties of the measurements.

The measurements are in good agreement with those by Tanzi et al.[12] taking into account the transformation between the two different photometric systems used[17]. The infrared data presented here confirm a modulation with orbital phase similar to the optical with two maxima of unequal depth. However the depth of the minima in the infrared is larger than in the optical and varies with wavelength.

The observed infrared colours, averaged over measurements taken at nearly equal phase, are given in Table 1. A phase modulation

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TABLE 1. *Infrared observations of V 861 Sco*

PHASE	J	J - H	J - K	J - L	J - M
0.00	5.57 ± .02	.09 ± .03	.16 ± .03	.35 ± .03	.35 ± .03
0.14	5.42 ± .03	.14 ± .04	.21 ± .04	.36 ± .04	.40 ± .04
0.50	5.81 ± .02	.13 ± .03	.28 ± .03	.41 ± .04	.48 ± .05
0.63	5.51 ± .02	.12 ± .03	.19 ± .03	.40 ± .03	.42 ± .03
0.75	5.43 ± .02	.10 ± .03	.20 ± .03	.42 ± .03	.50 ± .03
0.87	5.51 ± .02	.10 ± .03	.21 ± .03	.37 ± .03	.46 ± .03

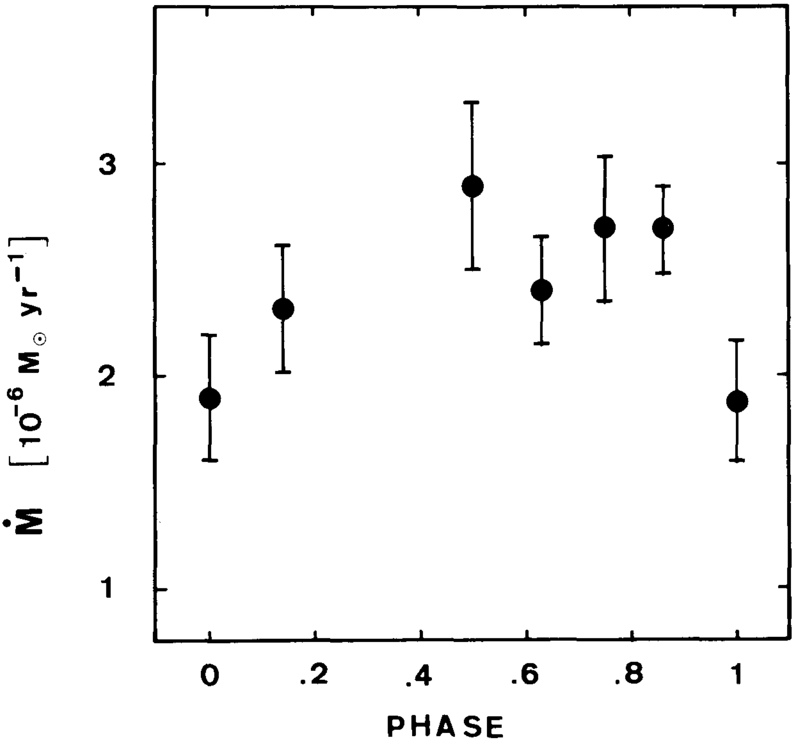

Fig. 1. Mass loss rates at different orbital phases for a spherically symmetric mass flow.

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effect is apparent. At phase 0.5 all the colours are redder than at phase 0, the effect being more pronounced in the J - M colour.

3. DISCUSSION

The observed magnitudes have been dereddened taking $A_V = 1.5$[1] and the reddening law given by (18) for filters J and K and by (19) for filters L and M (reddening in filter H has been obtained by interpolation). At each phase the dereddened spectrum of the source has been compared with a black body spectrum, normalized to the flux in filter J, with $T = 2.5 \times 10^4$ °K, which is appropriate for a BO Ia star. Strong excesses are apparent at all phases.

At phase 0, because of the large inclination of the system (see e.g. Ref. 6), the contribution of the eclipsed secondary to the total emission is negligible. The excess infrared emission at this phase can therefore be attributed to the wind of the primary and can be used to derive the mass loss rate. Following the model calculations described in (21), we find for a spherically symmetric mass flow: $\dot{M} = 2 \times 10^{-6}\ M_\odot yr^{-1}$. The wind velocity has been assumed to vary quadratically with distance from the photosphere until the terminal velocity is attained, with an initial value of 26 Km sec^{-1}, equal to the sound speed at the photosphere of the primary. The uncertainties in this procedure are discussed in (21). (In Tanzi et al.[12] a rough computation of the mass loss rate yielded $\sim 10^{-5}\ M_\odot yr^{-1}$. The difference with respect to the present result is due to the more refined method of computation used here). The derived mass loss rate compares well with the value determined from ultraviolet observations[11].

Outside phase 0 the colours are redder, that is the infrared excess over the assumed black body is larger. This could be due to the fact that the mass flow is not isotropic but is enhanced in the direction of the secondary, as indicated by the phase dependence of the velocities of various ionization species[5]. Neglecting the possible direct contribution of the colder secondary component, one can derive the phase modulation of the emission measure. Applying the model calculations used above to the infrared excesses observed at each phase one can determine the mass loss rates reported in Fig. 1. The apparent phase modulation of the mass loss rate is indicative of a non isotropic mass flow within the system.

An alternative possibility is to interpret the phase modulation of the infrared excess as due to a secondary component. A B 2-3 V star[2,12] can account for the larger infrared exce ses detected outside phase 0.

An improved knowledge of the infrared light curve may be helpful to discriminate between the two possibilities.

4. CONCLUSION

The infrared observations of V 861 Sco lead to a reliable estimate of the mass loss rate through the stellar wind. The observations are compatible with a B2-3 V companion, although its contribution in the infrared cannot be distinguished unambigously from that of a non isotropic stellar wind. The infrared measuraments cannot exclude that the secondary is a black hole as proposed on the basis of the Copernicus X-ray observations[3,4], which, however, have not been confirmed by instruments with better angular resolution[22,23].

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DISCUSSION

HOWARTH: How sensitive is the derived mass loss rate to the adopted stellar temperature? You use 28000 K but I think 24000-25000 is better for a BO Ia star.

TREVES: I agree that 25000 K could be better.

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