THE MASSIVE STELLAR WIND OF THE HUBBLE-SANDAGE VARIABLE S DORADUS

C. Leitherer[1], I. Appenzeller[1], G. Klare[1],
H.J.G.L.M. Lamers[2], O. Stahl[1], L.B.F.M. Waters[2],
B. Wolf[1]
1 - Landessternwarte Königstuhl, Heidelberg,Germany
2 - Space Research Laboratory, Utrecht, The Netherlands

We present coordinated spectroscopic and photometric observations obtained during the present bright phase of the luminous variable star S Dor in the LMC. High resolution spectrograms in the satellite UV and in the visual range were obtained with IUE and with CASPEC (attached to the ESO 3.6-m telescope), respectively. Moreover, photometric UBVRIJHKL observations were carried out.

Our new observations support earlier suggestions that S Dor consists of a hot stellar core which during the maximum state is surrounded by a very extended ($R \approx 300\ R_\odot$, $T_{eff} \approx 8000$ K) optically thick gaseous envelope. During the maximum state the surface of this optically thick envelope is observed as the star's pseudo-photosphere. From the line-intensity ratio of temperature sensitive absorption lines (Mg II 4481, He I 4471, etc.), we find physical conditions typical of an early A star in July 1983. In August 1984, when S Dor was visually fainter, the spectrum corresponds to a late B star. The radial velocity of the absorption lines varies around the systemic velocity with an amplitude of about 10 km s^{-1} and on time scales of months indicating pulsation-like motions of the pseudo-photosphere. Apart from these pulsating motions, a systematic, directed outflow of the pseudo-photosphere layers is not measurable. Only above the pseudo-photosphere (where the stellar wind flows) the outflow velocity increases.

The LWR-IUE spectrum is dominated by blue-shifted singly ionized metal lines arising in the stellar wind. The edge velocity v_{edge} of these lines increases with decreasing excitation potential. This relation can be understood in terms of a wind velocity field with outward increasing velocity.

The velocity field as derived from the UV absorption lines is consistent with the results obtained from the forbidden lines. The maximum wind velocity derived from the FWZI of the [Fe II]-lines in the visual is about 130 km s^{-1}.

C. W. H. De Loore et al. (eds.), Luminous Stars and Associations in Galaxies, 235–236.

https://doi.org/10.1017/S007418090014896X Published online by Cambridge University Press

Further support for an outward increasing velocity field provide the asymmetric line profiles of the forbidden [Fe II] lines: They are in striking agreement with those predicted theoretically for optically thin lines originating in expanding circumstellar envelopes with outward increasing velocity fields.

Our spectra also contain weak but reliably detected emission lines of [N II]. The [N II] $\lambda\lambda$6548, 6583 lines show approximately flat-topped and slightly double-peaked profiles, as predicted for spherically symmetric constant-velocity flows. As these lines (which have much lower critical densities than the [Fe II] lines) can only form far from the stellar surface, constant-velocity profiles are not unexpected. However, interestingly, the profiles of these lines have FWZIs of only 117 km s^{-1}, corresponding to flow velocities of <60 km s^{-1}. Hence, at the distance where these lines form (10^3 - 10^4 R_*) the flow velocity is significantly lower than the maximum velocity in the inner parts of the envelope. With a velocity field consistent with the other observational data a ballistic deceleration to such a low end velocity would require an unreasonably high mass of S Dor. Hence it seems more likely that the observed deceleration is due to an interaction between the wind and ambient interstellar matter. The density field and (in combination with the velocity field) the mass-loss rate $\dot{M}$ of S Dor can be derived from the IR emission and the Balmer emission lines. We find that a slow increase of the wind velocity with the terminal velocity being reached only at large distances (>10 R_*), and a mass-loss rate of $5 \cdot 10^{-5}$ $M_\odot yr^{-1} < \dot{M} < 1 \cdot 10^{-4}$ $M_\odot yr^{-1}$ can account for the observed infrared excess and Balmer-line profiles. This velocity law provides also an explanation for the χ-dependence of the edge velocity of the UV lines.

https://doi.org/10.1017/S007418090014896X Published online by Cambridge University Press