OPTICAL SPECTROSCOPY OF HD102567 (4U1145-61)

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Abstract: Analysis of optical spectra of HD102567 (HEN 715), the optical counterpart of the X-ray source 4U1145-61 is presented. Estimates of the star's rotation velocity, inclination angle, distance and envelope characteristics are given. Some consequences of the possible existence of a 190^d orbital period for this Be/X-ray sources are discussed.

I. SPECTROSCOPIC OBSERVATIONS

Ten spectra of HEN 715, the optical counterpart of the X-ray source 4U1145-61 (Sofia et al., 1974) were obtained in March 1976 and March 1977 at the ESO 1.5m telescope with the Echelec spectrograph equipped with a Lallemand electronographic camera. These spectra were taken in the first order at dispersions of 62 and 124Å/mm and wavelength ranges λλ4000-5000Å and λλ3600-5500Å, respectively. A detailed analysis of the observations will be present elsewhere (Janot-Pacheco et al. 1981b).

The spectrum of HEN 715 is that of a rapidly rotating B star. Hβ is seen in emission with asymmetric profile stronger at the red edge. Hγ is partially filled in by emission and other Balmer lines are present in absorption up to H16 (sometimes, up to H25). HeI absorption lines are prominent. The CIII-NIII-OII blend at λλ4634-51 is strongly marked and other strong OII lines are seen mainly around Hγ. Several weak and often diffuse emission lines were identified with FeII. Many weak interstellar lines are present throughout the spectrum. They show an average velocity of 7±1 Km/s. Two Balmer discontinuities seem to be present at λλ 3647 and 3700 although the low signal-to-noise ratio in this spectral region does not allow a clear conclusion.

Hβ and Hγ show drastic profile changes. Hammerschlag-Hensberge et al. (1980) reported variations in both the profile and central wavelength of Hβ in timescales of 4 min.

Based on the Ne-Si grid of Walborn (1971) we suggest for HEN 715 a

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spectral classification B0.7-B1 III-V. This classification agrees with a previous one by Feast et al. (1961). The difficulties of classifying Be stars should however be kept in mind.

II. ROTATION VELOCITY AND INCLINATION ANGLE

The width of the HeI lines indicate $V \sin i = 250 \pm 29$ Km/s. Some allowance should be given for instrumental profile effects. The width at base for the Hβ emission line is ∿500 Km/s, similar to that seen in other Be stars (Janot-Pacheco et al., 1981a).

The absence of shell lines and the shape of Hα, Hβ and Hγ lines favor $i<45^o$ (Poeckert & Marlborough, 1978).

III. VELOCITY VARIATIONS

Radial velocity variation for Hβ emission line and for HeI lines are shown in Figure 1. Note the variation for Hβ between JD2443212 and JD2443215, which indicates varying physical conditions in the envelope (see below).

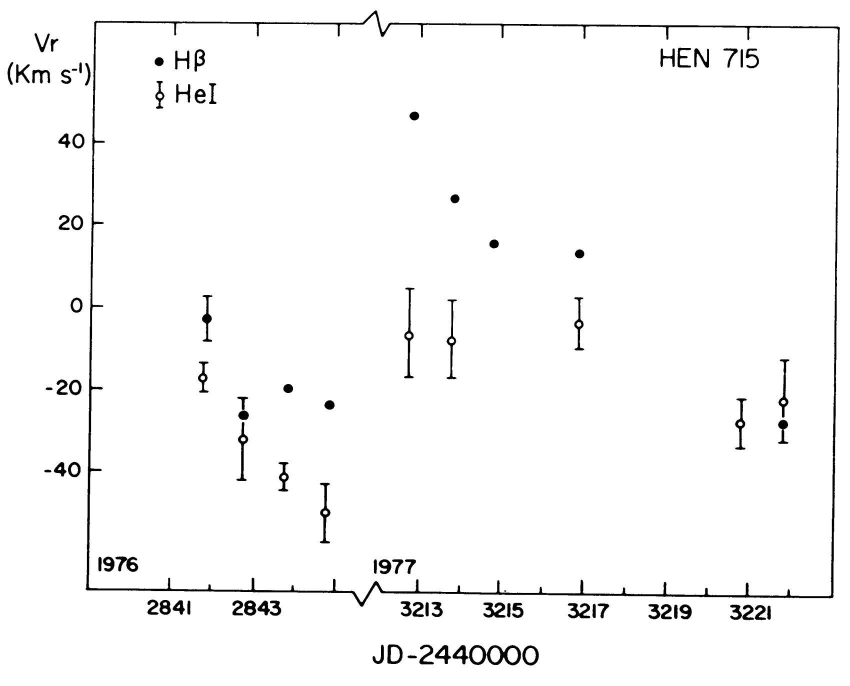

Fig.1 - Velocity variations for the Hβ emission line and HeI absorption lines of HEN 715. Two epochs are shown.

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Watson (1979) suggested a 188^d orbital period for the system 4U1145-61/HEN 715 on the basis of four strong X-ray flux enhancements seen by Ariel V from 1975 to 1978. Our 1976 and 1977 HeI velocities fit in well folded with Watson's ephemeris but they span only from 0.68 to 0.73 in phase.

IV. DISTANCE AND REDDENING

The equivalent width of the CaII K line indicates a distance of 1.3±0.3 Kpc.

Miller (1972) found $A_V < 1^m.5$ within the first 2-3 Kpc in the direction of the Carina spiral feature. The position of HEN 715 in the (U-B)X(B-V) diagram in 1964 (Feinstein, 1969) suggests $E_{B-V} \simeq 0^m.30$. This supports the (stellar) color-excess $E_{B-V} = 0^m.25$ derived by Bianchi & Bernacca (1980) from IUE observations. Taking M_V(B1V)=-2.9 (Panagia, 1973), V=9.39 (Feinstein, 1969) we obtain for the star a distance ∿1.9±0.1 Kpc.

Adopting a distance of 1.6 Kpc, the extreme flux densities of 4U1145-61 (Bradt et al., 1979) correspond to X-ray luminosities $L_X = 6.7 \times 10^{36}$ erg/s and 4.7×10^{34} erg/s, respectively.

V. SOME ENVELOPE CHARACTERISTICS - MASS LOSS

The observations indicate rapidly varying physical conditions in the envelope of HEN 715. Changes in density and/or in expansion velocity can account for line position and profile changes (Poeckert & Marlborough, 1978). The asymmetric Hβ and Hα (Watson et al., 1978) profiles stronger at the red edges indicate large expansion velocities in the envelope in the models of Poeckert & Marlborough.

The electron density can be estimated from the quantum number of the last visible Balmer line. This number varies from n=16 to n=25 yielding $12.78 < \mathrm{Log}\ N_e < 14.23$.

The mass loss can be estimated from $dM/dt = 4\Pi R^2 \rho(R)V(R)$. Taking R=6.8 $R_\odot$ (Underhill et al., 1980), V=40 Km/s (the average velocity of the upper Balmer lines) and the densities above we get $3.6 \times 10^{-8} M_\odot/yr < dM/dt < 8 \times 10^{-7} M_\odot/yr$.

VI. DISCUSSION

Maraschi et al. (1976) suggested the existence of a class of binary X-ray sources wherein the primary would be a rapidly rotating BVe star. Janot-Pacheco et al. (1981a) argued that direct interaction of a compact object with a typical Be envelope could be important in the production of X-rays. If the system 4U1145-61/HEN 715 has indeed an orbital period of $\sim 190^d$, the dimension of the orbit of the compact object will be

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$\sim 1.7 \times 10^{13}$cm for typical masses of the objects involved. This corresponds to a distance of $\sim$35 stellar radii from the Be star. If the density in the envelope varies as $r^{-\alpha}$ ($\alpha>2$), at $r=35R_*$ the densities will be of the order 10^7-10^9cm^{-3}. Accretion onto a neutron star passing through a gas of such densities could explain the 1978 flare of 4U1145-61 (see section IV) for relative velocities of at least $\sim$100 Km/s (see Ostriker & Davidson, 1973). Assuming that the envelope is supported by centrifugal forces, such high relative velocities could only be achieved with retrograde motion or in an eccentric orbit.

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