# THE PECULIAR BINARY SYSTEM HD 45166 (SdO+B8V?)

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Although clearly a peculiar object (Anger 1933), HD 45166 has been the subject of remarkably few published optical studies. Heap & Aller (1978, HA) discuss its optical spectrum and give evidence that the object is a binary system comprising a B8v star and a hotter WR-like object, denoted qWR by van Blerkom (1978). This paper presents the first UV observations of the system obtained with IUE at the epochs listed in Table 1. These new data show drastic line (but not apparently continuum) variations with epoch, which cast doubt on the WR-connection, although herein we still adopt the notation "qWR".

## 1. LINE VARIATIONS

In the following, IUE images in which the spectra show pronounced emission lines are superscripted "e"; those with a predominant absorption line character by "a". SWP11043$^{a}$, taken at high resolution, shows many strong absorption lines of highly ionised species (FeV being very prominent) with only weak CIV λ1550, NV λ1240 P-Cygni profiles and HeII λ1640 emission (cf Fig 1), although SWP1307$^{e}$ (at low resolution) (taken by S.R. Heap in 1978) shows very strong emissions in these lines as well as NIV λ1718 (Fig 3). The absorption lines in SWP11043$^{a}$ show similar strengths to those in ζ Pup, O4f, (Morton & Underhill 1977) demonstrating that we are dealing with the photosphere of a hot star, and when coupled with the observation of B8V absorptions in the visible (HA) confirms the binary nature of the object.

Table 1: Log of IUE observations taken in 1978 & 1981

| EPOCH | IMAGE | RESOL. | APER | EXP (s) |
|---|---|---|---|---|
| 19 March 1978 | SWP1307 | LORES | LAP | 150 |
| 13 Jan. 1981 | SWP11043 | HIRES | LAP | 2400 |
| 13 Jan. 1981 | LWR9705 | LORES | LAP | 140 |
| 27 April 1981 | LWR10455 | HIRES | LAP | 6000 |

SWP = λλ1150-2000; LWR = λλ1850-3300
LORES: Δλ = 6Å (SWP), Δλ = 10Å (LWR); LAP = 10"x20" spect. aperture



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Fig 1: Sections of SWP11043[a] showing FeV absorptions & CIVλ1550 P-Cygni

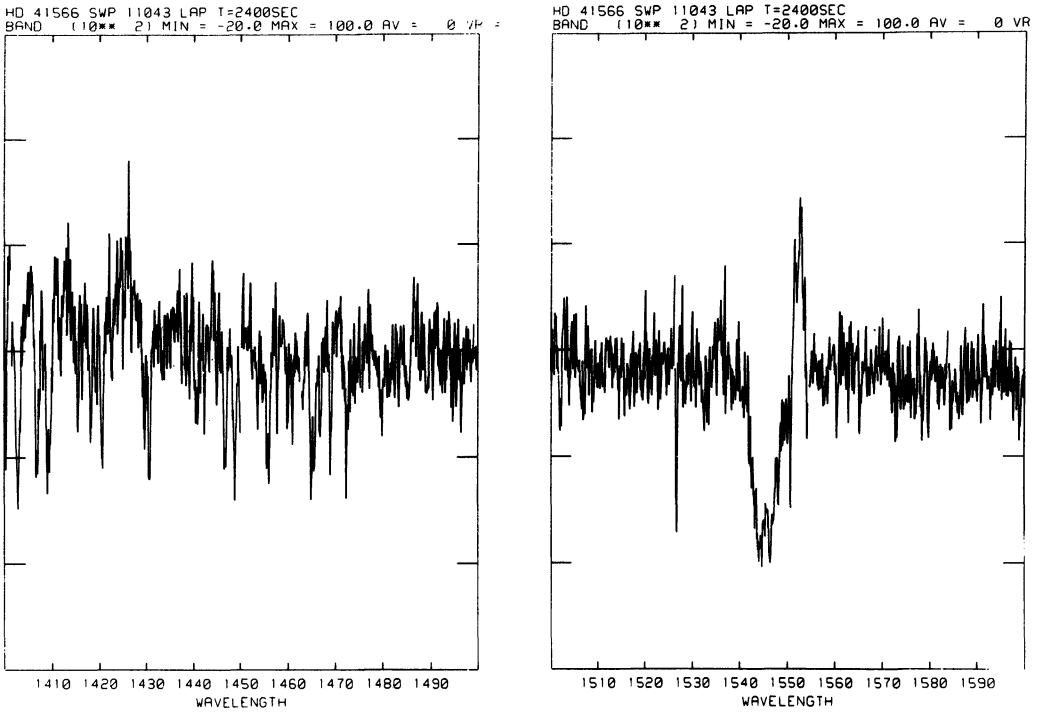
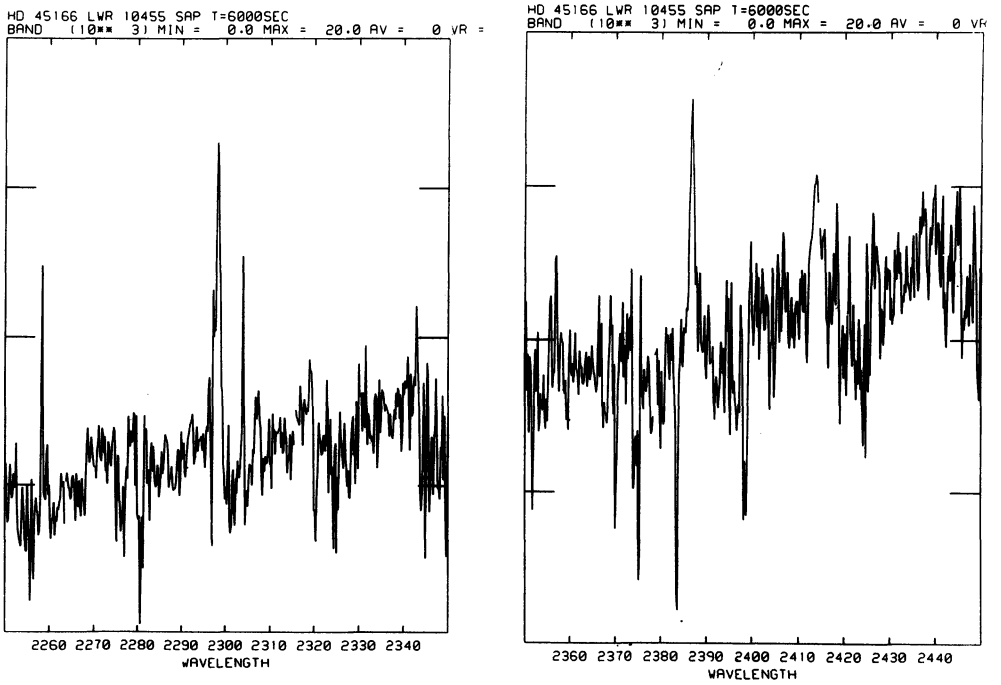



Fig 2: Sections of LWR10455[e] showing CIIIλ2297 and HeIIλ2385 emissions.

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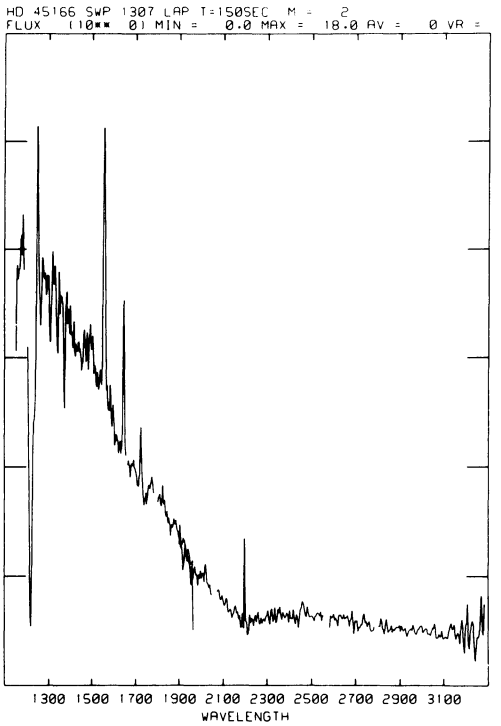


Fig 3:
Combined SWP1307[e]+LWR9705[a] UV spectrophotometry of HD 45166. These data, taken at different epochs, and showing different emission/absorption phases of the system, overlap well in the continuum. Ordinate scale is $10^{12}F_\lambda$ ( erg cm-2 s-1 Å-1 )

LWR9705[a] also shows no emission features although WR-like emissions are seen in LWR10455[e] in CIII$\lambda$2297 and the HeII (n-3) series (Figs 2 & 3). Nevertheless when the high excitation emissions have diminished or vanished, the stellar wind of the qWR star is still observed in the CIV and NV resonance line P-Cygni profiles in SWP11043[a]. If, as seems plausible, these line variations are linked to the binary nature of the system, viz some kine of eclipse effects, we conclude that the bulk of the emissions are not formed in the qWR wind, since when they are absent we still see both the photosphere and wind of the qWR star! Possibly the "WR-like" emissions are formed in a region of interaction of the qWR wind and the atmosphere of the B8V star. The apparent violet asymmetry of CIV$\lambda$1550 in SWP11043[a] may be suggestive of material streaming from the hotter to cooler component. The interaction hypothesis may also explain the sharpness of most of the emissions $\sim$5-10 times less than expected from the measured $v_\infty$ for the qWR wind of 1200 km/s.

## 2. INTRINSIC PROPERTIES OF THE "qWR" STAR

Fig 3 plots the combined LORES spectra SWP1307[e] + LWR9705[a] on an absolute flux scale, which shows that despite gross line variations no changes in the continuum level have occurred. The observed $\lambda$2200 band strength gives $E_{B-V} = 0.15$, and combining the UV data with the visible energy distribution given by HA, we have dereddened the UV-visible continuum of the system. Adopting the conclusion of HA that both components have equal continuum luminosities at $\lambda$4340, and using a B8V model atmosphere from Kurucz (1979) with $T_{eff}$ = 13000K and log g = 4.0, we have subtracted the

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expected B8V continuum contribution from that observed to derive the intrinsic energy distribution of the qWR in the range λλ1150-7500. We find this to be very well fitted with a blackbody distribution at 60000K and adopt this as $T_{eff}$. Comparison of the separated B8V fluxes with the Kurucz model, implies a distance of 605 pc if a radius R(B8V)= $3R_\odot$ is adopted. This results in a deduced radius of R(qWR)=$0.77R_\odot$, a luminosity L(qWR) = $7.5 \times 10^3$ $L_\odot$ and $M_v$(qWR) = +0.9.

The CIVλ1550 and NVλ1240 P-Cygni profiles seen in SWP11043[a] both give $v_\infty$ = 1200 km/s. If we assume the usual relation of $v_\infty = 3\ v_{esc}$ for hot stars, suitably amplified for radiation pressure terms by the expression given by Castor, Lutz & Seaton (1981), with the deduced L(qWR) and R(qWR) above, we estimate M(qWR) = $0.5M_\odot$ and a surface gravity of log g = 4.38.

With these parameters we locate the qWR object in a region of the HR diagram occupied by both (a) the hottest, most luminous and presumably youngest central stars of planetary nebula, and (b) by some SdO stars. Since HD 45166 is not (to our knowledge) surrounded by a nebula, we conclude that the latter possibility is most likely, and that the qWR component in HD 45166 bears all the hallmarks of a SdO star. Thus the WR connection may in fact be misleading. Current data suggest that we are dealing with a SdO+B8V binary system, with the possibility that interaction effects of the SdO wind with the B8V atmosphere are giving rise to the often observed emission line spectrum. Such interaction effects are not to our knowledge known for other systems, and their confirmation and study is clearly of great interest. To this end we are currently acquiring further visible and IUE spectra of the system, with the aim of defining its binary orbital parameters and further study the phase dependence of the spectral variations.

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## DISCUSSION FOLLOWING WILLIS AND STICKLAND

Massey: About five years ago, Sally Heap came through JILA and gave a lunch talk on this star. I've been taking optical spectra ever since. I've not seen any dramatic changes in the line spectrum or radial velocities during this time, although there is historical evidence that the spectrum is different now than it was 40-50 years ago (see Hiltner and Schild, 1966, Ap.J. 143, 770). Any radial velocity variations are small, suggesting either the period is quite long or we

are looking at the system pole on. I also have some IRS spectrophotometry of this system.

Willis: I find it strange that no radial velocity variations are found in the visible spectra. Do you have observations at time intervals less than one day? If the system is pole on, this would probably rule out our interpretation of the emission line variations as being due to binary eclipses of the interaction region of the WR stellar wind and the atmosphere of the B8V star.

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