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# Revisiting the unique qWR – B7V composite binary HD 45166

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**Abstract.** We applied wavelength space binary spectral disentangling for a FEROS observation of HD 45166 and derived the atmospheric parameters of the binary components. Our results suggest a B7V-type companion in the system and prefer a lower mass solution for the quasi-WR primary than previous analyses, resembling a He-rich sdO star.

**Key words:** massive stars – composite spectrum binaries

## 1. Introduction

The one-of-a-kind composite spectrum binary HD 45166 astonished spectroscopists for decades. The emission line component resembles a Wolf-Rayet (WR) star and the companion is proposed to be a late B-type star. Comprehensive studies for precise stellar and wind parameters have been performed. Groh et al. (2008) found wind asymmetries in the quasi-WR (qWR) star and Shenar et al. (2023) found pulsations in the B star and a strong magnetic field in the qWR, which is believed to be the precursor of a magnetar. Although these comprehensive studies recognized the composite nature of the object, they did not resolve or analyze the members of the system.

Here we apply the latest version of XTGRID to address the composite spectrum. We modeled the binary members in parallel and coadded the individual models to fit a FEROS observation with the linear combination of two synthetic spectra. We took the best of two worlds and modeled the B7V component with TLUSTY v208 and the qWR component with the 2017 version of CMFGEN. This is the first time the two codes are connected to model the components of a physical binary.

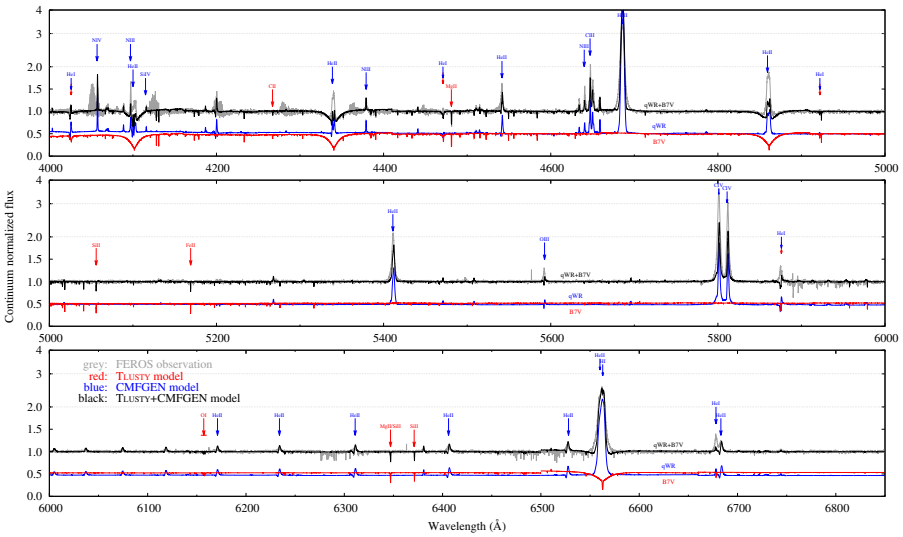


**Figure 1.** Our near-best-fit XTGRID / TLUSTY+CMFGEN composite model for HD 45166 shown in *black*. The FEROS observation is in *grey*, the CMFGEN model is in *blue*, and the TLUSTY model is shown in *red*. Line identifications for the B7V star are in *red* and for the qWR component in *blue*. The model parameters are available on request.

## 2. Spectral modeling with TLUSTY and CMFGEN

We processed one FEROS spectrum to show that non-LTE radiative transfer models calculated with TLUSTY and CMFGEN are perfectly adequate to derive the stellar and wind parameters. Our iterative, data-driven spectral analysis pipeline XTGRID determines the surface properties of the stars by managing 36 free parameters and using a robust chemical composition including heavy elements such as Fe and Ni. Along the spectral modeling of the observation as in Figure 1, the actual CMFGEN+TLUSTY model was used to predict the binary spectral energy distribution (SED), which is compared to observed broad-band photometric data from VizieR in Figure 2.

## 3. Results

Our main result is the reclassification of the qWR component as a He-dominated hot subdwarf (sdO) star, which is based on the SED contributions of the binary members and the resulting lower mass of the primary. This suggests a recent merger event in an initially triple system, where the B-star was the distant tertiary component. The disrupted lower-mass companion formed a hot

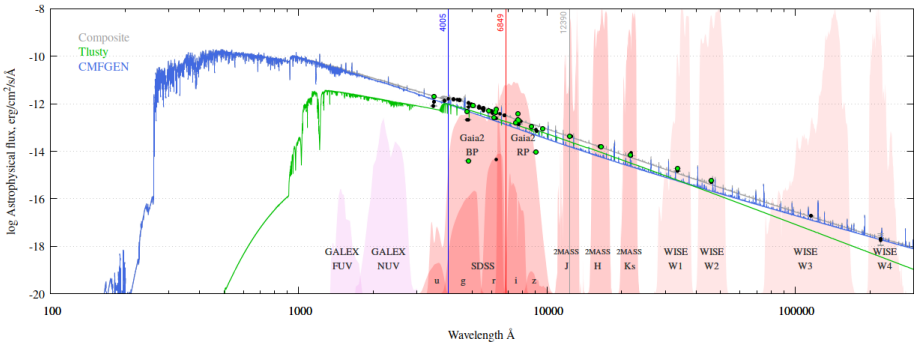


**Figure 2.** SED of HD 45166. All data points were taken from the VizieR Photometry Viewer service. The photometric data were de-reddened using $E(B-V) = 0.16$ mag (stilism.obspm.fr). The green points were used to match the slope of the passband convolved combined CMFGEN and TLUSTY fluxes to the observations and the model was normalized to the observed SED in the 2MASS/J band.

corona around the more massive star in the inner binary, potentially exhibiting a magnetic field.

Although based on a single spectrum, our findings highlight the importance of binary disentangling in exploring the system properties. With appropriately stacked models, one can reproduce the members' surface properties. The orbital parameters will become available once all spectra are processed. That will allow us to determine the dynamic mass ratio from radial velocity measurements, and reconcile the spectral and photometric variability of the system. Our results demonstrate that wavelength space decomposition, using the right combination of hydrostatic plane-parallel and spherical wind models, is effective for modeling HD 45166, and similar systems.

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