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Observational Constraints on the Disk Size and Kinematics of HD 327083*

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Abstract. The existence of dust around hot, massive and luminous objects, such as B[e] supergiants, is still not well understood. One possible scenario is linked to the presence of a high density and low expansion velocity equatorial disk, which would harbor neutral and low ionized gas and dust. However, the formation of a stable disk is physically challenging. A possible answer would be the detection and channeling of the mass ejected towards the equatorial plane of the supergiant by a faint companion. In this work, we present VLTI/MIDI high angular resolution observations and GEMINI/PHOENIX infrared spectra to describe the gas and dust environments around the galactic B[e] supergiant HD 327083, which is suspected to have a F-type companion.

1. Introduction

B[e] supergiants (sgB[e]s) are massive and luminous evolved B-type stars that show the B[e] phenomenon (Lamers et al. 1998). They exhibit a hybrid spectrum with strong P Cygni-type profiles in the Balmer lines, narrow low-excitation emission lines of permitted and forbidden transitions, broad absorption features of higher-excitation levels, and a strong near/mid-infrared excess due to hot circumstellar dust (Zickgraf et al. 1986). Spectroscopic and polarimetric data suggest the presence of non-spherical circumstellar environments (CEs) around these stars that might be related to the rapid stellar rotation (Kraus et al. 2007, 2008) or gravitational interactions with a companion. High angular interferometric observations confirmed the presence of a companion in HD 87643

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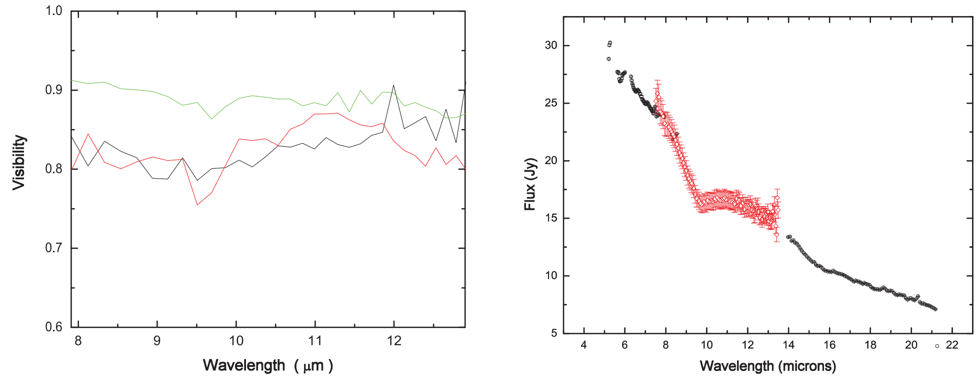

Figure 1. *Left:* VLTI/MIDI visibilities for three different baselines and position angles; Black: April 25th, UT3–UT4, B_p=60.5 m, θ=131.1°; Red: April 26th, UT2–UT3, B_p=41.1 m, θ=54.6°; Green: May 25th, UT2–UT3, B_p=46.6 m, θ=25.6°. *Right:* Flux for HD 327083; in red: Our MIDI data; in black: Spitzer archive data

(Millour et al. 2009) and V921 Sco (Kraus et al. 2012), and revealed disks around the binary HD 62623 (Millour et al. 2011) and HD 50138 (Borges Fernandes et al. 2011)

HD 327083 is a very reddened early B-type star, $E(B-V)$ ~1.9 mag (Kozok 1985) that exhibits a strong emission-line spectrum, mainly from H I, He I and Fe II ions (Carlson & Henize 1979). Olnon et al. (1986), using IRAS satellite, detected a strong mid-IR flux, with a steep decrease towards longer wavelengths, and a featureless spectrum in the 10 μm region. Near-IR spectroscopy revealed strong CO band emission features at 2.3 μm (Whitelock et al. 1983; McGregor et al. 1988). Based on line profile fits of Balmer lines, Machado et al. (2001) derived a very high luminosity ($\geq 10^5$ L$_\odot$) and mass-loss rate ($\geq 10^{-5}$ M$_\odot$ yr^{-1}). Miroshnichenko et al. (2003) reported the presence of numerous absorption lines of neutral metals in the spectrum of this star. They suggested that HD 327083 should be a binary system and that the reported absorption lines belong to a moderately cool companion of F-type spectral class. They estimated a distance for this source of $D \sim 1.5 \pm 0.5$ kpc. Wheelwright et al. (2012) confirmed HD 327083 as a Galactic sgB[e] based on the presence of ^{13}CO emission seen in VLTI/AMBER observations. They also found that the best model that fits their data is a binary system with an elongated circum-binary gaseous disk where the near-IR excess is originated.

2. Observations

We observed HD 327083 in the optical, near-IR and mid-IR wavelength ranges with CASLEO/REOSC and Gemini/PHOENIX spectrographs, and with VLTI/MIDI (high angular resolution optical interferometry). The observations were performed during differents nights in April and May 2010.

Interferometric Data The *N*-band spectrum as well as spectrally dispersed fringes were recorded between 7.5 μm and 13 μm with a spectral resolution of R = 30. In total, 3 data sets were obtained for HD 327083 using the UT2–UT3 and UT3–UT4 baselines. The calibrator used was HD 152980: $\Theta_{UD} \pm 0.19$ mas and $F_{12\,\mu m}$ = 22.03 Jy (http://nsted.ipac.caltech.edu/index.html). Data reduction was carried out with MIA+

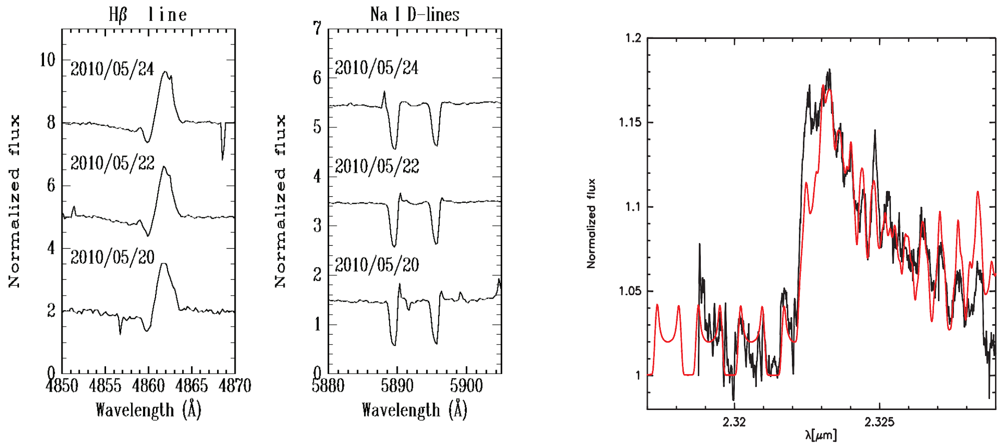

Figure 2. *Left:* CASLEO/REOSC spectra showing short-term variations of Hβ (left) and Na I D-lines (right). *Right:* Preliminary fitting model (red) to the observed flux-calibrated CO bands (black)

EWS packages (Leinert et al. 2004). For a detail of the observation logs, see the caption of Fig.1 (left).

Spectroscopic Data: PHOENIX is a long slit, high-resolution IR visitor spectrograph at Gemini South telescope. The spectra was taken using the K4308 filter centered at 2.323 μm with $R \sim 50\,000$. A telluric star was observed to correct the spectrum: HIP 84690. We selected a B late-type (B9 V) standard star because it has only intrinsic neutral hydrogen lines. Quasi-simultaneously to Phoenix observations four spectra were obtained using REOSC echelle spectrograph with $R \sim 13\,000$ attached to the 2.15 m telescope at CASLEO (May 20th, 22nd and 24th, 2010). All reductions were performed using IRAF software package routine.

3. Results and Model

Our combined multiwavelength observations allow us to study the structure and kinematics of the ionized wind and molecular and dusty disk in detail. Visibilities are presented in Fig. 1 (left) for the three baselines and their corresponding position angles. The source remained unresolved since the visibilities were all near to unity and almost flat. A Gaussian size FWHM was computed for each wavelength using the formula given in Leinert et al. (2004) and we found that the FWHM grows with wavelength from about 5 mas to 10 mas and there is no indication of a more extended envelope in the silicate band region. In Fig. 1 (right) we present the good match between the mean calibrated *N*-band spectral fluxes taken with MIDI and Spitzer. A silicate absorption feature is clearly observed, suggesting the presence of a very compact dust structure.

The optical spectra display many emission lines from the ionized wind. Comparing the lines from the different observing periods, Hβ and Na I D-lines show evidence of short-term variations in their profiles, in both intensity and shape (Fig. 2, left). However, Hα line profile exhibits no change.

The molecular emission originates from disk regions closer to the star than the dust. To model these regions we used the disk code of Kraus et al. (2000). A preliminary fit of the second CO bandhead (Fig. 2, right) was obtained assuming a ring of CO gas with a projected velocity (Keplerian rotation or equatorial outflow) of about $55\,\mathrm{km\,s^{-1}}$ and a temperature of about 1400 K.

4. Discussion

The optical spectrum shows P Cygni-type profiles which evidence short-term variable outflows since the minimum period of the binary system was estimated around 60 days (Miroshnichenko et al. 2003). Our preliminary fit of the CO bandhead suggests the presence of a ring with a projected velocity of $55\,\mathrm{km\,s^{-1}}$ in the CO emitting region. Our poor fit indicates that an elliptic emission region rather than a ring might be more appropriate. Such a gas ring with a size of 10.6 mas inside a large dusty disk was suggested by Wheelwright et al. (2012). However, our VLTI/MIDI observations do not resolve any dusty environment, suggesting probably the presence of a cool compact source. More high angular mid-IR observations are needed to better understand the circum-binary structure of this system.

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