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# Resolving the dusty circumstellar environment of the A[e] supergiant HD 62623 with the VLTI/MIDI

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**Abstract.** HD 62623 is one of the very few A-type supergiants showing the B[e] phenomenon. We studied the geometry of its circumstellar envelope in the mid-infrared using the VLTI/MIDI instrument. Using the radiative transfer code MC3D, we managed to model it as a dusty disk with an inner radius of 3.85 AU, an inclination angle of $60^o$, and a mass of $2 \times 10^{-7} M_\odot$. It is the first time that the dusty disk inner rim of a supergiant star exhibiting the B[e] phenomenon is significantly constrained. The inner gaseous envelope likely contributes up to 20% to the total N band flux and acts like a reprocessing disk. Finally, the hypothesis of a stellar wind deceleration by the companion gravitational effect remains the most probable case since the bi-stability mechanism is not efficient for this star.

**Keywords.** techniques: high angular resolution, stars: emission-line, Be, stars: winds, outflows

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The B[e] phenomenon is defined by strong Balmer lines in emission, low-excitation and forbidden emission lines, and strong infrared excess due to hot circumstellar dust. However, these objects are not a homogeneous group of stars in terms of stellar evolution, as such features have been detected for both pre-main sequence and evolved stars. Thus, this group of stars has been divided into four subclasses: B[e] supergiants, Herbig AeB[e] stars, compact planetary nebulae B[e]-type stars, and symbiotic B[e]-type stars.

HD 62623 is one of the very few A-type supergiants showing the B[e] phenomenon. The formation mechanisms responsible for supergiant B[e] stars' circumstellar environment is still an open issue. Zickgraf *et al.* (1985) proposed a general scheme for these stars consisting of a hot and fast line-driven polar wind responsible for the presence of forbidden lines and a slowly expanding dense equatorial region where permitted-emission lines and dust can form. The deviation from the spherical geometry for this model can be due to rotation or binarity.

The VLTI/MIDI (Leinert et al 2004) observations were carried out at Paranal Observatory between 2006 and 2008 with the 1.8 m Auxiliary Telescopes (ATs). We obtained nine visibility measurements with projected baselines ranging from 13.4 to 71.4m and with various orientations on the skyplane. All observations were made using the SCI-PHOT mode, which enables a better visibility calibration since the photometry and the interferometric fringes are recorded simultaneously. Thanks to the PRISM low spectral dispersion mode, we obtained spectrally resolved visibility and spectra with R=30 in the N band (7.513.5 $\mu$m). Standard reduction packages MIA and EWS were used to reduce these data.

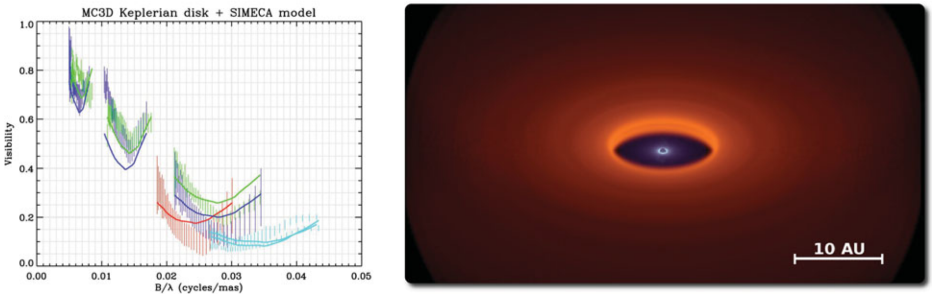


**Figure 1.** Left: Visibility plotted as a function of the spatial frequency for the nine baselines. The best SIMECA + MC3D model curves are overplotted as solid lines. Right: Corresponding SIMECA (in blue) + MC3D (in orange) composite image for the best-fit model.

We tried to model our interferometric measurements using MC3D (Wolf *et al.* 1999), a Monte-Carlo radiative transfer code for dusty circumstellar envelopes. We probed different disk structures including equatorial wind and Keplerian viscous disk. No model managed to fit all the visibilities simultaneously. In the best-fit models, the longest baselines visibilities are underestimated This suggests the presence of structures not fully resolved with the 70 m baselines, which are not taken into account in our MC3D model.

The residual visibility might be due to inhomogeneities or clumping in the disk. However, the most probable hypothesis is that it originates from a non-resolved inner gaseous environment surrounding the central star. We decided to take into account the emission of the ionized gas and modeled it using SIMECA (Stee 1996), a code developed to model gaseous environment of hot stars. As the extension of the gaseous emission is much smaller than the dust inner radius, we could compose the two models in an ad-hoc way by adding directly the complex visibilities extracted from each model.

The fit of the visibilities and a composite image of the MC3D + SIMECA best-fit model are presented in Fig 1. We were able to constrain the total mass of the disk, i.e. about 2x$10^{-7}$ $M_{\odot}$, and the dust sublimation radius and temperature, i.e. 3.9 $\pm$ 0.6 AU and 1250 K, respectively. It is the first time that the dusty disk inner rim of a supergiant star exhibiting the B[e] phenomenon is significantly constrained. HD 62623 is seen under an intermediate inclination angle of 60 $\pm$ 10 $^{o}$ and with a position angle of its major-axis on the sky plane roughly perpendicular to polarization measurement, i.e. 15 $\pm$ 10 $^{o}$. As expected from the existence of the residual visibility, 10 to 20% of the total N-band flux are likely to originate from the free-free emission of the circumstellar ionized gas.

Using vsini measurement, stellar parameters, and our estimation of the object inclination angle, we were able to constrain HD 62623 rotational velocity, i.e. between 30 and 60% of its critical velocity. Consequently, rotation seems not to be efficient enough to explain the break of the spherical symmetry of the mass-loss and the formation of the equatorial disk. The putative presence of low mass companion could explain such geometry. However, considering the expected brightness ratio and the accuracy on our measurements, it cannot be detected in our dataset. These VLTI/MIDI observations and modelling are presented in details in Meilland *et al.* (2010).

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