High-resolution near-infrared speckle interferometry and radiative transfer modeling of the OH/IR star OH 104.9+2.4

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Abstract We present near-infrared speckle interferometry of the OH/IR star OH 104.9+2.4 in the K' band obtained with the 6m telescope of the Special Astrophysical Observatory (SAO) in Sep. 2002 and Oct. 2003. At a wavelength of $\lambda = 2.13\,\mu$m the diffraction-limited resolution of 74 mas was attained. The reconstructed visibility reveals a spherically symmetric, circumstellar dust shell (CDS) surrounding the central star. The visibility function shows that the stellar contribution to the total flux at $\lambda = 2.13\ \mu$m is less than 30% at all phases, indicating a rather large optical depth of the CDS. To determine the structure and the properties of the CDS of OH 104.9+2.4, radiative transfer calculations using the code DUSTY [1] were performed to simultaneously model its visibility and the spectral energy distribution (SED). Since OH 104.9+2.4 is highly variable, the observational data taken into consideration for the modeling correspond to different phases of the object's variability cycle. This offers the possibility to derive several physical parameters of the central star and its CDS as a function of phase.

1 Observations

The majority of OH/IR stars are long-period variables (LPVs) of variability type Me, extending the sequence of optical Mira variables towards longer periods, larger optical depths, and higher mass-loss rates. As a consequence of their high mass loss, OH/IR stars are surrounded by massive, optically and geometrically thick circumstellar envelopes composed of gas and dust.

For OH 104.9+2.4, a highly dust-enshrouded OH/IR type II-A class star, we obtained visibilities from speckle-interferometric observations with the SAO 6 m telescope on Sep 22, 2002 and Oct 11, 2003 by applying the speckle interferometry method [2]. The measurements were accomplished with a K'-band filter at $\lambda = 2.13\,\mu$m ($FWHM = 0.11\,\mu$m). Although obtained at different epochs, both visibilities exhibit striking similarity and reveal that

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the CDS is fully resolved by our measurements (see Fig. 1a). From the 2D-visibilities no major deviation of the CDS from spherical symmetry could be detected.

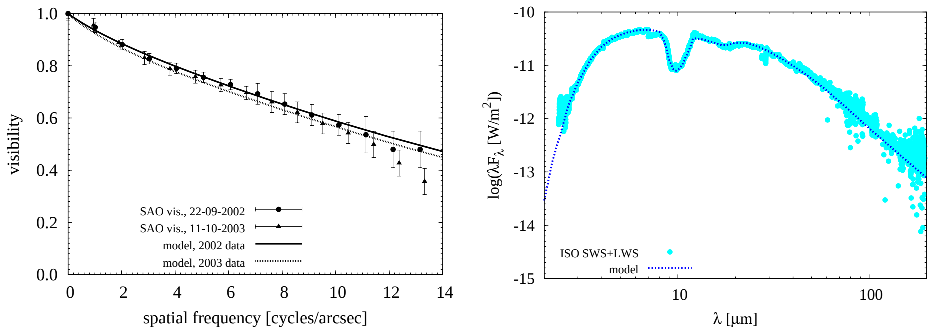

Fig. 1. Comparison of K'-band visibility (**left**) and SED (**right**) from our best-fitting model (solid lines) to the SAO (left) and ISO (right) measurements of OH 104.9+2.4. Different bolometric flux values have been used for the SED and visibility model in order to account for the different epochs/phases of the observations. For more details on the model parameters see [4].

2 Results

Our goal was to simultaneously model the K'-band visibilities and the SED of OH 104.9+2.4 measured at different epochs to determine the temporal change of some physical parameters of the CDS. To accomplish this goal, we used the 1D radiative transfer code DUSTY [1] and calculated several 10^5 models to scan large fractions of the corresponding parameter space.

According to our final model (see also Fig. 1) the effective temperature of the central star increases from $T_{\rm eff} = 2250$ K at minimum phase ($\Phi = 0.5$) to $T_{\rm eff} = 3150$ K at maximum phase ($\Phi = 0.0$), while the stellar radius decreases from R = 730 $R_\odot$ at $\Phi = 0.5$ to 675 $R_\odot$ at $\Phi = 0.0$. For the CDS, we found that the inner boundary of the dust shell is located at 8.3 $R_\star$ at minimum phase and approximately a factor of two further away at maximum phase ($R_{\rm in}/R_\star = 17.5$). The optical depth at 2.2 μm decreases from 8.5 to 3.5 between minimum and maximum phase. Our detailed analysis demonstrates the potential of dust shell modeling constrained by both the SED and visibilities obtained from interferometric measurements. For further details on the modeling the reader is kindly refered to [3] and [4].

References

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