The circumstellar environment of SV Psc probed by mid-infrared interferometry: Evidence for a close binary?

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FWF Der Wissenschaftsfonds

1. Scientific Background

✧ Asymptotic Giant Branch (AGB) stars are subject to heavy mass loss that is responsible for the formation of circumstellar envelopes. Even though studied for over four decades, the origin of the geometry of this outflow is still poorly understood.

✧ Double velocity features (a narrow velocity feature is centered on a much broader one) are observed in the mm-CO-line profiles of some AGB stars. The oxygen-rich AGB star SV Psc presents one of the most extreme cases of such a line profile.

✧ The origin of these composite profiles is still puzzling. Mid-IR high-angular-resolution observations allow to study the morphology of the close circumstellar environment, hence providing constraints on the mechanism responsible for such a line profile.

2. Observations

SV Psc was observed in 2008 and 2010/2011 with the 1.8 m ATs of the VLT Interferometer MIDI (Fig. 1).

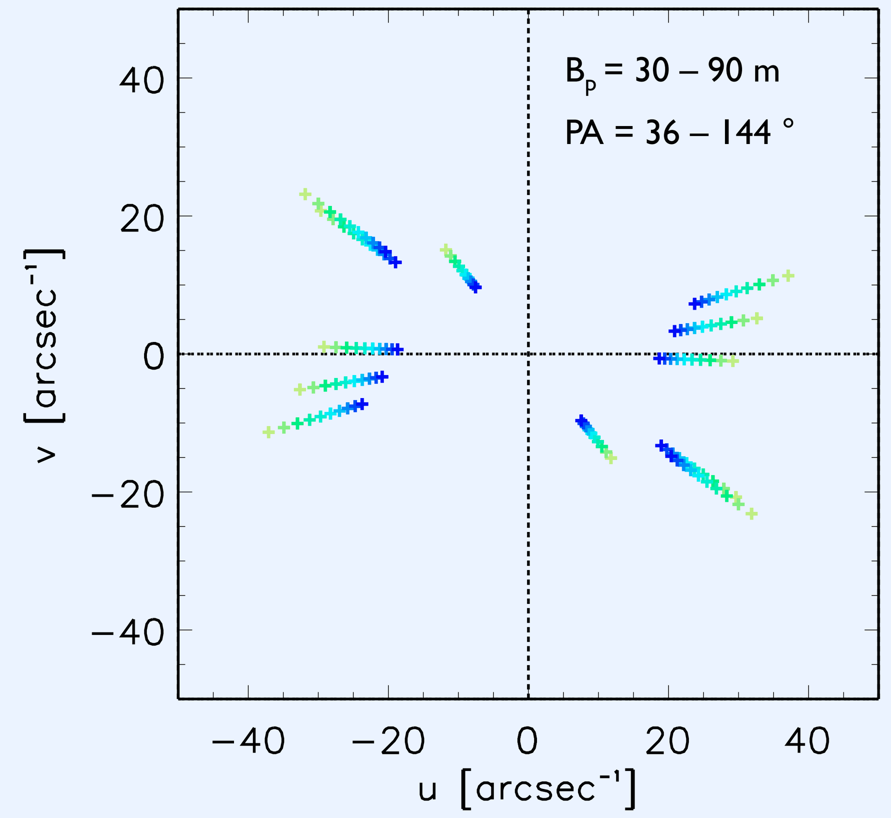


Fig. 1. *N*-band spectrally dispersed *uv*-coverage of the MIDI observations.

3. Geometrical Model Fitting & Morphological Interpretation

MIDI observations were fitted with 2D geometrical models using GEM-FIND (GEometrical Model Fitting for INterferometric Data, Klotz et al. 2011, A&A, subm.).
Model parameters and reduced minimum χ^2 values are given in Table 1.

✧ Spherically symmetric models (#1, 2, 6, 8) are not able to reproduce the data.

✧ One-component elliptical models (#3, 4) are also unable to provide a good fit.

✧ The elliptical two-component model (#7) allows a better fit (Fig. 3). This is expected from an optically thin environment where both central star and dust envelope are observed.

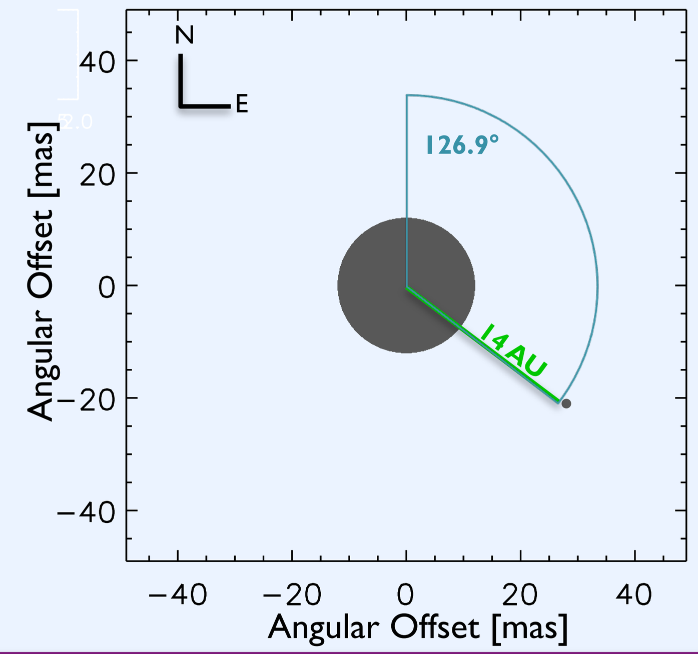
✧ A binary model consisting of a resolved primary component (AGB star) and an unresolved companion (#5) also gives a good fit (Fig. 2).

Table 1. Parametric description of the geometrical models used in this study.

#	Model	λ independent fixed	grid	λ dependent	χ^2_{min}
1	Circular UD			θ	8.37
2	Circular Gaussian			FWHM	7.47
3	Elliptical UD		ψ, η	θ_{maj}	5.25
4	Elliptical Gaussian		ψ, η	$FWHM_{maj}$	3.87
5	**UD+Dirac**		$\Delta\alpha, \Delta\beta$	f, θ_{prim}	0.98
6	CircUD+CircGauss	θ_{cen}		FWHM, f	5.96
7	**CircUD+EllGauss**	θ_{cen}	ψ, η	$FWHM_{maj}, f$	0.91
8	UD+Ring	θ_{cen}		$\theta_{out}, \theta_{in}, f$	8.88

FWHM… Full Width at Half Maximum
θ… Angular diameter
$\Delta\alpha, \Delta\beta$… Angular offsets of companion
ψ … Inclination angle of ellipse
η … Axis ratio
f … Flux ratio

Binary Model



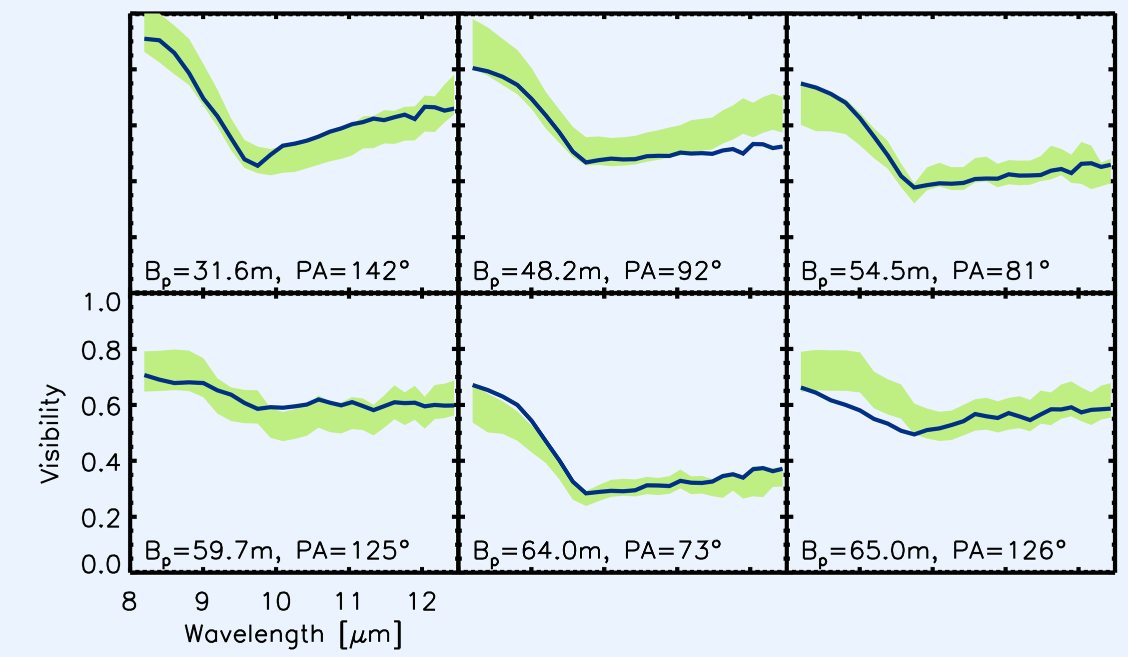
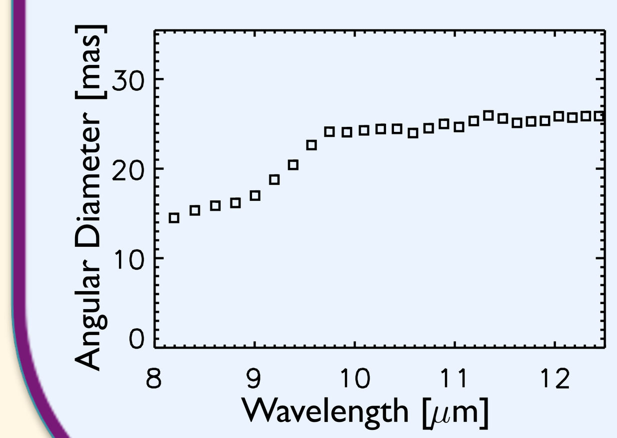
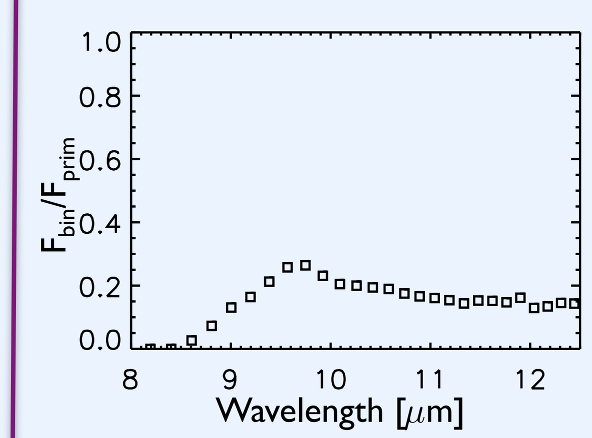


Fig.2. Binary-model visibilities (line) superimposed on the MIDI visibilities (shaded area).



The diameter of the primary star increases from 8 to 10 μm

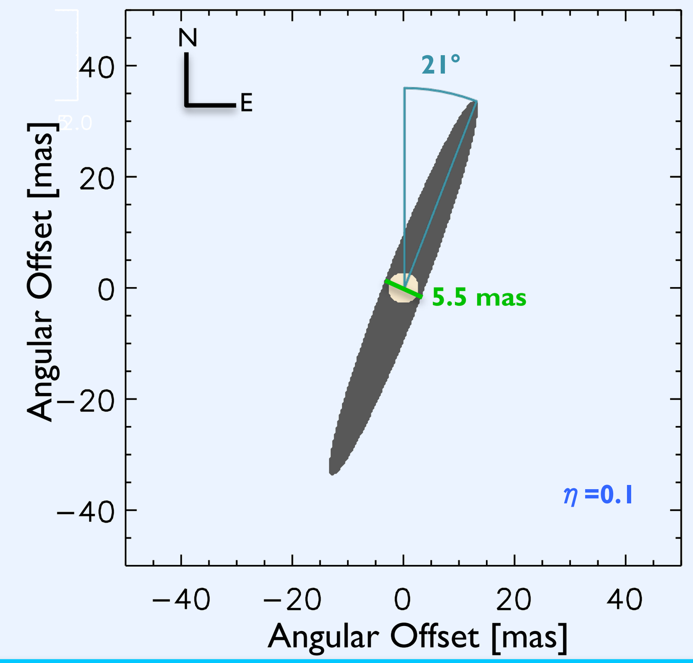
➔ The silicate dust present in the O-rich environment of AGB stars has a larger opacity at 10 μm



The flux ratio F_{bin}/F_{prim} increases from 8 to 10 μm

➔ The emission of the silicate-rich accretion disk surrounding the companion is higher at 10 μm

Disk Model



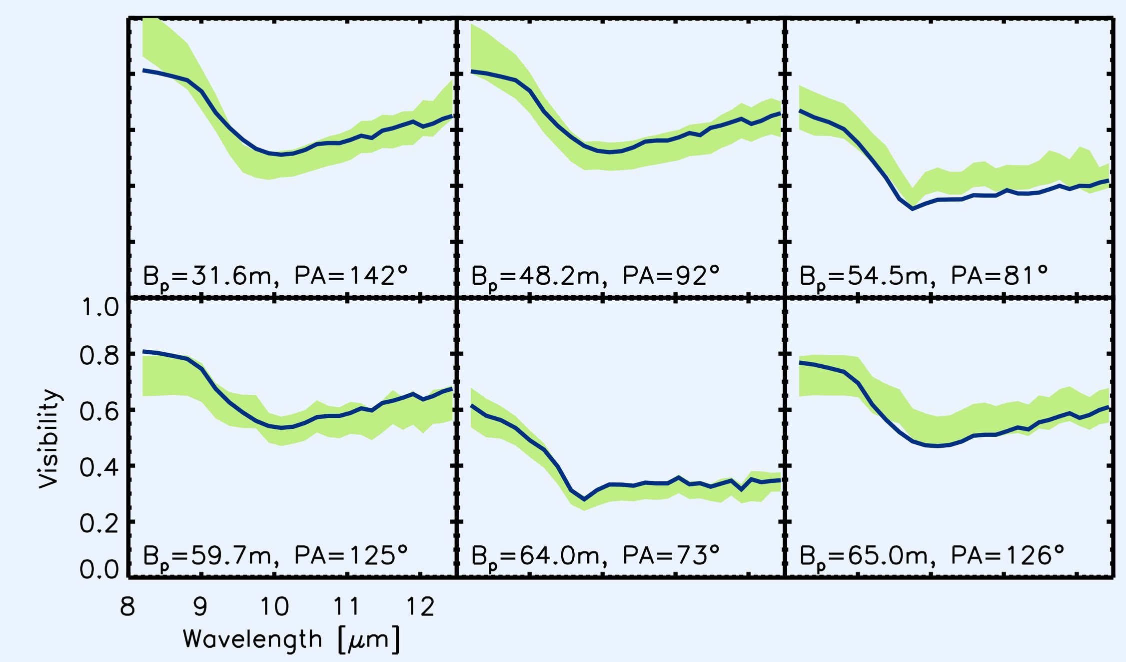
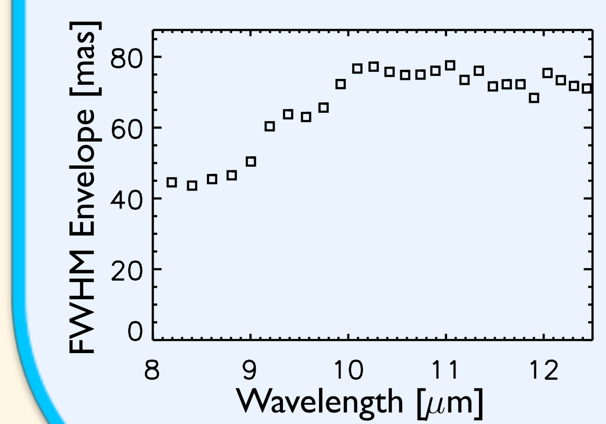
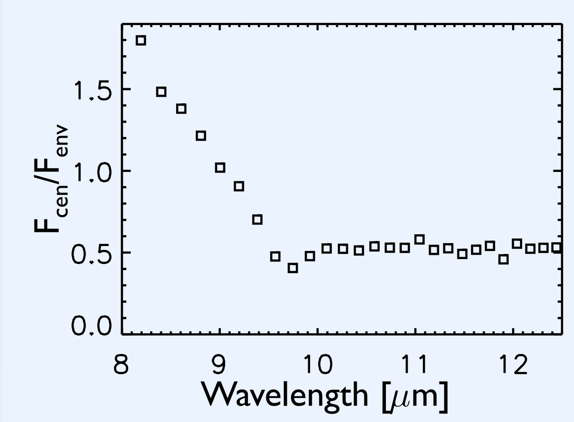


Fig.3. Disk-model visibilities (line) superimposed on the MIDI visibilities (shaded area).



The FWHM steeply increases from 8 to 10 μm

➔ This is a typical signature of a silicate-rich dusty environment



The flux ratio F_{cen}/F_{env} steeply decreases from 8 to 9.5 μm

➔ The emission of the central star becomes less effective at 9.5 μm due to the silicate dust obscuration

4. Conclusions

✧ With GEM-FIND we found two models that are able to reproduce the observations: Disk model and Binary model, proving that the close environment of SV Psc deviates significantly from sphericity.

✧ MIDI observations at larger baselines and position angles perpendicular to the binary axis are needed to fully discriminate between these two scenarios.

✧ A binary companion could be the origin of a disk-like density distribution. This has been shown by theoretical simulations (Mastrodemos & Morris 1999, ApJ, 523, 357) and could be tested with additional MIDI observations.

✧ Such a disk could be the reason of the broad feature that is visible in the CO line profile of the star.

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