First VLTI spectro-interferometry of a YSO with a spectral resolution of 12000: the gas distribution around the Herbig Be star MWC 297

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Introduction

Circumstellar disks play a fundamental role in the formation of stars and planets. The inner circumstellar region hosts fascinating astrophysical phenomena such as inner gaseous accretion disks, disk winds, jets, dust sublimation, etc. To obtain spatially resolved observations of these phenomena, milli-arcsecond angular resolution with high spectral resolution is needed. NIR interferometry with high spectral resolution is able to spatially resolve the gas and dust distribution in the innermost regions of disks and constrain their physical properties. Therefore, such observations allow us to probe the nature of the accretion process and the launching of jets and winds. For the more luminous Herbig Be stars, optically thick gaseous disks, which extend well inside the dust sublimation radius, seem to play an important role. Some of the observed emission lines are possibly emitted by matter which is either accreting or being ejected from the system, rather than from the gaseous disk itself.

The Herbig Be star MWC 297 is one of the closest (~ 250 pc), young, massive (~ 10 solar masses; B1.5V) stars (Drew et al. 1997). Previous interferometric observations (Millan-Gabet et al. 2001, Eisner et al. 2003, Monnier et al. 2006, Malbet et al. 2007, Acke et al. 2008, Kraus et al. 2008) have shown that the fitted radii of the IR emission region are much smaller than the 1500 K dust sublimation radius of ~ 3 AU.

MWC 297 Observations and Results

We report the first spectro-interferometric observations of the massive Herbig Be star MWC 297 with a spectral resolution of 12000 using VLTI/AMBER. This high spectral resolution is crucial for studying the visibilities and closure phases in several spectral channels within different Doppler-shifted parts of emission lines. The fringe tracker FINITO allowed us to use exposure times up to 8 s. Our VLTI/AMBER interferometry of MWC 297 shows the detailed wavelength dependence of the visibilities, closure phases, and differential phases within the Brackett γ emission line (see Fig. 1).

We derived the size and asymmetry of both the continuum- and the line-emitting region in many spectral channels within the Brγ line. At the center of the Brγ line, we obtained a Gaussian diameter (FWHM, continuum-subtracted) of 14 mas (3.5 AU; see Fig. 2). In the continuum, we fitted 2-component Gaussian models with FWHM diameters of 4.5 mas (~ 1 AU; dominant compact component) and 80 mas (weak extended halo component), i.e., the AMBER measurements resolve a compact circumstellar structure with a continuum radius (0.5 AU HWHM Gaussian) which is much smaller than the dust sublimation radius (~ 3 AU). The line-emitting region is approximately three times larger than the continuum-emitting region.

To explain the wavelength dependence of the visibilities and phases, we performed detailed 3-D radiative transfer modeling using a magneto-centrifugally driven disk-wind model of a compact disk inside the dust sublimation radius (Blandford & Payne 1982, Knigge et al. 1995, Kurosawa et al. 2006, Grinin & Mitskevich 1990, Tambovtseva et al. 2001) . Figure 3 shows intensity maps of one of our models at the center of the Brγ line and at velocities of ±30 km/s. Our results show that the best fit is obtained for disk wind models with large opening angles (up to 80 °) and inclination angles from 10 to 30 °.

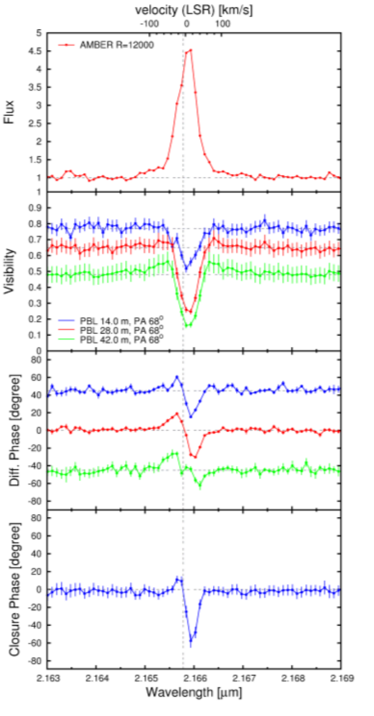

Figure 1 VLTI/AMBER spectro-interferometry of MWC 297 with a spectral resolution of 12000. The panels show (from top to bottom) the spectrum (Brγ line), the wavelength dependence of the visibility for 3 different baselines, the differential phases for the same 3 baselines, and the closure phase.

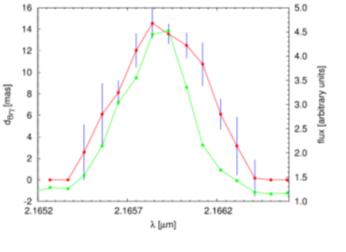

Figure 2 Size of the Brγ line-emitting region in approx. 10 spectral channels. The AMBER spectrum is shown for comparison (green line).

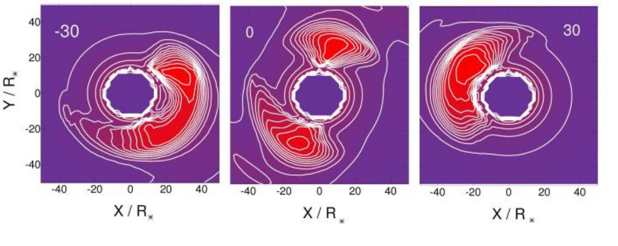

Figure 3 Intensity maps of one of the 3-D radiative transfer models of a magneto-centrifugally driven disk-wind (at the center of the Brγ line and at velocities of ±30 km/s; inclination angle 20°).