DETERMINING THE ORIGIN OF THE WIND IN HERBIG AEBE STARS: AMBER MEASUREMENTS OF AB AUR.

M. Benisty, J-P. Berger, F. Malbet, *Laboratoire d'Astrophysique de Grenoble, France - (Myriam.Benisty@obs.ujf-grenoble.fr)*, E. Tatulli, A. Isella, A. Natta, L. Testi, *Osservatorio Astrofisico di Arcetri, Firenze, Italy*, S. Kraus, G. Weigelt, *Max-Planck-Institut fur Radioastronomie, Bonn, Germany*, and the AMBER consortium.

1 Introduction

Herbig AeBe stars (HAeBe) are intermediate-mass pre-main-sequence objects that show remarkable signs of wind activity (Böhm&Catala, A&A 1993, 101, 629). Typical P-Cygni profiles are observed in the Balmer or other optical lines of both HAe and HBe stars (Finkenzeller&Mundt A&A, 1984, 55, 109). Large scale molecular outflows and optical jets are also detected (Mundt&Ray, ASPC, 1994, 62, 237) and the observed radio continuum emission is consistent with thermal emission by ionized winds (Skinner et al., ApJ 1993, 87, 217). In the IR, the spectra of these objects are often characterized by the presence of ionized (e.g. Fe+), neutral (e.g. HI, He) and molecular (CO, H2) emission lines. Such lines originate in the inner and warm regions of the disk, either in the *accretion region* connecting the disk to the star, in a *polar wind* from the star, or in an *outflow from the disk* (Nisini et al. ApJ 2002, 574, 246). They can therefore be used to probe such different environments.

Recent studies of HAeBe circumstellar environments suggested that the wind launching mechanisms are different for the HAe and for the HBe. First, Monnier&Millan-Gabet (ApJ 2005, 624, 832) presented the correlation between size and luminosity for a large sample of HAeBe observed with interferometry and noticed that the two groups don't follow the same evolution. Their models for the dust emission consist in accretion disks with different inner regions: for the HAe, the innermost part of the disk is a 'puffed-up' rim, with an empty central cavity, whereas for the HBe, the inner rim doesn't puff up and the cavity must be filled with optically thick gas. With the first spectrally dispersed interferometric observations of a YSO, Malbet et al. (A&A 2007, 464, 43) modelized the emission lines of a HBe with an expanding **stellar wind**. On the other hand, Tatulli et al. (A&A 2007, 464, 55) concluded that the emission lines from a specific HAe arise from a compact **disk wind** emitted very close to the inner rim location. Recently, Garcia Lopez et al. (A&A 2006, 459, 837) presented high resolution spectra for a sample of Herbig Ae and Be stars. The HBe show emission with very strong and relatively narrow lines, compared to the HAe. All these recent studies point towards **very different mechanisms at the origin of the outflow for the Herbig Ae and the Herbig Be stars**.

AMBER/VLTI **unique** combination of spatial and spectral resolutions permits to probe, measure and localize the extension of the gas and dust emissions at the AU scale in order to constrain the origin of the wind - whether it comes from a disk or from the star. In this abstract, we present very preliminary results obtained with AMBER/VLTI on AB Aurigae (A0Ve, d=144 pc) around the Br_γ emission line that traces the outflowing gas. These medium spectral resolution ($R = 1500$) observations are part of a large program that aims at spatially resolving the wind launching regions of Herbig AeBe stars on sub-AU scales.

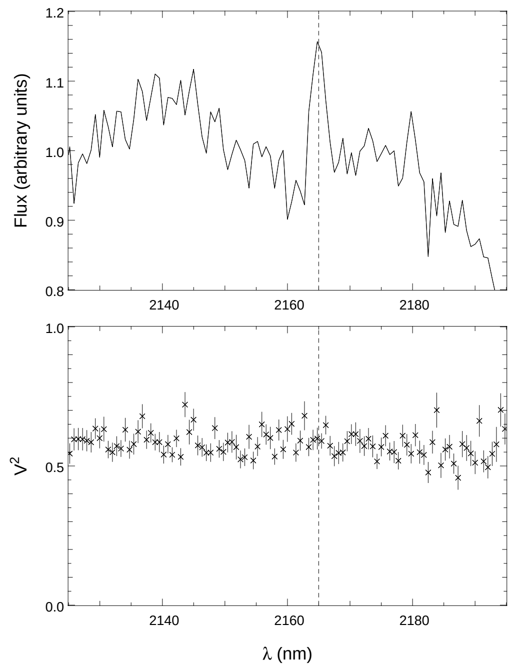

Figure 1: AMBER observations of the Herbig Ae star AB Aur with a spectral resolution of 1500. Top: in this raw AMBER spectrum, the Br_γ emission (dash line) is clearly visible. Down: the squared-visibilities don't present any clear changes across the line compared to the continuum.

2 Observations and data reduction

These AMBER observations were made in December 2005, with a 43-meters projected baseline at the VLTI, using two UTs (UT3-UT4). The spectral medium resolution of 1500 was used to probe a spectral range of [2.10-2.26] around the Br_γ emission line. We recorded 5 files of 250 frames, each of the latters with a 100ms integration time.

The data is of bad quality due to the faint magnitude of the star (K=4.5 is at the limit of the current AMBER capacity in medium resolution due to the existence of UTs vibrations on the VLTI). The data was pre-processed by the AMDC code (Li Causi et al. 2007, in prep.) in order to remove the spurious fringes due to the detector itself that could bias the visibilities. No selection within the frames was made in order to maintain as much statistics as possible. Data reduction was done with

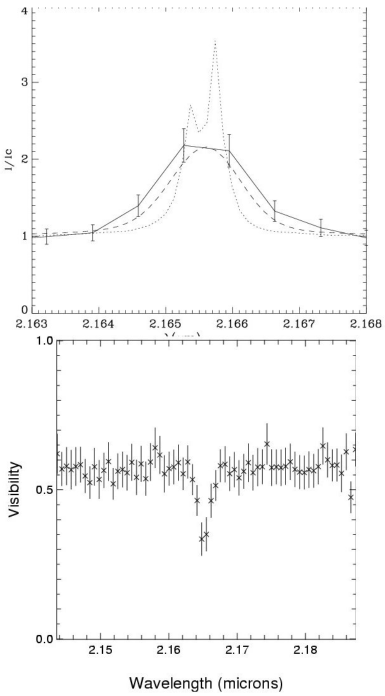

Figure 2: AMBER observations of the Herbig Be star MWC297. Top: the Br_γ emission line is very strong. The dotted line is a high resolution ISAAC spectrum (R=9200) while the solid line was obtained with AMBER (R=1500). Down: the squared-visibilities present a very clear drop across the line compared to the continuum.

the AMBER Data Reduction Software, provided by the JMMC (v 2.0) following the data processing presented in Tatulli et al. (2007 A&A 464, 29).

In this abstract, we present **spectrally dispersed visibilities** which absolute level was determined using measurements made by previous authors (Eisner et al. 2004, ApJ, 613, 1049). We therefore aim at giving an estimation of the **relative** geometry between the gas (line visibilities) and the dust (continuum visibilities) of AB Aurigae.

3 Results and discussion

Although AB Aurigae's environment is complicated, its near-infrared emission was modelized with a ring-like structure located at the dust sublimation radius (Eisner et al. 2004, ApJ, 613, 1049; Millan-Gabet et al. 2006, ApJ, 645, 77; Isella et al. 2007, A&A, 451, 951). This 'puffed-up' inner rim model leads to an optically thin inner cavity, consistent with the small accretion rates derived by Garcia Lopez et al. 2006 for the Herbig Ae. Following Eisner et al. 2004, we take R=0.40AU (ie 3.2mas) for the extension of the K-band emission. Fig.1, lower pannel, shows the AB Aur visibilities over wavelength: within the error bars, the **visibility does not change across the Br_γ line**, even if the photometric signal clearly shows an emission of 30% above the continuum (see Fig.1, top pannel). This means that, within the error bars, the continuum emission from the surrounding dust is of similar extent than the gas emission in the K-band.

Until now, few competing models involving stellar-driven or disk-driven winds have successfully fitted the observables obtained by spectroscopy and spectro-polarimetry and two main classes of wind models have been proposed for low-mass stars, depending on the geometry of the magnetic field lines: the disk wind (Casse&Ferreira, A&A 2000, 361, 1178), resulting of the interaction of an accreting disk with the disk magnetic field, and the X-wind (Shu et al., ApJ 1994, 429, 781) that originates at the corotation radius of the disk and that is due to the interaction of an accreting disk with the stellar magnetic field. Recent detections of rotation signatures seem to favor the disk wind model for the T Tauri stars (Ferreira et al., A&A 2006, 453, 785). On the other hand, expanding uncollimated stellar winds (Be stars; Stee et al., A&A 1995, 300, 219) could explain some of the observed features of more massive young stars. It is in fact this kind of model that was used to explain the AMBER observations of MWC297, a Herbig Be star. For this star, a clear drop in visibility was observed across the Br_γ line pointing towards a larger extent of the gas emitting region compared to the dust continuum emission. Fig.2 gives the observed spectrum (top pannel) and visibilities (lower pannel).

To explain our observations - for which no change in visibility was observed - we are currently studying various scenarios in order to give spatial constraints to the wind emission. If the Br_γ line was emitted within **magnetospheric accreting** columns, it would require the line emitting region to be inside the corotation radius. In that case, it would have a smaller size than the inner rim of the disk, responsible for the continuum emission, and one should see a clear increase in visibility across Br_γ. If the line was emitted by the **gaseous disk** inside the dust sublimation radius, the visibility should also present an increase. If the line was emitted in an **outflowing wind** of extension larger than the disk - like in MWC297, see Fig.2 - the visibility should increase. Since none of these is observed, we confirm the trend suggested by Tatulli et al. 2007 for which the Herbig Ae stars may have an **outflowing disk-wind** originating very close to the disk inner rim, at a few tenth of AU from the star - in contrast with the results obtained on MWC297, a Herbig Be star.

4 Conclusion

Our AMBER spectrally dispersed measurements delivered no difference between the continuum emission due to the dust and the Br_γ emission, due to the gas, even if the emission line is clearly detected in the photometric measurements. This means that the dust and line emissions have similar extents which most probably implies that an outflowing disk-wind originates very close to the disk inner rim.