CONSTRAINING THE WIND LAUNCHING REGION IN HERBIG AE STARS: AMBER/VLTI SPECTROSCOPY OF HD 104237.

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The spectra of pre-main sequence stars of all masses show prominent strong and broad emission lines of both hydrogen and metals. These lines trace the complex circumstellar environment that characterizes this evolutionary phase, and are very likely powered by the associated accretion disks. The emission lines are used to infer the physical properties of the gas, and to constrain its geometry and dynamics. Their exact origin, however, is not known. The hydrogen lines, in particular, may originate either in the gas that accretes onto the star from the disk, as in magnetospheric accretion models (Hartmann et al. 1994), or in winds and jets, driven by the interaction of the accreting disk with a stellar (Shu et al. 1994) or disk (Casse et al. 2000) magnetic field. For Herbig Ae stars, it is additionally possible that they form in the inner disk (Tambovtseva et al. 1999). For all models, emission in the hydrogen lines is predicted to occur over very small spatial scales, a few AUs at most. To understand the physical processes that occur at these scales, one needs to combine very high spatial resolution with enough spectral resolution to resolve the line profile. AMBER, the three-beam near-IR recombiner of the VLTI, simultaneously offers high spatial and high spectral resolution, with the sensitivity required to observe pre-main sequence stars.

In this Poster we show AMBER observations of the Herbig Ae system HD104237 (see Tatulli et al. 2007). The central emission line star, of spectral type between A4V and A8, is surrounded by a circumstellar disk, which causes the infrared excess emission and drives a jet seen in Ly-α images (Grady et al. 2000). The optical spectrum shows a rather narrow Hα emission with a P-Cygni profile. The disk is seen almost pole-on ($i = 18^{\circ}{}^{+14}_{-11}$; Grady et al. 2001), consistent with the low value of $\mathrm{v}\sin i$ (12 km s^{-1}). Donati et al. (1997) detected a stellar magnetic field of 50 G. Böhm et al. (2004) have revealed the presence of a very close companion of spectral type K3, orbiting with a period of ~ 20 days, and whose bolometric luminosity is 10 times fainter than the one of the central star. In the near infrared domain, spatially unresolved ISAAC observations (Garcia Lopez et al., 2006) show a strong $\mathrm{Br}\gamma$ emission line, with a peak flux 35% above the continuum.

Within the fairly small error bars, the visibility does not change across the $\mathrm{Br}\gamma$ emission line (Fig. 1). This result is robust and puts strong constraints on the relative spatial extent of the line and continuum emission regions, demonstrating that they have very similar apparent sizes. We use this constraint to probe the processes responsible for the the $\mathrm{Br}\gamma$ emission in this star, and consider in turn the three main mechanisms usually invoked to interpret the hydrogen line emission in pre-main-sequence stars: magnetospheric accretion, gas in the disk and outflowing wind. We translate each mechanism to simple geometrical models of specific spatial extension, with the line strength fixed at the observational value, and evaluate the resulting visibility across the line.

Scaling the continuum visibility with a “puffed-up” inner rim model, we show that the line emission is unlikely to originate in either magnetospheric accreting columns of gas or in the gaseous disk. It is much more likely to come from a compact outflowing disk wind launched in the vicinity of the rim, about 0.5 AU from the star (see Fig. 2). This does not preclude accretion from occuring along the stellar magnetic field detected by Donati et al. (1997), and accreting matter might even dominate the optical hydrogen line emission, but our observations show that the bulk of the $\mathrm{Br}\gamma$ emission in HD 104237 is unlikely to originate in magnetospheric accreting matter.

Our results show that AMBER/VLTI is a powerful diagnostic of the origin of the line emission in young stellar objects. Observations of a consistent sample of objects will strongly constrain the wind launching mechanism.

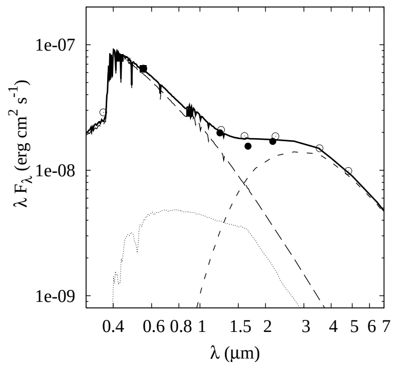

Figure 1: Left: SED predicted by the "puffed-up" rim model (Isella and Natta, 2005) used to normalise the K-band continuum visibility. The contributions of the A star (long-dashed line), the K3 star (dotted line) and the rim (short dashed line) are shown (see the text for the stellar parameters). Center: Comparison of $\mathrm{Br}\gamma$ observed with AMBER in the photometric channels (solid line) and ISAAC (dotted line); the dashed line shows the ISAAC spectrum smoothed to the spectral resolution of AMBER. Right: Visibility of HD 104237 as a function of wavelength. The continuum has been normalised using the star + rim model, as described in the text. The vertical line shows the $\mathrm{Br}\gamma$ wavelength.

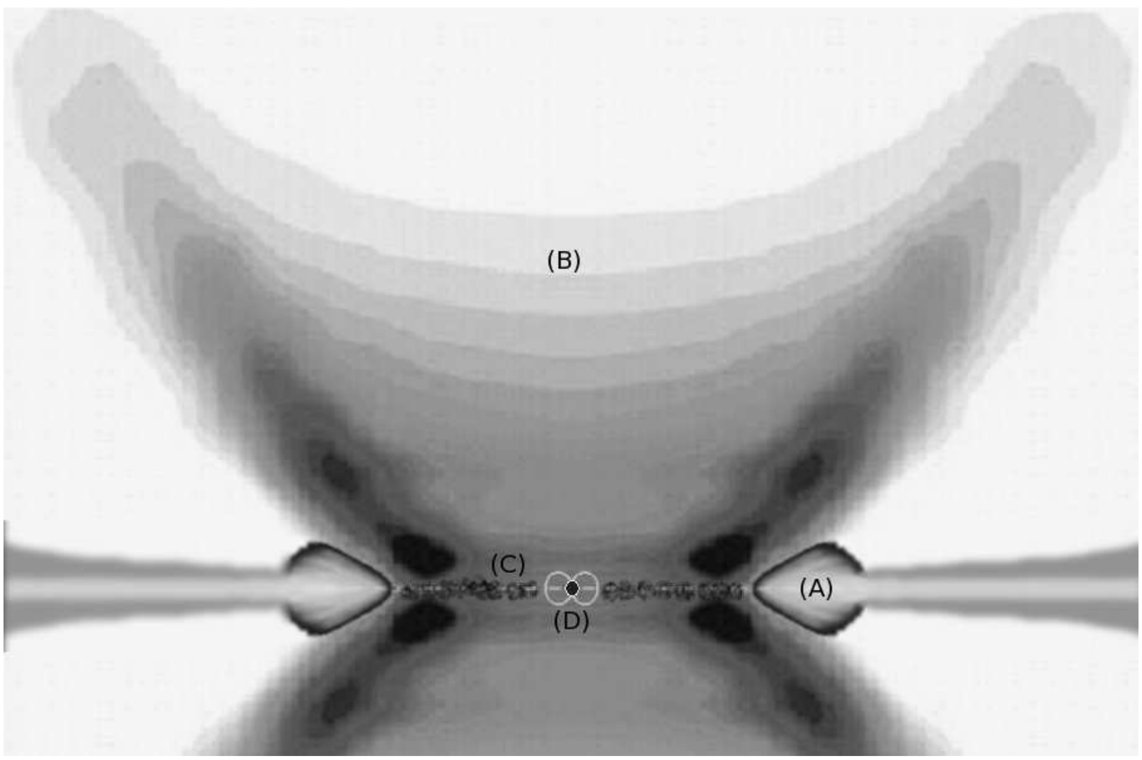

Figure 2: Pictorial conception of the inner part of the HD 104237 circumstellar disk obtained from the combination of the "puffed-up" inner rim model of Isella & Natta (2005) and the wind model of Thiébaut et al. (2003). In this vertical section on the disk, the intensity of the NIR emission is indicated with the gray color scale with the black corresponding to the highest emission. (A) The dusty disk inner rim, located at the dust evaporation radius of 0.45 AU, emits more than 80% of the total NIR emission. (B) The spatially resolved $\mathrm{Br}\gamma$ emission is consistent with a diffuse wind propagating by the disk region at $R<0.45$ AU. (C) The gas existing inside the dust evaporation radius is settle on a geometrically thin disk. (D) For R less than 0.1 AU the gas is captured by the stellar magnetic field and moves towards the stellar surface forming ionized accretion columns (Hartman et al. 1998).