An interferometric view of protoplanetary inner disks : constraining the dust size and the wind launching region

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We adopted the *puffed-up inner rim* model (Isella and Natta, 2005) to analyze near infrared interferometric observations of the best observed Herbig Ae stars. Our analysis is based on the assumption that the inner disk structure is controlled by the silicate evaporation temperature through its dependence on the gas density. The model is used to fit the observations and to determine both the dust properties and the orientation in the sky of the inner disk. In four cases, silicate grains larger than 1.2µm are either required by or consistent with the observations (Isella, Testi & Natta, 2006). When applied to the new VLTI/AMBER interferometric observations, our model allows to constrain the wind lauching region as seen through the Brγ line emission. In the case of the Herbig Ae star HD104237 we conclude that the observed emission arise from a compact disk wind, with a spatial extent similar to that of the near infrared continuum emission region (Tatulli et al.2006).

The structure of protoplanetary inner disks

The model developed to analize the near infrared excess observed around the most of the Herbig Ae stars, assumes that the circumstellar dusty disk is internally truncated by the dust evaporation and that the structure of the inner rim is controlled by the dependence of the grains evaporation temperature on the gas density. Circumstellar disks are characterized by a very large variation of the density in the vertical direction, so that the dust evaporation temperature varies by several hundred degrees in a few scale heights; moving vertically away from the disk mid plane, dust will evaporate at lower and lower temperatures, i.e., further away from the central star. Our numerical models show that the bright side of the inner rim is naturally curved and is the domimant source of near infrared radiation (see Fig 1). Assuming the dust model of Pollack et al. (2004), the location of the inner rim strongly depends on the dimension of the silicate grains: due to their higher cooling efficiency, micron size grains survive twice as close to the central star than much smaller grains. Measuring the inner rim radius we can thus use our model to constrain the dust grain size on the disk midplane.

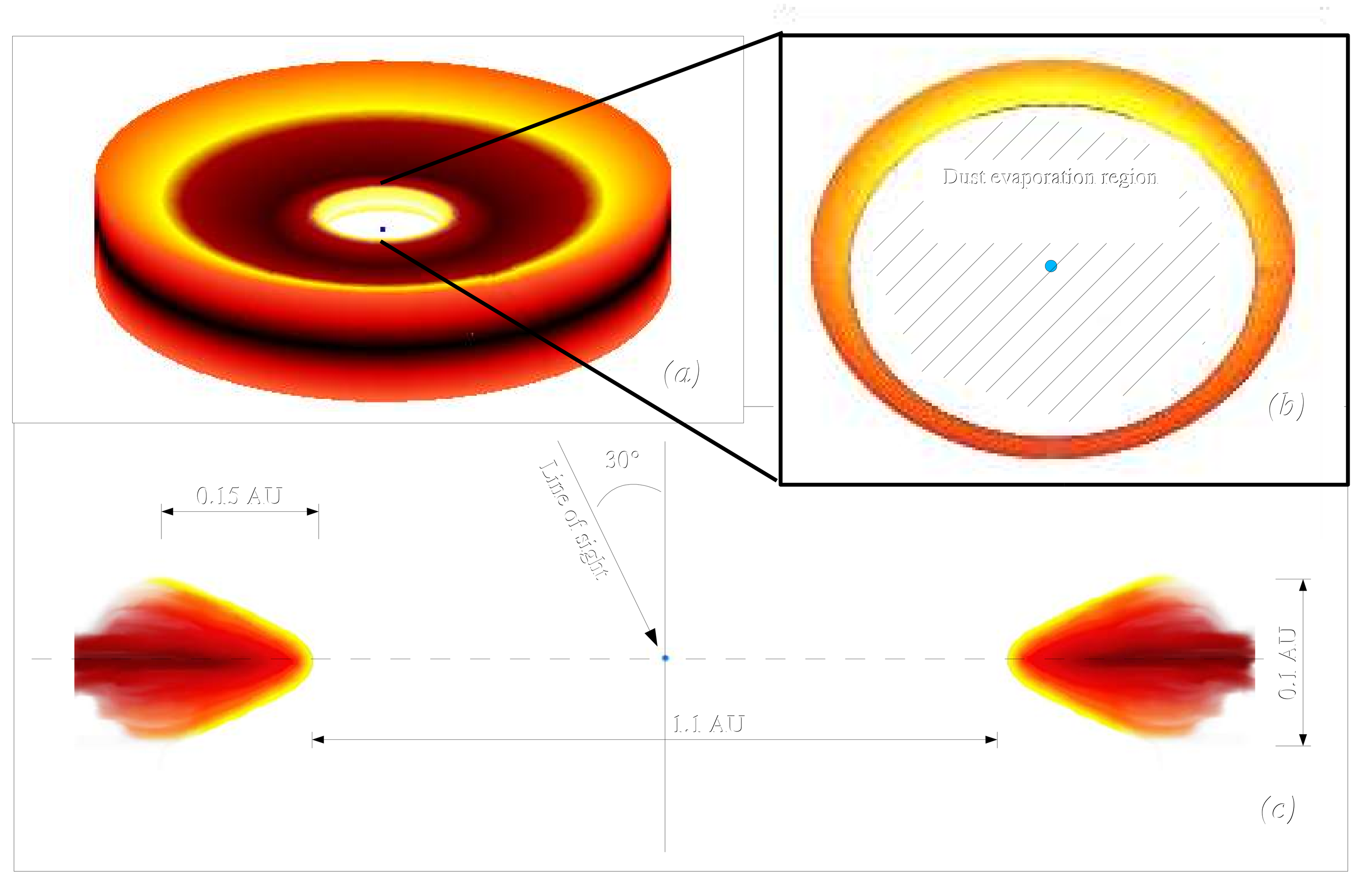

Fig. 1 Sketch of structure of the inner disk for a fiducial Herbig Ae star. (a) The dust evaporation produces a dust-depleted inner hole and a *puffed-up inner rim*. (b) The inner rim appears as a bright ring in the sky and can be observed with the new NIR-interferometers. (c) The vertical section of the inner rim shows that the bright surface of the rim is curved, while the inner radius depends strongly on the dust grain size.

Large dust grain in the inner region of protoplanetary disks

We used the *puffed-up inner rim* model to analyze the near infrared interferometric observations of the six best observed Herbig Ae stars: in four cases, dust grains larger than 1.2µm are either required by or consistent with the observations (Isella et al. 2006). The results shown in the table have been obtained through a model fitting in the UV plane, varying independently the dust grain radius *a*, the inclination ι and the position angle PA. The inner radius R_{in} is NOT an independent variable. For MWC758 (see also Fig. 2), VV Ser and CQ Tau, the available observations constrain both the structure of the inner rim and its orientation in the sky. For V1295 Aql and MWC 480, many different disk models are in agreement with the observations and the constraint on the disk parameters is poor. In the case of AB Aur, no model can reproduce the observations. The table also shows that our values of inclination and PA are in good agreement with those obtained by millimetric interferometric observations (Mannings & Sargent 1997; Testi et al. 2003) and relative to the outer region of the disks.

Source	IN05 model				mm	
	a (µm)	R_{in} (AU)	ι (deg)	PA (deg)	ι (deg)	PA (deg)
MWC 758	≥ 1.2	0.32	38^{+3}_{-3}	144^{+5}_{-9}	46	116^{+6}_{-5}
VV Ser	≥ 1.2	0.69	51^{+2}_{-2}	115^{+6}_{-3}		
CQ Tau	$0.25 \div 1.2$	$0.16 \div 0.25$	$41 \div 56$	$144 \div 188$	63^{+10}_{-15}	2 ± 13
V1295 Aql	$0.25 \div 1.2$	$0.7 \div 1.2$	$40 \div 65$			
MWC 480	$0.2 \div 0.3$	$0.53 \div 0.63$	$30 \div 60$		$26 \div 38$	$148 \div 170$
AB Aur	impossible to fit				$15 \div 35$	$50 \div 110$

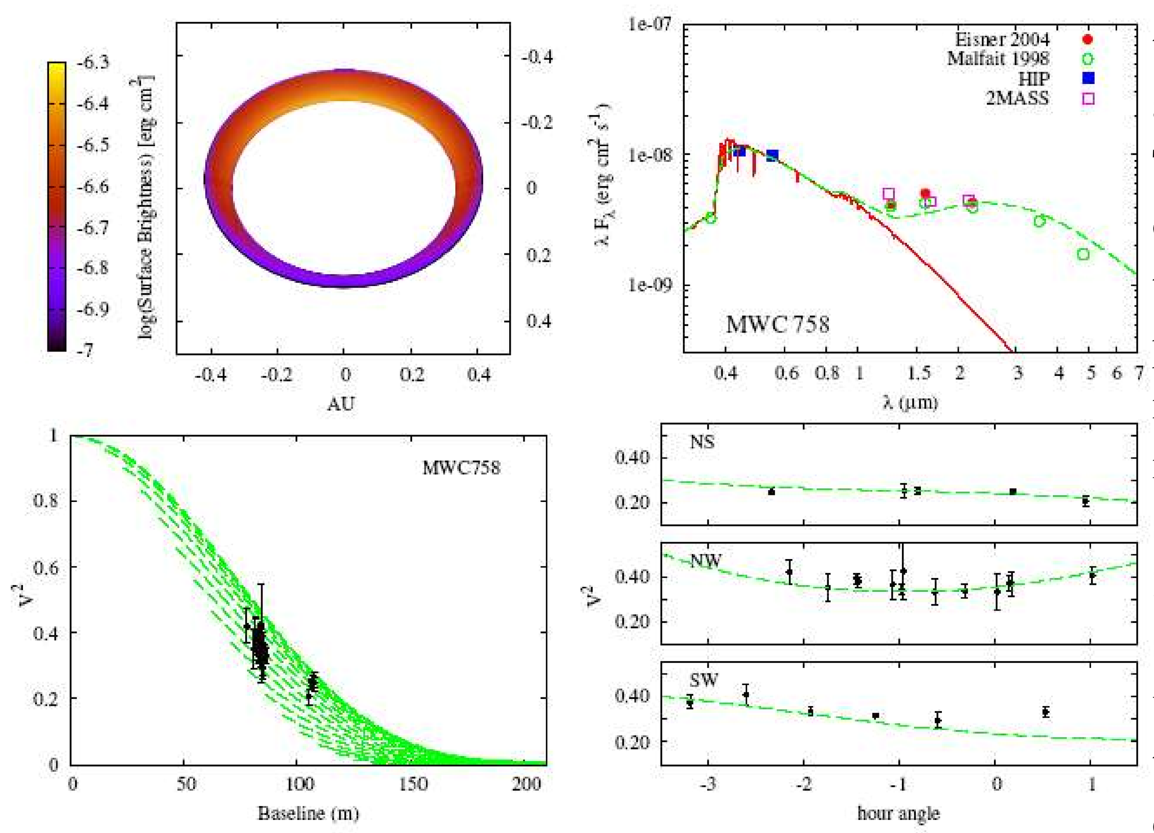

Fig. 2 Inner rim model for the star MWC 758 obtained analysing the Palomar Testbed Interferometer observations at 2.2µm. The top-left panel shows the predicted image of the inner rim, characterized by an inner radius of 0.32AU seen under an inclination of 38°. The bottom-left panel shows the corresponding visibilities as function of the baseline length (green dashed line) and the observed visibilities (dots) with the relative error bars. The three bottom-right panels show the comparison between the observed and the predicted visibilities for each of the three available PTI baselines as function of the hour angle of the star in the sky. Finally, the top-right panel shows the comparison between the observed flux and the predicted SED.

Wind launching region: AMBER/VLTI spectoscopy of HD104237

We investigate the origin of the Brγ emission of the Herbig Ae star HD104237 on Astronomical Unit scales. Using AMBER/VLTI at spectral resolution R=1500 we spatially resolve the emission in both the Brγ line and the adjacent continuum. The visibility does not vary between the continuum and the Brγ line, even though the line is well detected in the total photometric spectrum. This demonstrates that the line and the continuum emission have similar size scale. We assume that the K-band continuum excess originates in the *puffed-up inner rim* of the circumstellar disk, and discuss the likely origin of Brγ (Tatulli et al. 2006). We conclude that this emission arises from a compact disk wind, lauched from a region at 0.2-0.5 AU from the central star, very close to the inner rim location.

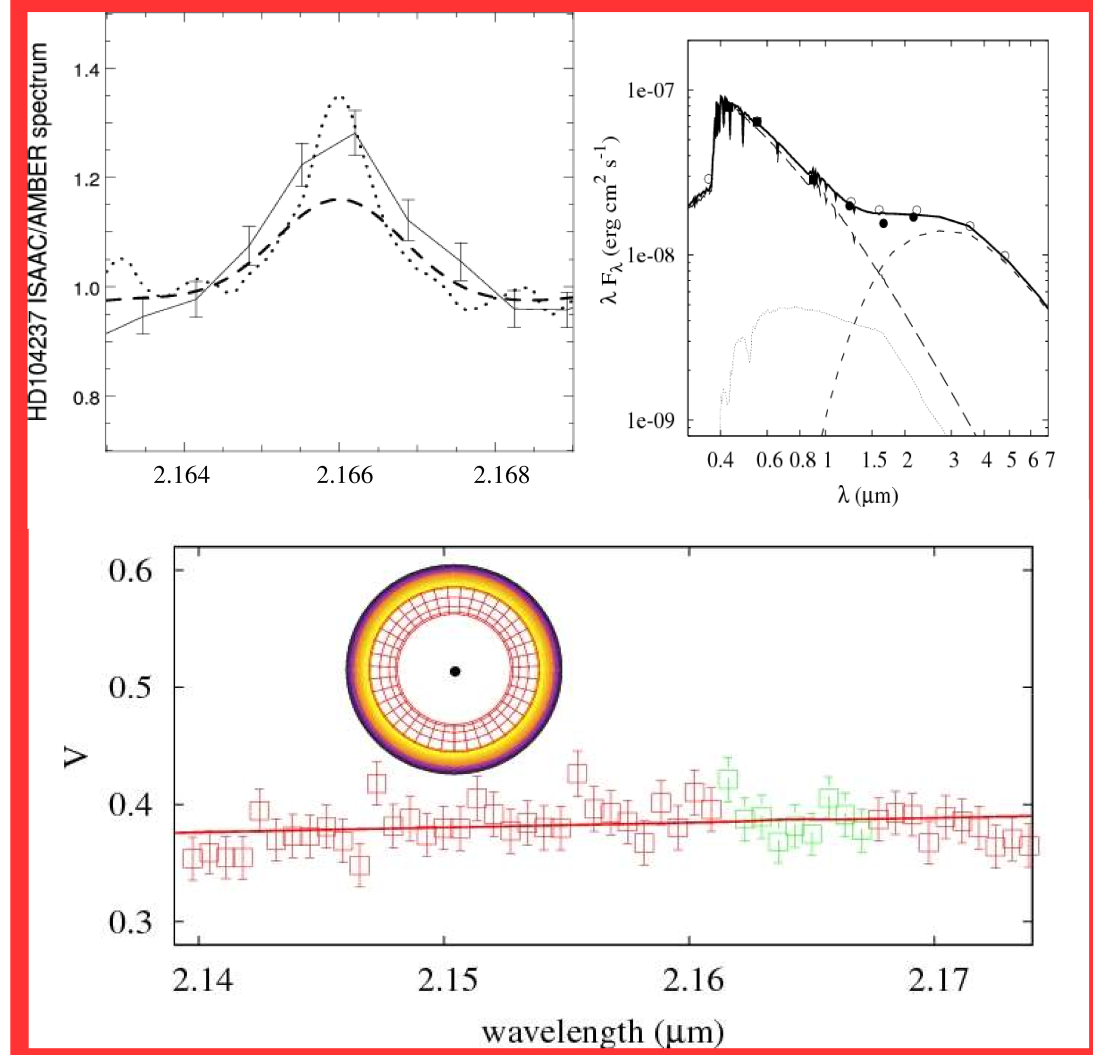

Fig. 3 *Upper-left* panel: Amber spectrum (solid line) of the Brγ line compared with the ISAAC spectrum (dotted-line). *Upper-right* panel: SED predicted by *the puffed-up inner rim model* (solid line) compared with the available photometric values. The contributions of the pricipal A star (long-dashed line), the K3 companion (dotted line) and the rim (short dashed line) are shown. *Bottom panel:* comparison between the observed visibilities (empty squares) and the model prediction (solid curves) for the Brγ emission (sketched in the same panels). The continuum emission arises both from the stellar photosphere (30%) and from the dusty disk inner rim, located at the dust evaporation distance (0.45AU). The Brγ emission region (shown as grid surface) is confined close to the inner rim, between 0.2 and 0.5 AU.

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