The structure of protoplanetary disks surrounding three Herbig Ae/Be stars

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[1] Introduction

We resolve the distribution of gas in the circumstellar disks of 3 Herbig stars – young intermediate mass stars surrounded by an optically thick circumstellar disk in which planet formation is currently on-going – by fitting very high resolution (R = 77000) optical spectra of the 6300 Å [OI] line originating from the upper layer of circumstellar disks.

[2] Targets and Observations

We have observed the 3 southern Herbig stars listed in table 1 with the UVES (echelle spectrograph) on the ESO VLT. Two of these objects are classified as 'group I' – indicating that they are surrounded by a flared circumstellar disk - and the other is a 'group II' - Indicating a more flat, self shadowing disk – as shown in Figure 4. The resulting observations are shown in Figures 1-3.

[3] Method

Acke et al. (2005; A&A 436, 209) have established that most of the emission (typically >90%) in the 6300 Å [OI] line is not thermal but rather originates from the photo-dissociation of H_2O and OH molecules by stellar UV flux. We assume that this emission originates from the surface layer of a circumstellar disk in Keplerian rotation and have built a model that reconstructs the amount of emitting gas as function of radius.

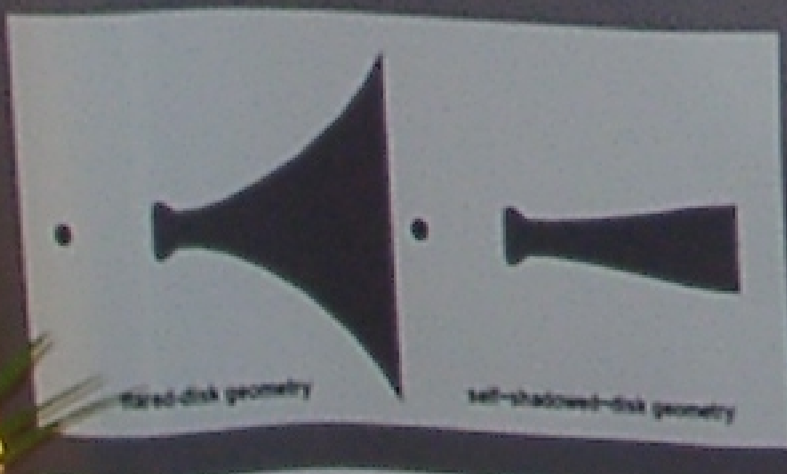

Figure 4. The flared (left, group I) and flat, self shadowed (right, group II) disk models.

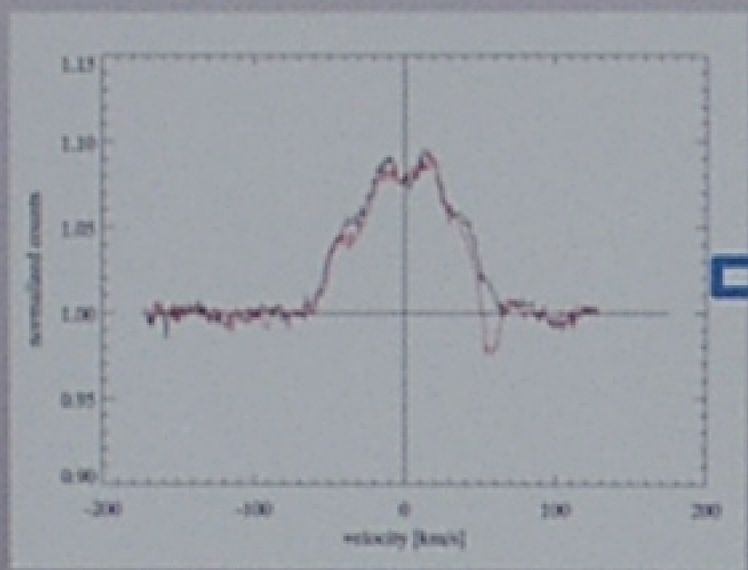

Figure 1. The normalized spectrum of HD 101412, converted to velocity around 6300 Å. The 2 lines indicate observations taken at different dates.

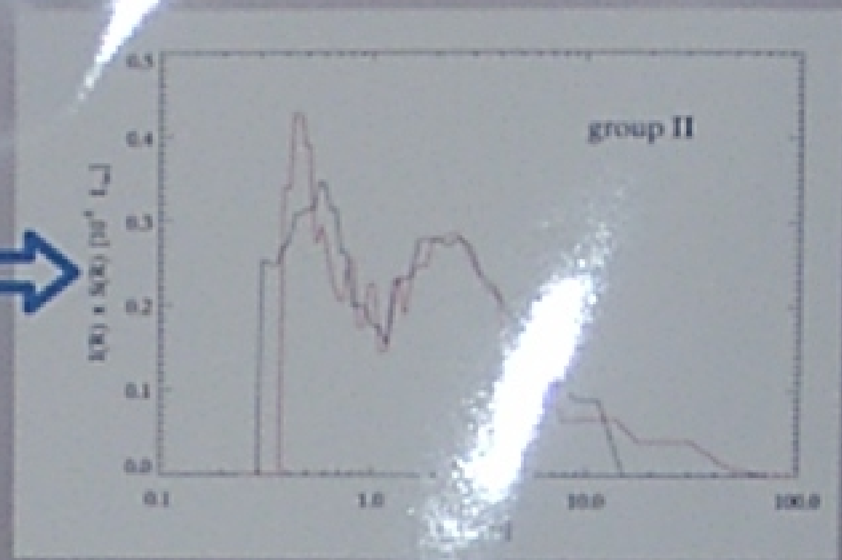

Figure 5. The Intensity versus radius profile of HD 101412 showing the distribution of [OI] emission as a function of distance from the central star. The two lines refer again to data from different dates.

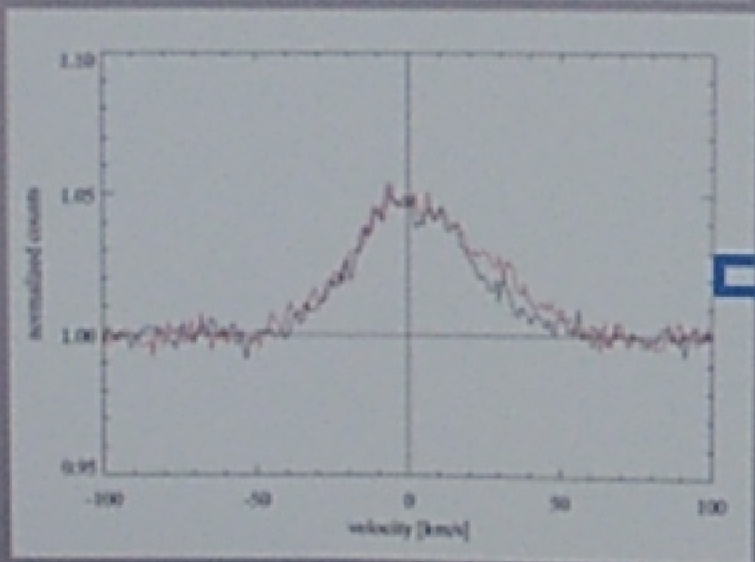

Figure 2. Same as Figure 1 for HD 179218.

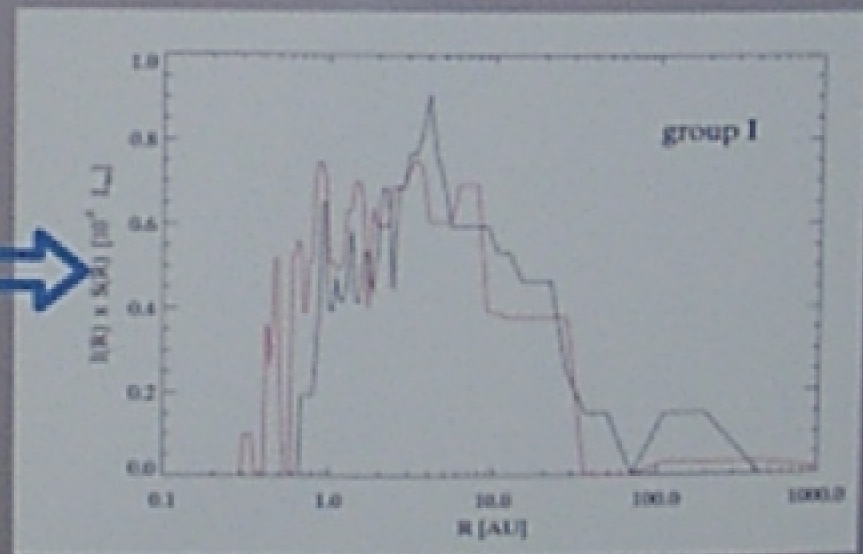

Figure 6. Same as Figure 4 for HD 179218.

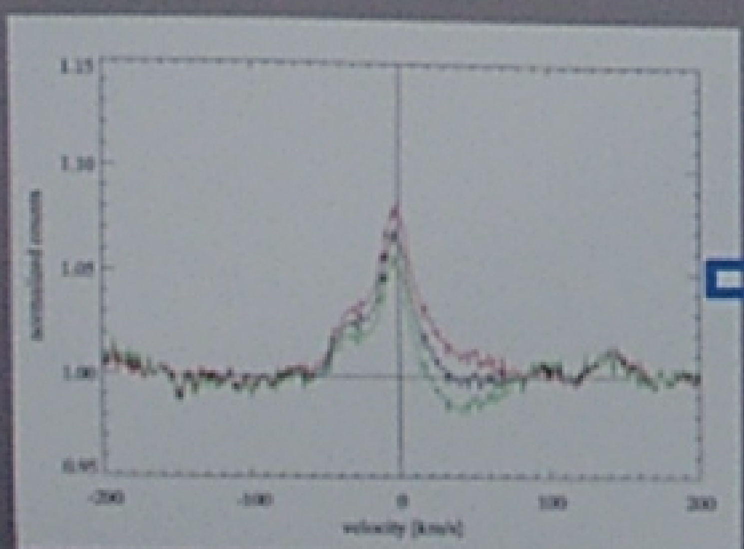

Figure 3. Same as Figure 1 for HD 135344. Here the 3 lines denote 3 models used to correct for photospheric absorption.

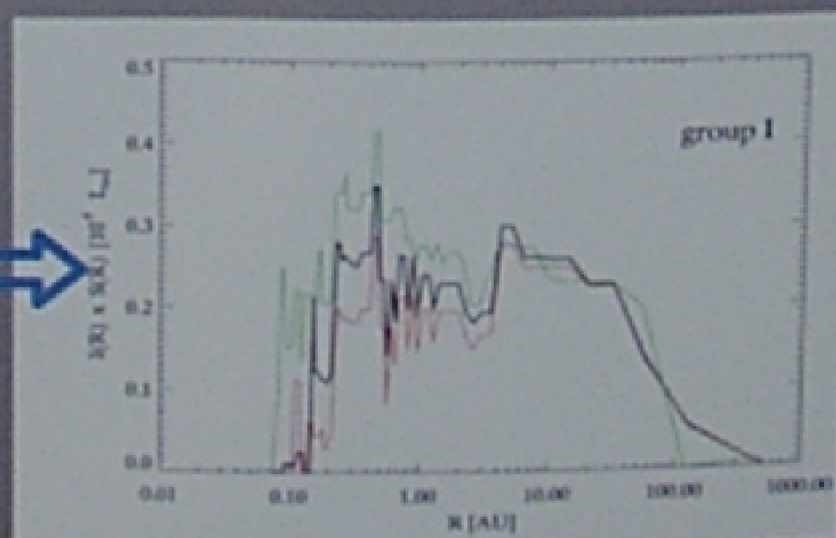

Figure 7. Same as Figure 4 for HD 135344. Just like in Figure 3, the 3 lines refer to different models rather then to data taken on different dates.

[4] Results & Discussion

A difference between the two group I and the group II sources can clearly be seen. The amount of [OI] emission of HD 101412 in figure 5 shows a clear drop at 1 AU, whereas HD 135344 and HD 179218 show a more continuous profile that extends to a greater distance from the central star. We speculate the gap in HD 101412 to be caused by the shadow cast on the disk by the 'puffed up' inner rim of the disk. The further extending emission of the two other sources could be caused by the flaring disk, capturing more UV photons at larger distances.

[5] Future work and relevance to VLTI

In order to compare e.g. how well the gas and dust are coupled in these object we have also made VLTI/MIDI observations to obtain spatially resolved observations of the 10 micron silicate bump. This dust emission originates from the same region as the [OI] emission and the combination of these two observations will provide us with a valuable tool to study this coupling.

Table 1. Stellar parameters

Name	Spectral Type	$\log T_{eff}$ log [K]	$\log L_{bol}$ log [$L_\odot$]	L_{IRE} [L_*]	M [$M_\odot$]	Distance [pc]	v_{rad} [km/s]	vsini [km/s]	[OI] flux [$L_\odot$]	Inclination [°]	Group
HD101412	B9.5Ve	4.02	1.40	0.27	2.3 ± 0.2	160	16.9 ± 0.2	8 ± 1	8.94 10^{-12}	≤89.2	II
HD135344	F4Ve	3.82	1.01	0.43	1.7 ± 0.2	140	1.6 ± 1.3	75 ± 5	1.61 10^{-11}	45, 11	I
HD179218	B9e	4.02	1.88	0.28	2.7 ± 0.3	240	15.4 ± 2.3	72 ± 5	3.33 10^{-11}	40	I