Star-disk interaction in young intermediate-mass stars

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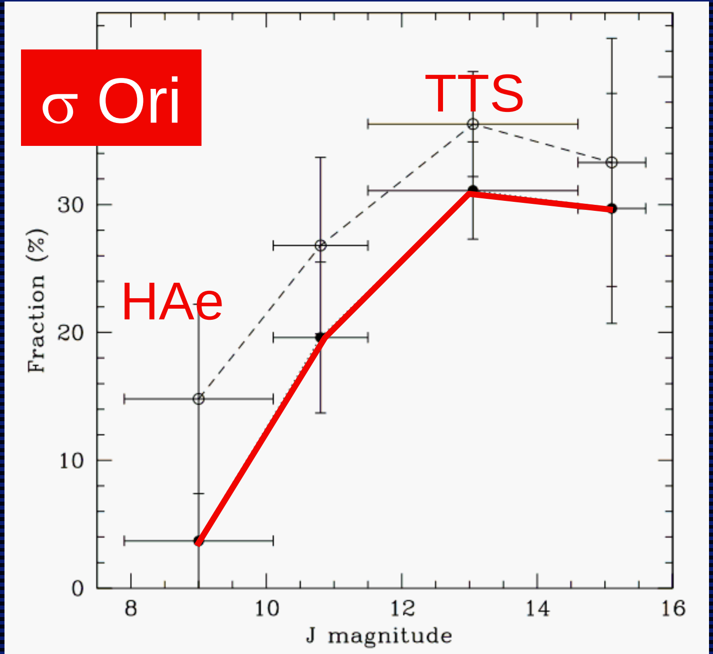
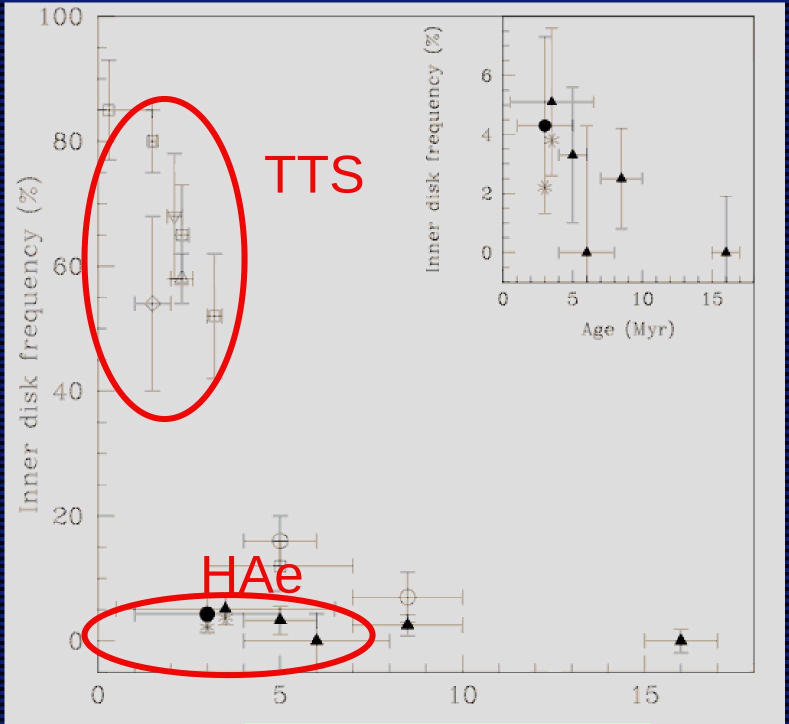
The sample of active intermediate-mass stars

Very few in star-forming regions



Hernandez et al. 2007

Fig. 12.— Disk … mass range (see Figure 11) … Solid circles + dotted line indicate thick disks fraction. Open circles + dashed line are the fraction of disk-bearing stars. The lowest disk fraction is observed in the HAeBe mass range, while the highest frequency of disks is observed in the TTS mass range.



Hernandez et al. 2005

FIG. 10.—Inner disk frequency as a function of the age of the stellar group.

Why?

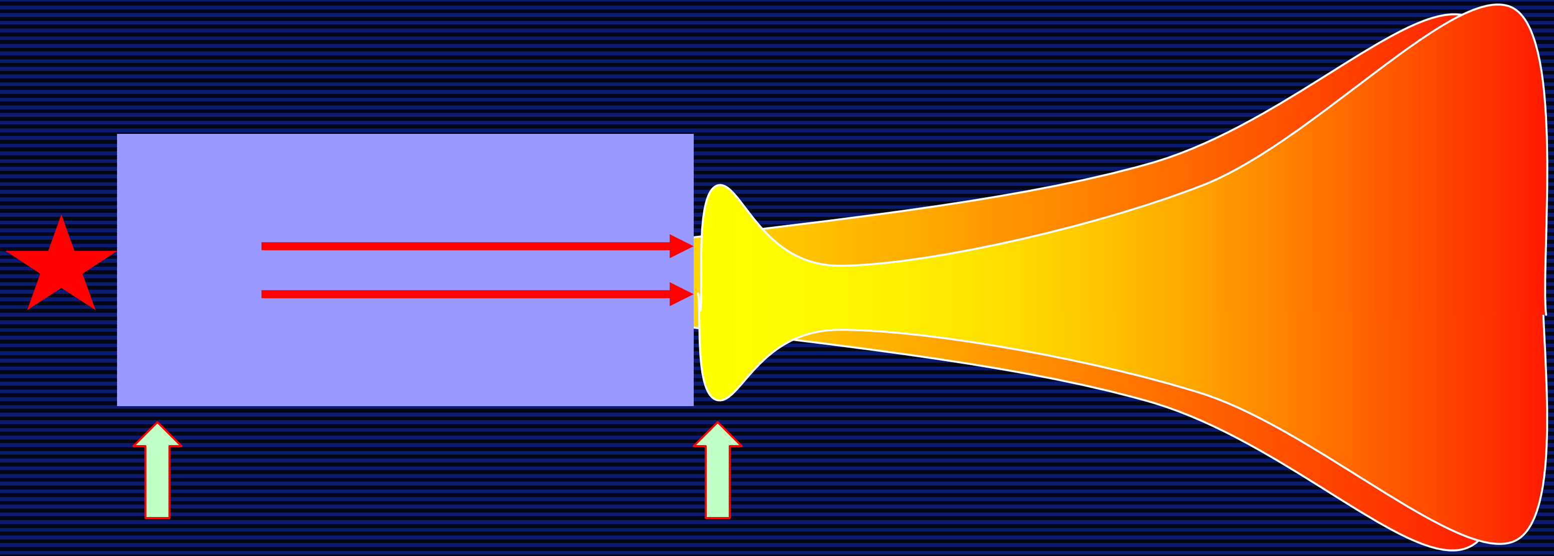
The Herbig AeBe stars

- A non-homogeneous sample
- Not in star forming regions, many are “isolated”

The Herbig Ae - late Be look similar to TTS

But we should not forget that they may be survivors, i.e., very exceptional objects

Inner disk: rims

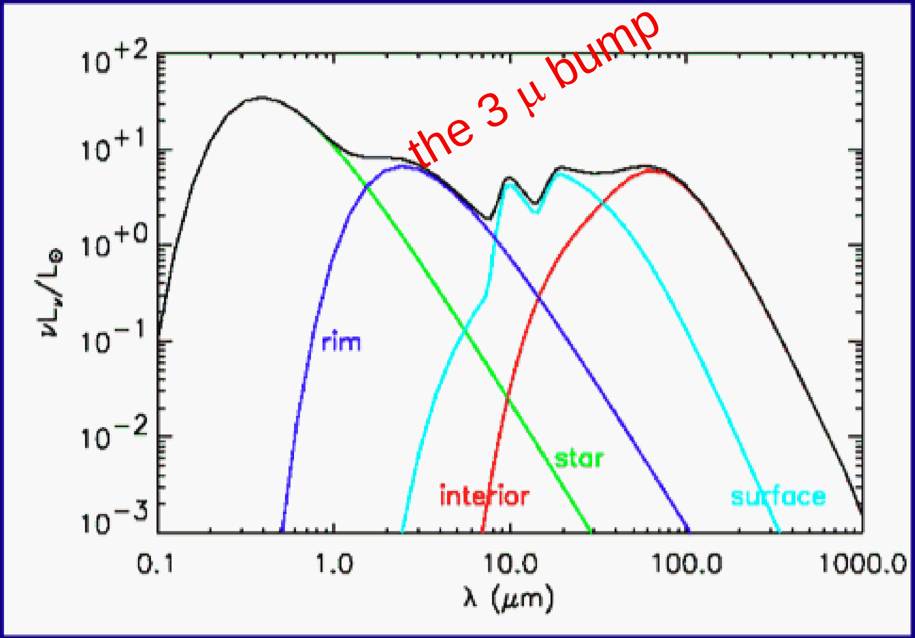


- The edge of the disk is always at the dust evaporation temperature
- It is further away from the star
- The rim is hotter than the disk behind it: it puffs-up

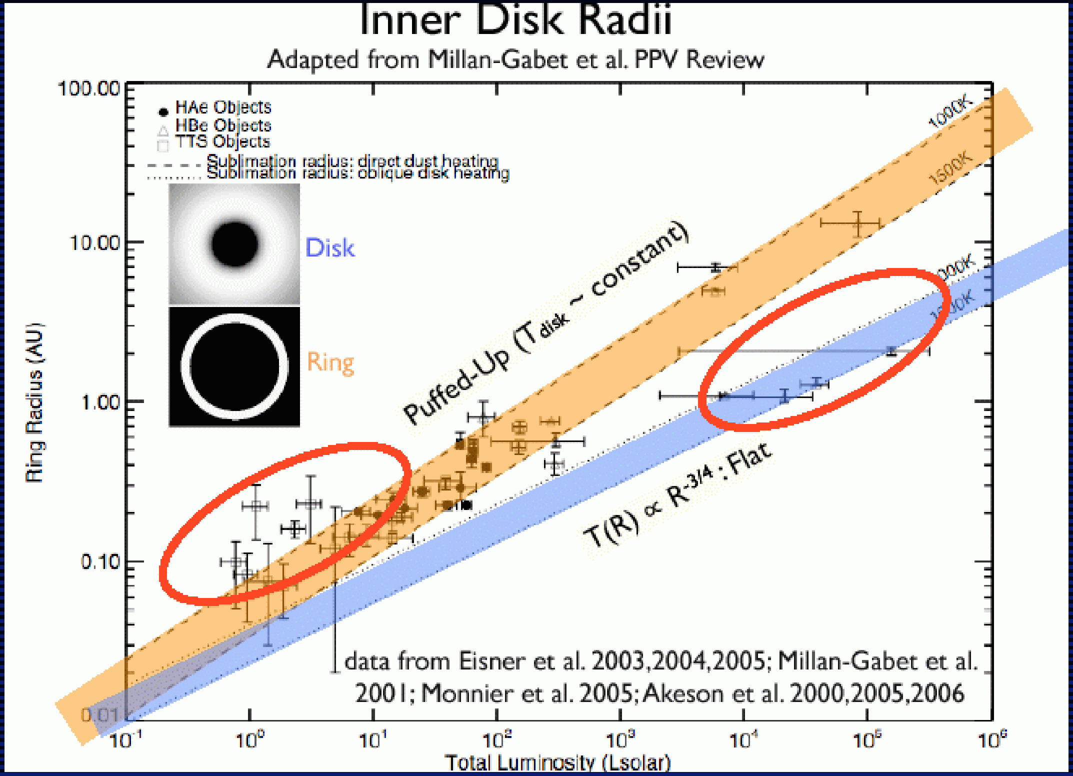
Natta et. al (2001)
Dullemond et al. (2001)
Isella & Natta (2006)

Why think of it? The SED of HAe stars

- HAe stars have a large excess in the near-IR (10-25%), which peaks at about 3μm
- It is not possible to reproduce the shape and intensity of this excess with flared or flat disk models
- A puffed-up rim works, it has the right temperature and intercepts the right fraction of L_*



Near-IR interferometry results: "empty" rings on the sky



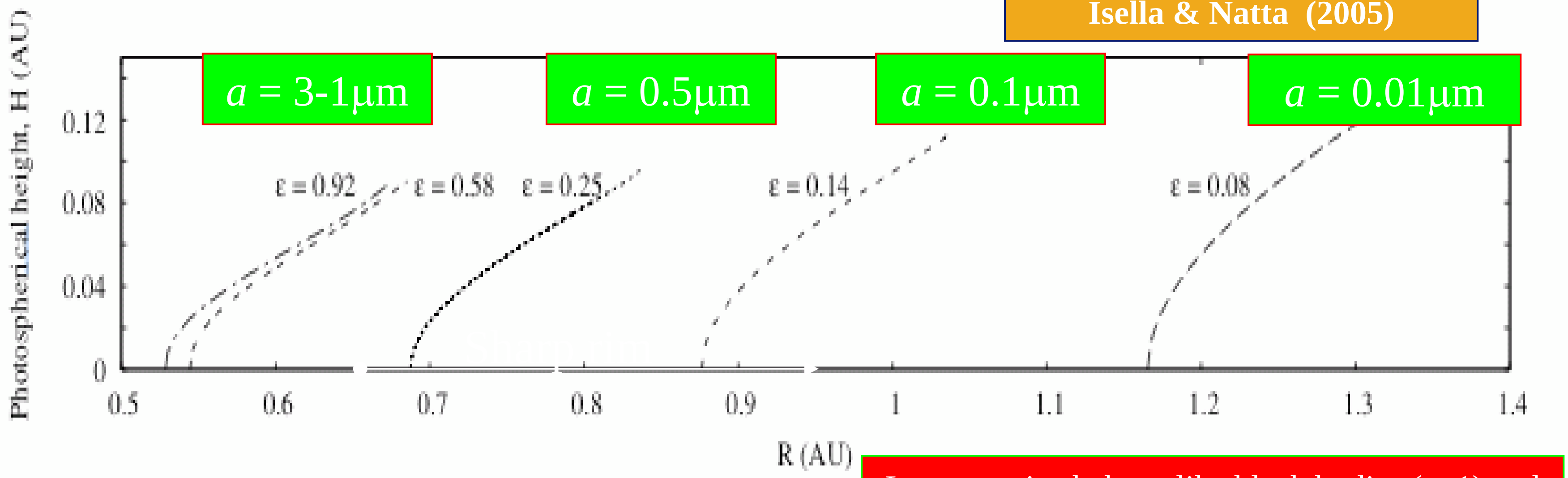
Inner Disk Radii

Adapted from Millan-Gabet et al. PPV Review

data from Eisner et al. 2003,2004,2005; Millan-Gabet et al. 2001; Monnier et al. 2005; Akeson et al. 2000,2005,2006

Consistent with rim models

Tevap depends on gas density



Isella & Natta (2005)

a = 3-1μm

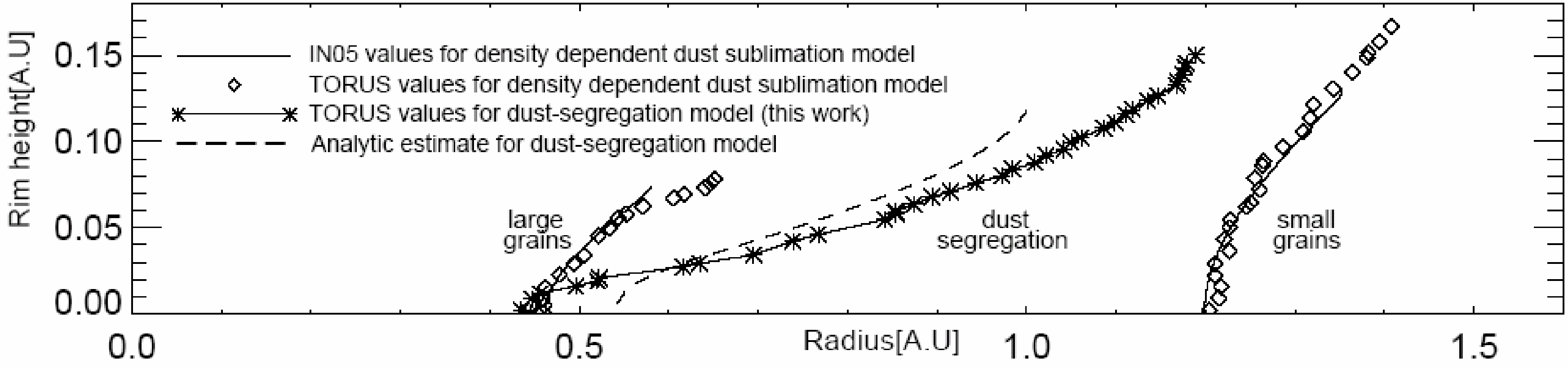
a = 0.5μm

a = 0.1μm

a = 0.01μm

Larger grains behave like black bodies (ε=1) and evaporate at the same distance from the star

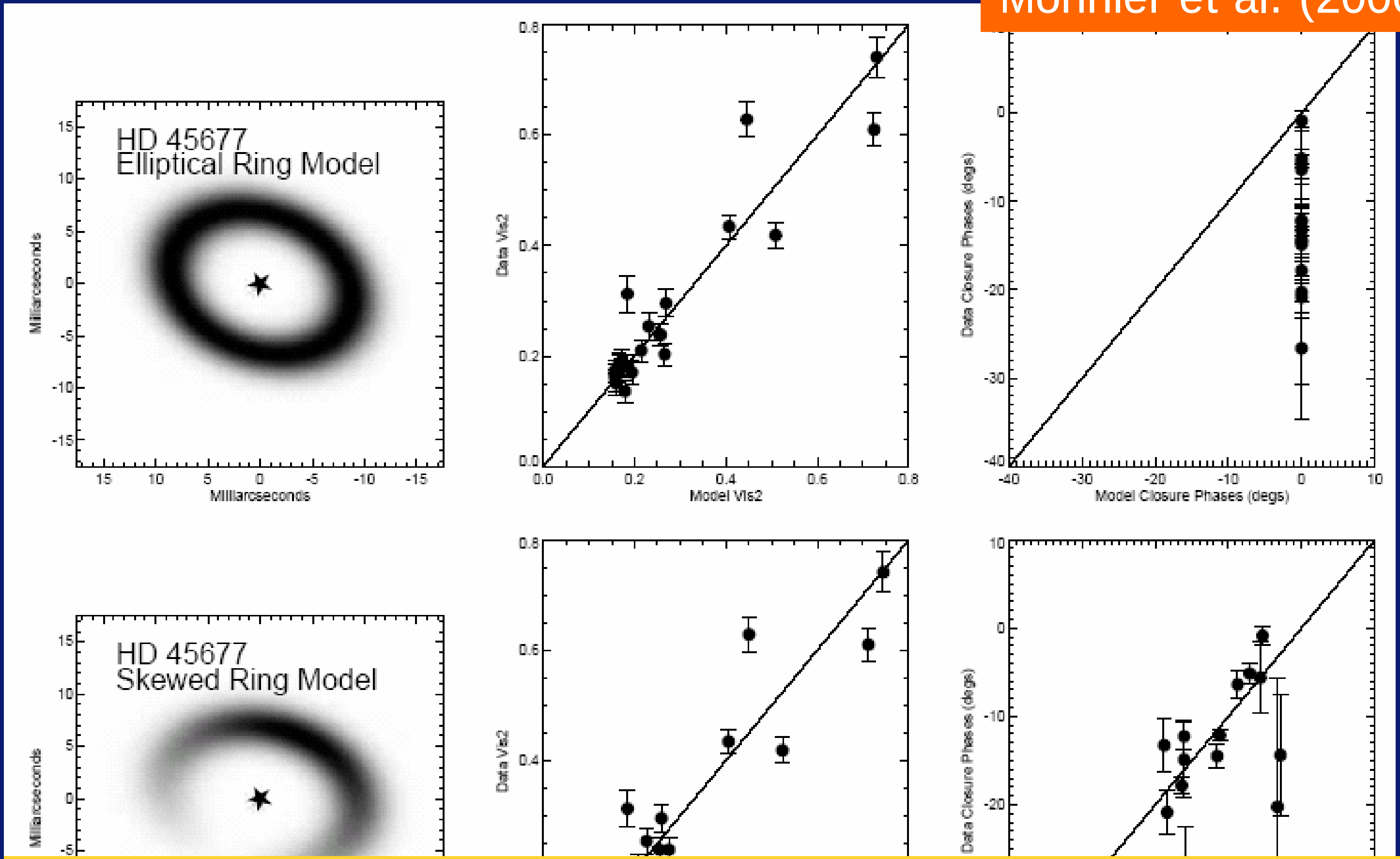
Dust settling and rim curvature



Tannirkulam et al. (2007)

Recent observations of HAe stars

Monnier et al. (2006)

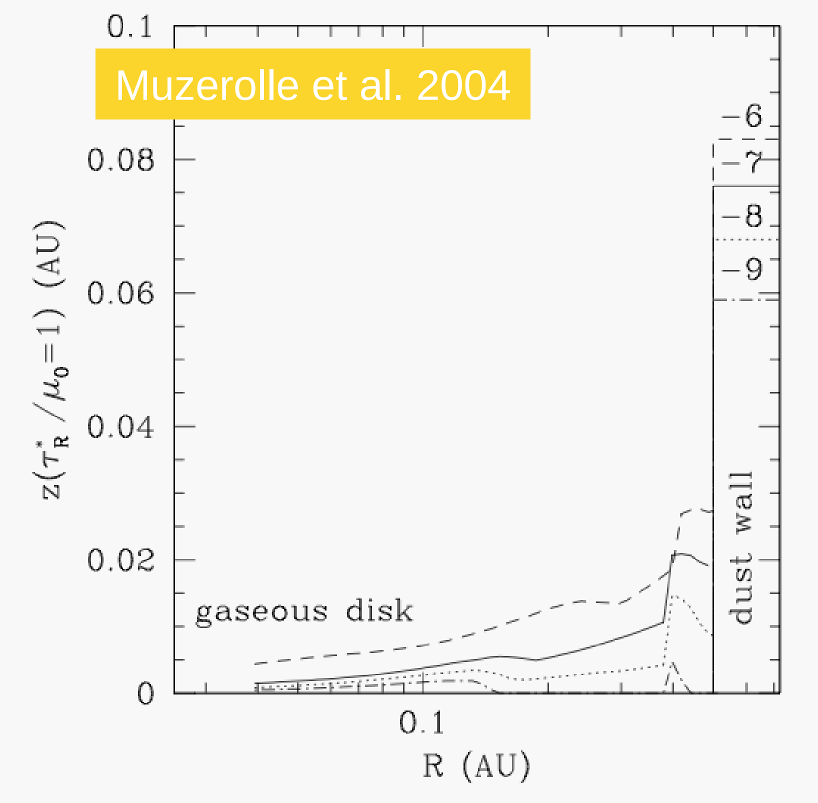


Rims are still consistent with the observations, but the observations are still sparse, and the constraints weak

Do all Hae disks have rims?

- The gaseous disk inside the evaporation radius
  - Gas temperature and density
  - Accretion rate

Yes, if M_{acc} <10^{-7} Msun/y


Muzerolle et al. 2004

Do we know the accretion rates in Hae stars?

From the Balmer discontinuity

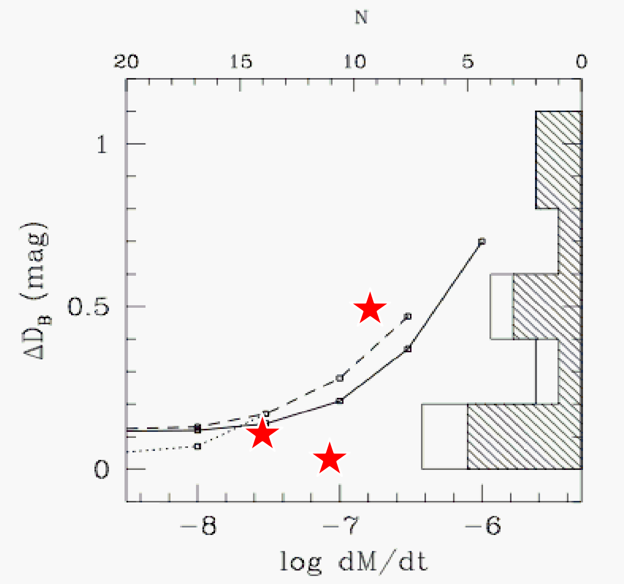
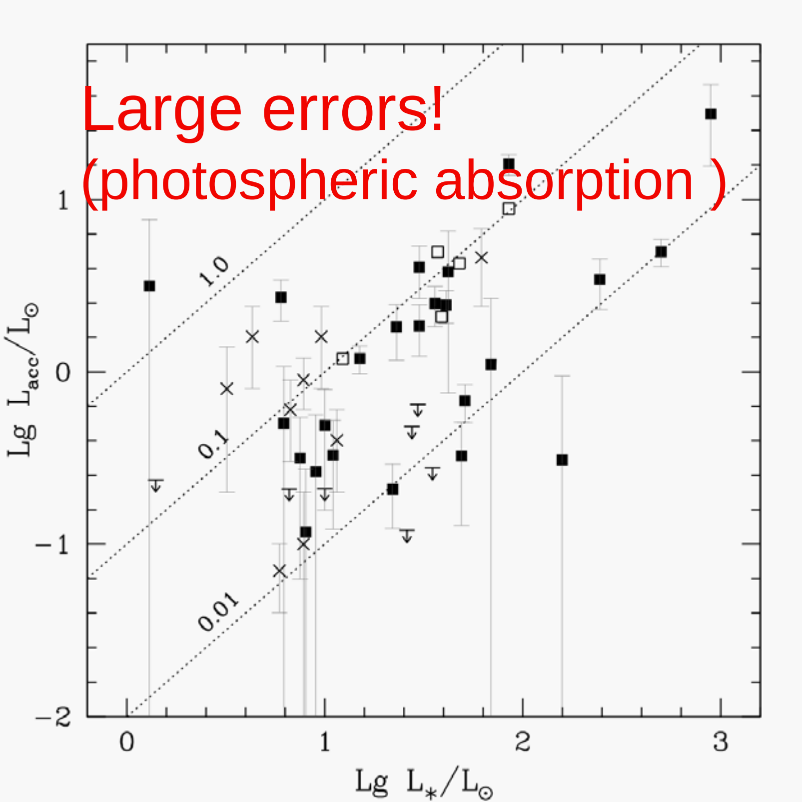


FIG. 8.—Predicted excess in the Balmer discontinuity as a function of mass
accretion ra ... (dotted
line), 10^{11} e ... lid line).
The distribu ... ars from
G78 is show ... tribution
of excesses for the HAe stars in the G78 sample. Labels for the distribution are
si

Muzerolle et al. 2004

Data from Garrison 1978 (9 HAe)

From ... nes



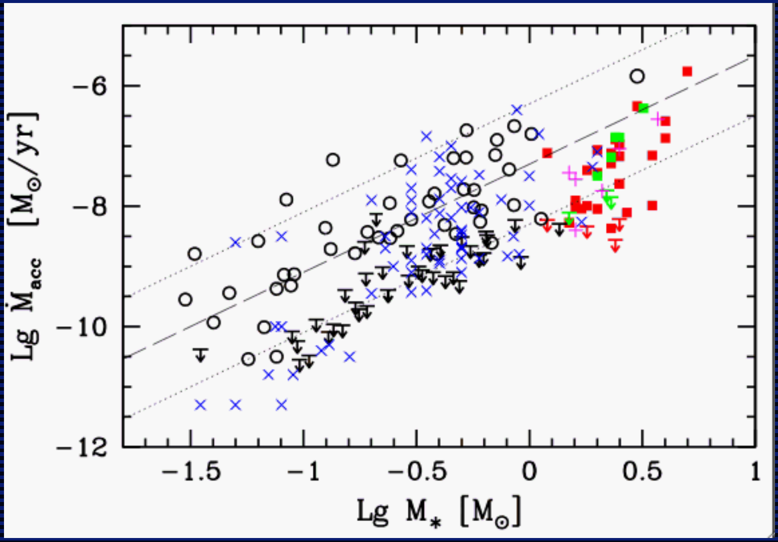
Large errors!
(photospheric absorption)

Testi et al., in preparation

variability ≤ factor 3 (10 stars)

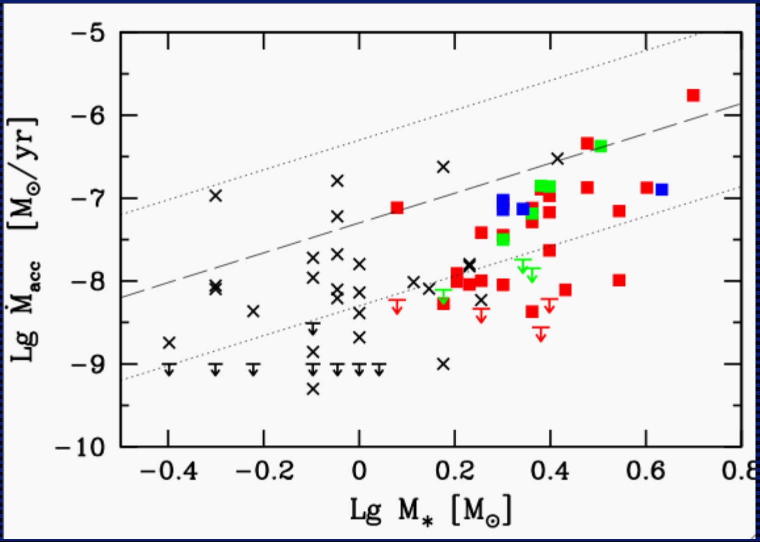
- Accretion rates ~ 10^{-8} - 10^{-6} M_{sun}/y
- Lack of strong accretors ?

Comparison with ρ-Oph & Taurus



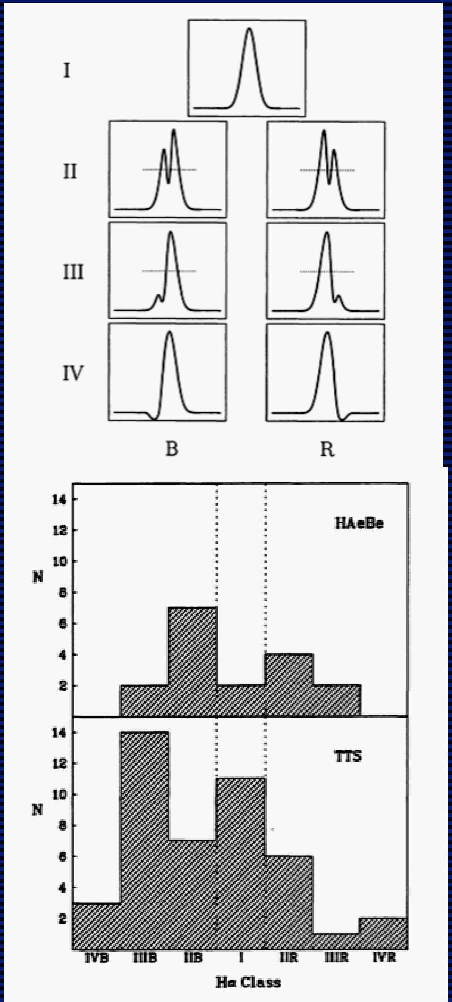
From Natta et al. 2006

Comparison with Tr 37

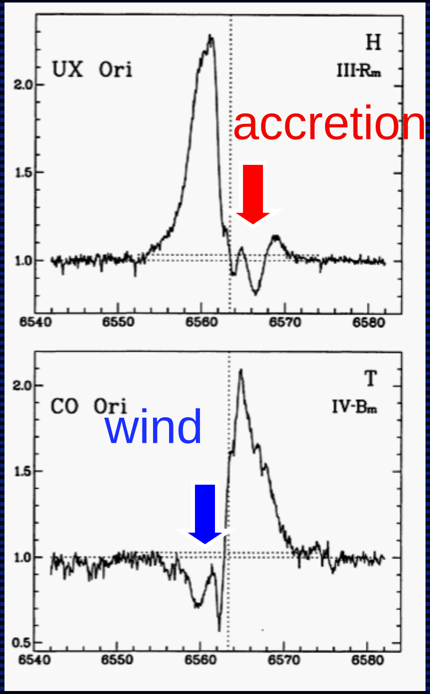


From Sicilia-Aguilar et al. 2007

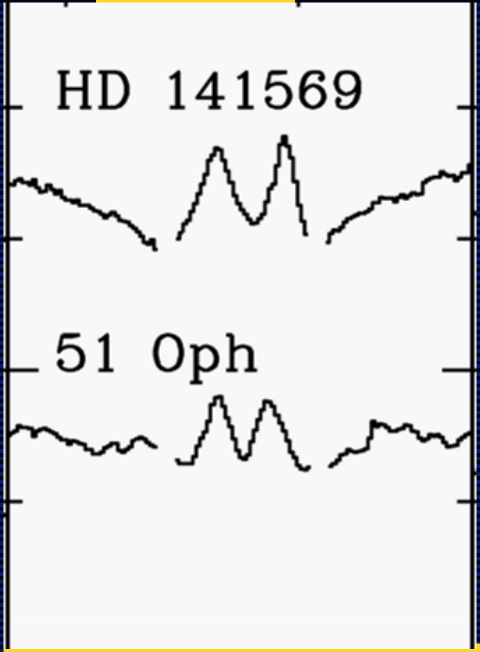
Lines: accretion or winds?



Reipurth et al. 1996



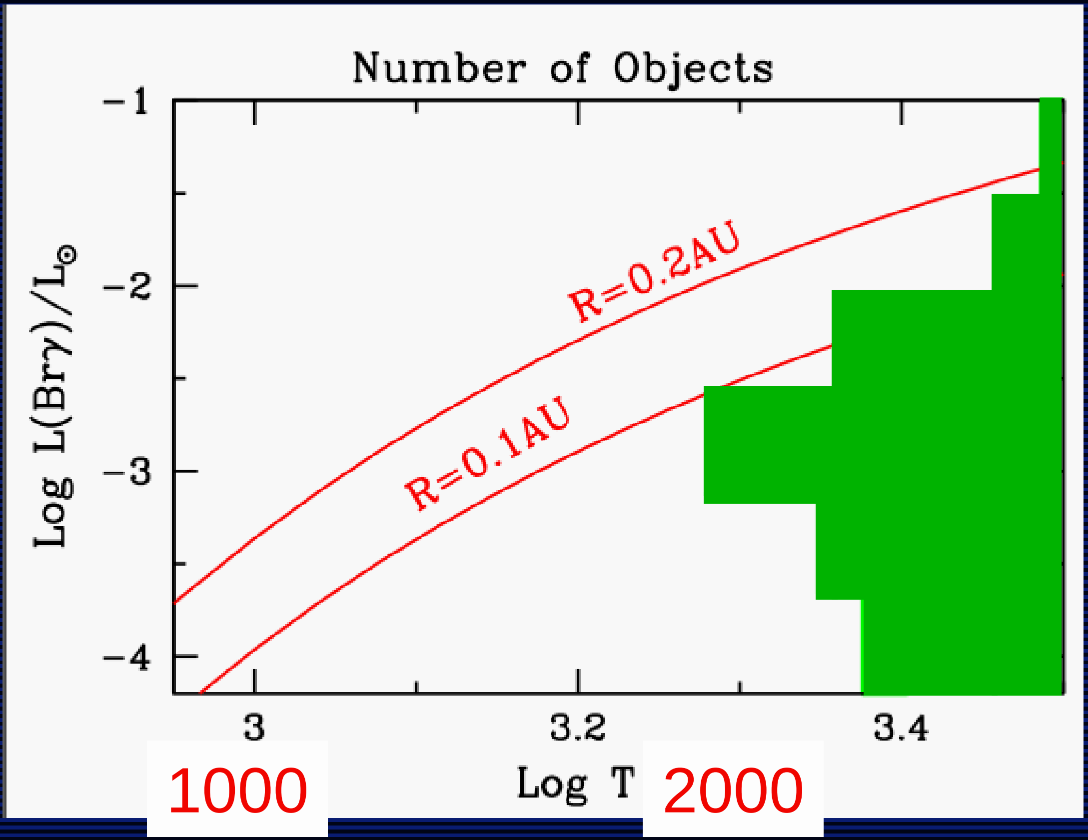
Disk?



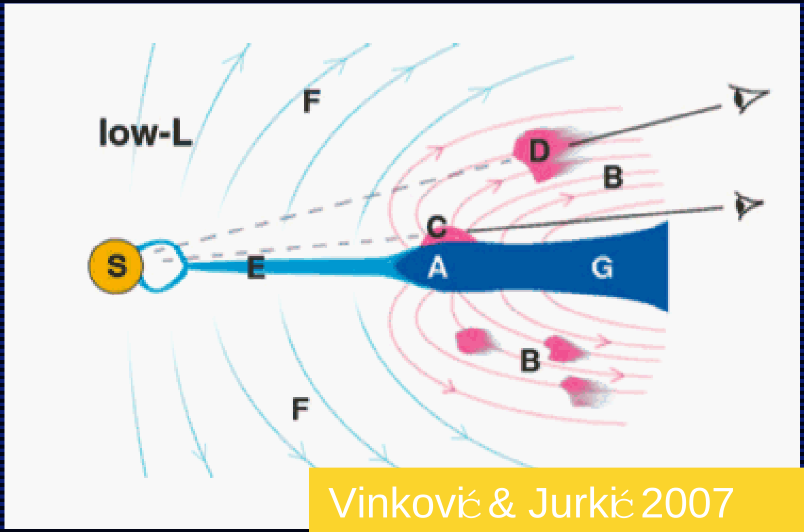
Garcia Lopez et al. 2006

we need to understand which component of the circumstellar gas (infall, wind, disk) dominates the line flux

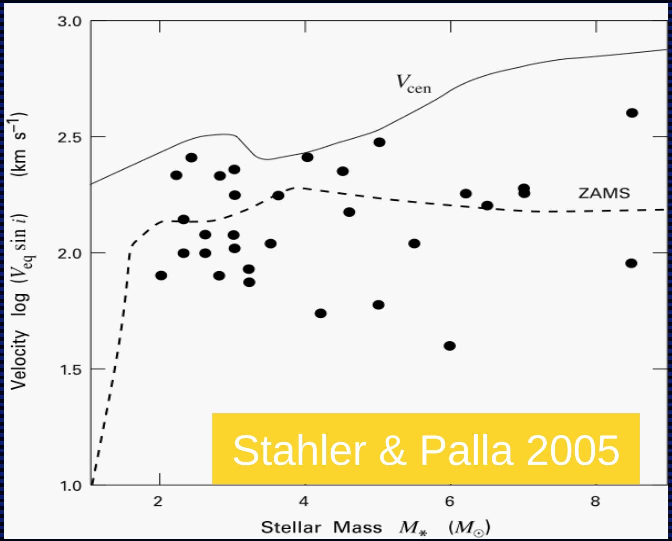
Can the gaseous inner disk contribute to the H IR lines ?



In Hae stars, we expect the size of the accreting region to be much smaller than the rim



Vinković & Jurkić 2007



Stahler & Palla 2005

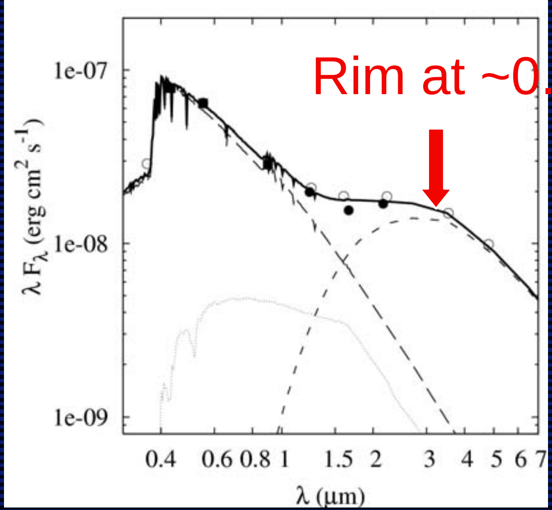
- Fast rotation → the corotation radius is very close to the star
- Only ~10% Hae stars have strong (~1 kG), ordered magnetic fields
  - (FORS1/VLT, ESPaDOnS/CFHT)
- Even if Macc $\lesssim 10^{-8}$ Msun/y → Racc ~ 0.1 Rrim

Winds are easy!

- X-wind IR line emission likely smaller than the rim
- Disk winds ≥ Rrim

Interferometric observations of Brγ in HD104237

Differential visibility with AMBER



Rim at ~0.3AU

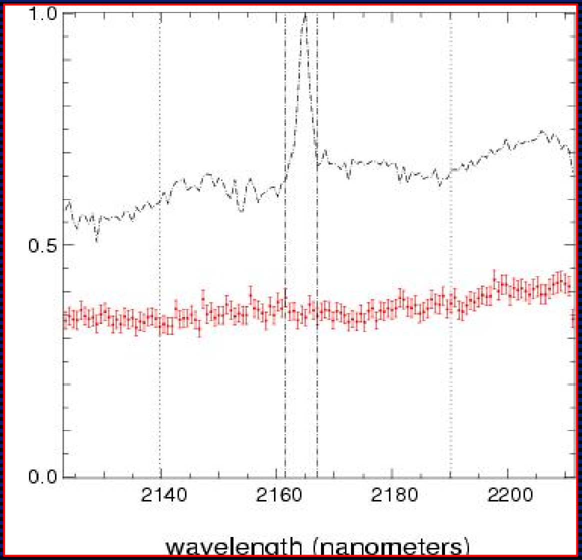
A4-A8

D~115 pc

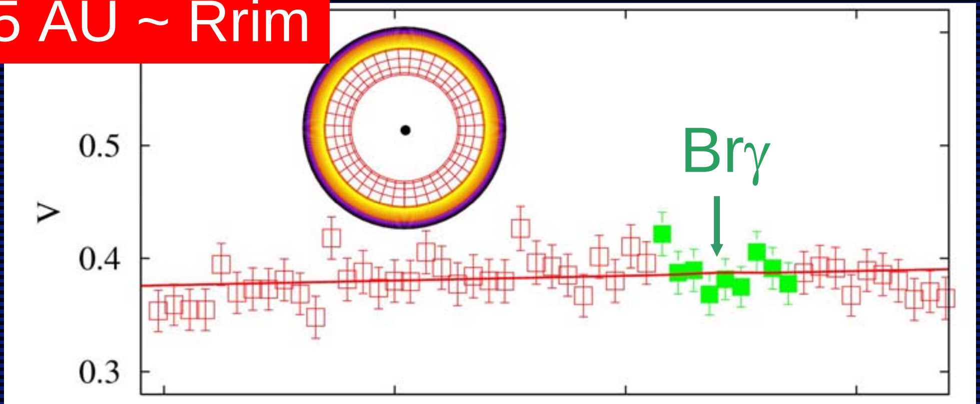
L_{star}~30L_{sun}

i~10-30^o

Strong, narrow Brγ



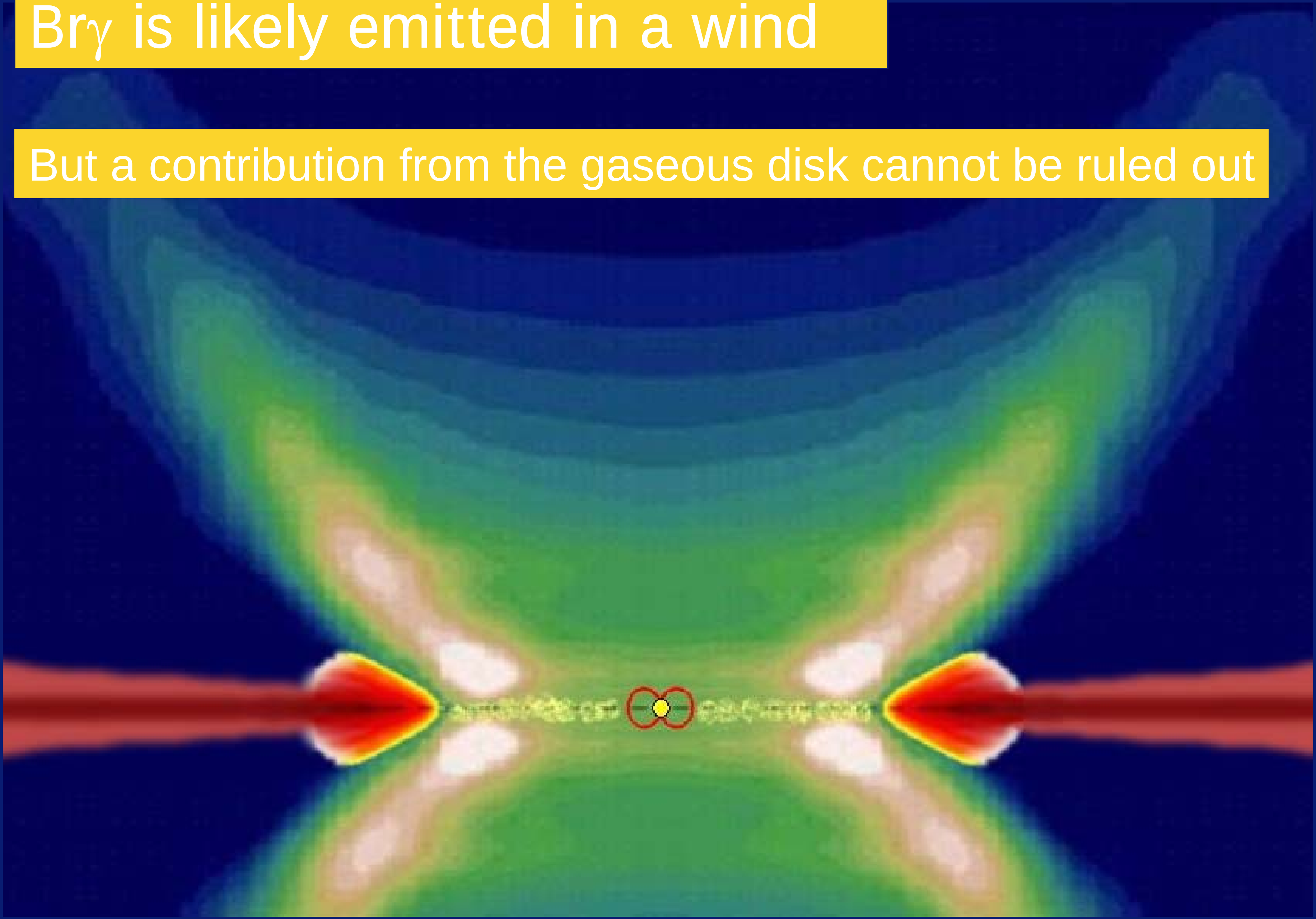
R(Brγ) ~ 0.2-0.5 AU ~ Rrim



Tatulli et al. 2007

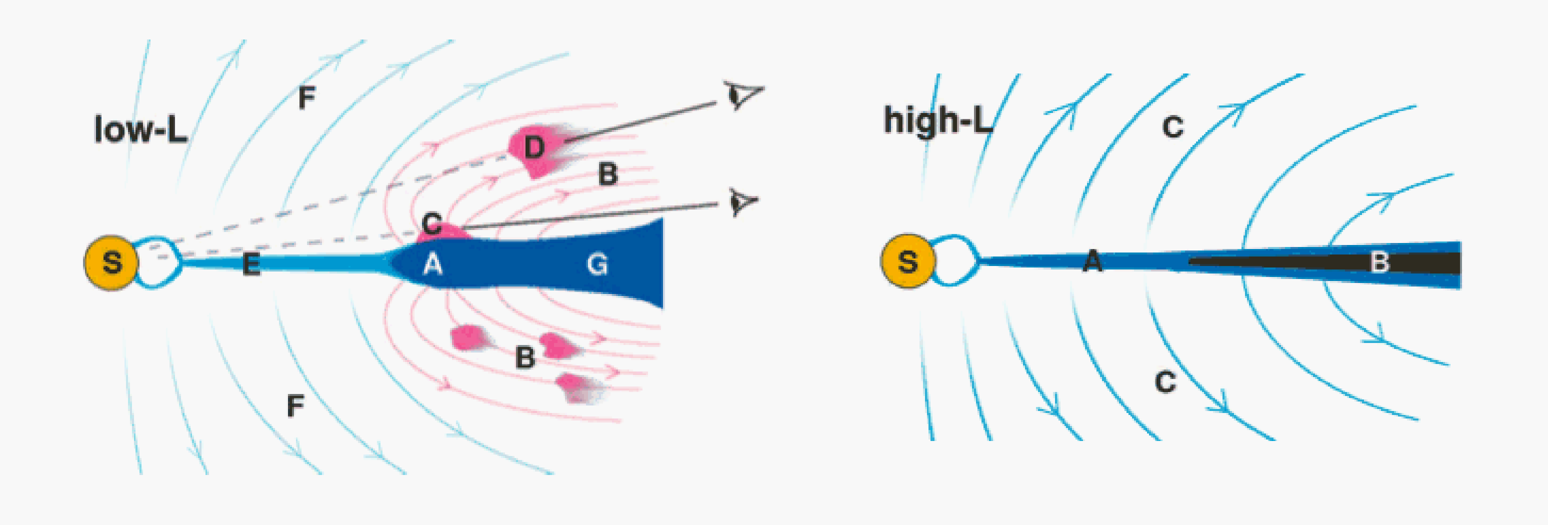
Brγ is likely emitted in a wind

But a contribution from the gaseous disk cannot be ruled out



From A. Isella, MHD wind model by Thiebaut et al.

Early B Herbig stars



- First mm detection of a very light disk in R Mon
    - Alonso-Albi et al 2007
- Observations of the inner disk are consistent with standard accretion disks (thick gas, no rims)
    - H optical line polarization (Vink and collaborators)
    - results of near-IR interferometry
- Stellar (radiation driven?) winds are important

In MWC297 (O9) the Brγ emission comes from a wind

Malbet et al. 2007

summary

- Intermediate mass stars in star forming regions are diskless/non active
- Herbig Ae stars are a sample with no statistical significance (odd cases?)
- To zero order, their properties are similar to those of TTS
- The inner disks of Hae stars are free of dust to ~0.2-0.5AU → RIMS
- The accretion rates are very poorly known, and the applicability of magnetospheric models is dubious
- More massive (early B) stars seem to have optically thick inner gas disks, no rims, stellar winds
- Winds may dominate the emission of many lines; the inner gaseous disk may also contribute (IR lines)
- Near-IR interferometry in the hydrogen lines will provide crucial information
- We need models