~~The state of our knowledge~~

What we understand about star formation

Some things we'd like to understand that studies with the great observatories might clarify

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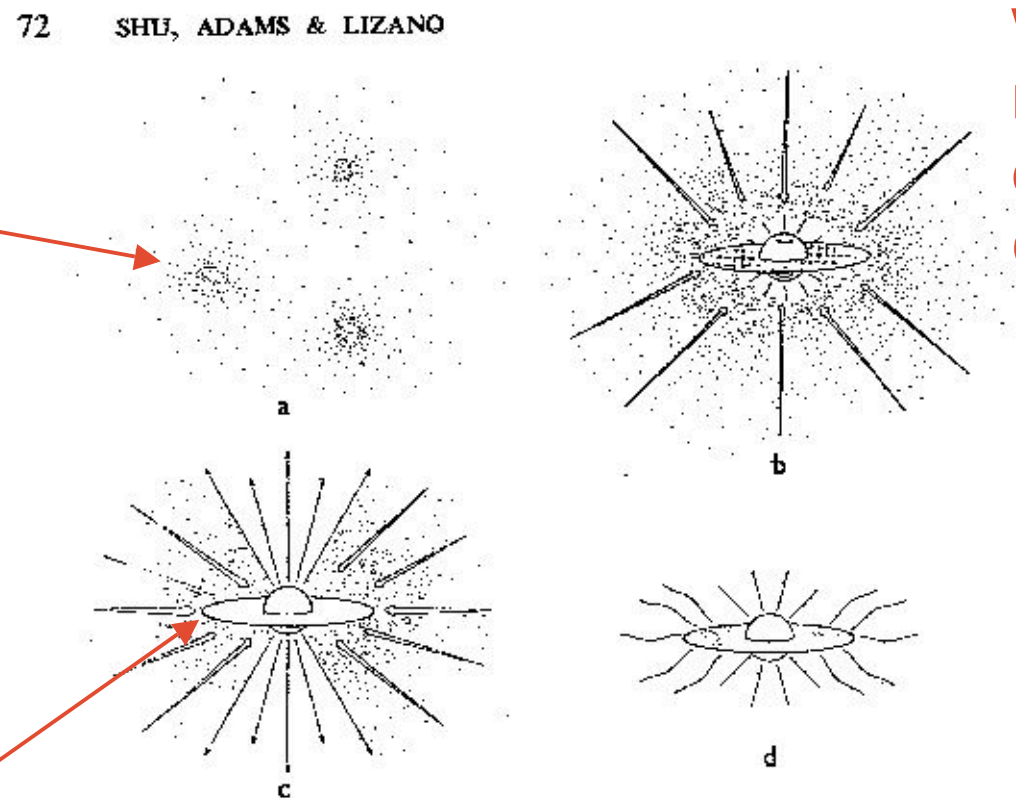
Star formation “theory”

How do protostellar cores form?



Rapid collapse with angular momentum conservation; OK

Why do disks accrete? - gravity early... Then Magnetorotational Instability ??

Planet formation ?

The brown dwarf "problem"

$M_J = (\pi\, c_s^2/G)^{3/2}\, \rho^{-1/2} \sim 5.4\, T_{10}^{3/2}\, (N_{H2}/10^4)^{-1/2}\, M_\odot$;

$M = 0.05\, M_\odot$, T=10K, $\Rightarrow N_{H2} \sim 10^8$ cm^{-3}

or $M_J = 17\, T_{10}^2\, (P/k/10^4)^{-1/2}\, M_\odot$;

$M = 0.05\, M_\odot$, T=10K, $\Rightarrow P \sim 10^5 \langle P \rangle_{ISM}$

Form BDs in (dense) disks, then eject (Reipurth & Clarke)?

but:

BDs with disks (Luhman, Mohanty, Jaywardhana, etc.); can they survive ejection? young binary BDs? (Luhman)

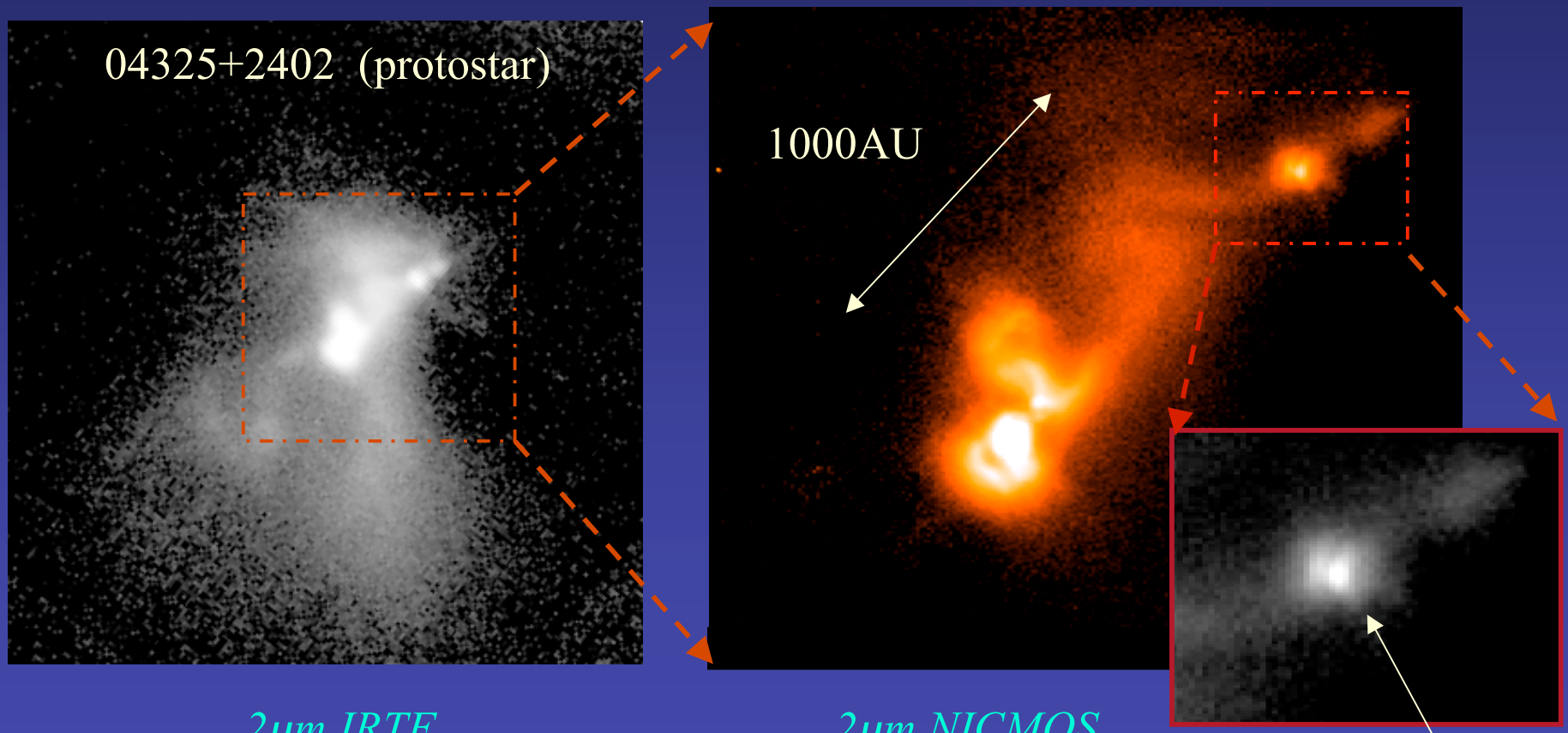
If BDs form in the same way as stars:

$\Rightarrow$ DYNAMIC CONDITIONS IN MOLECULAR CLOUDS!

Spitzer, HST, ground studies

Ejection or independent formation?

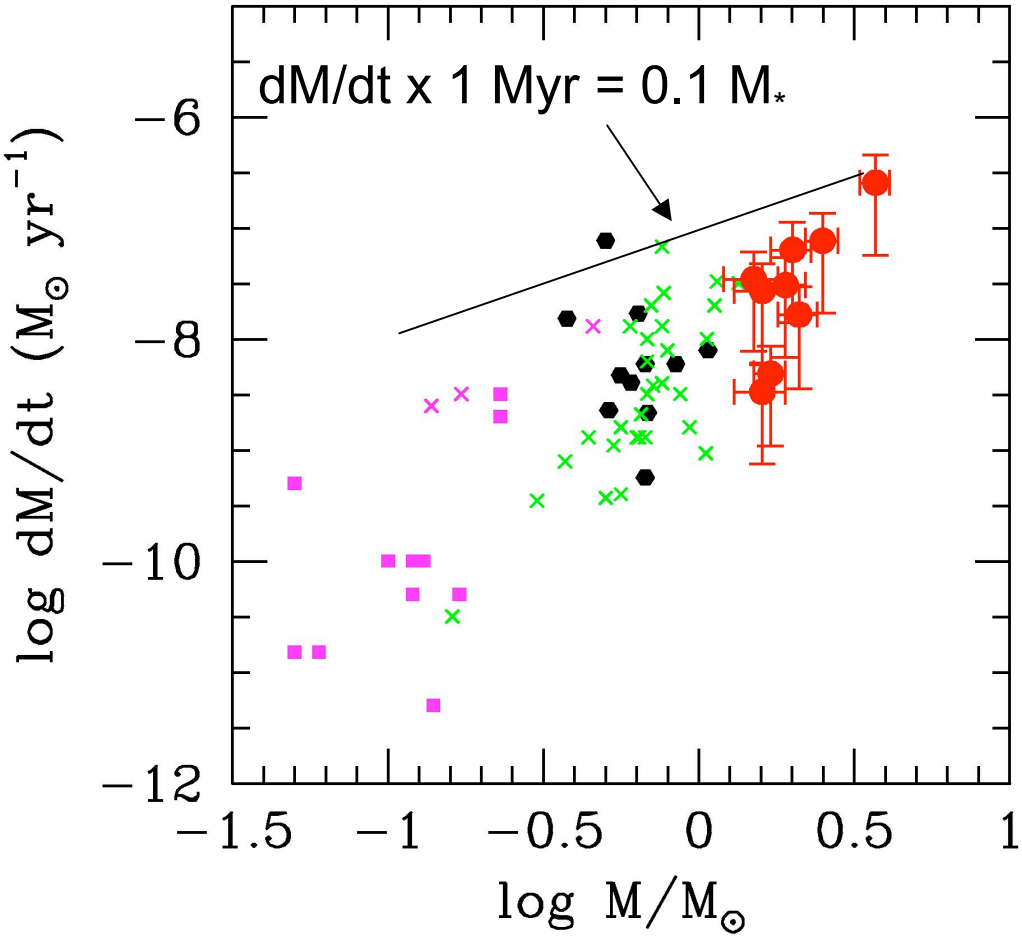
Fragmentation in disk (ring) plus ejection? (e.g., Reipurth & Clarke)
and/or independent core (dynamic formation)? (Bate, Bonnell, & Bromm)



2μm IRTF *2μm NICMOS*

(Hartmann, Calvet, Allen, Chen, Jayawardhana 1999)

Proto(stellar, planetary) disks accrete



Calvet, Muzerolle et al. 2004

dM/dt ∝ M^2 approximately; why??

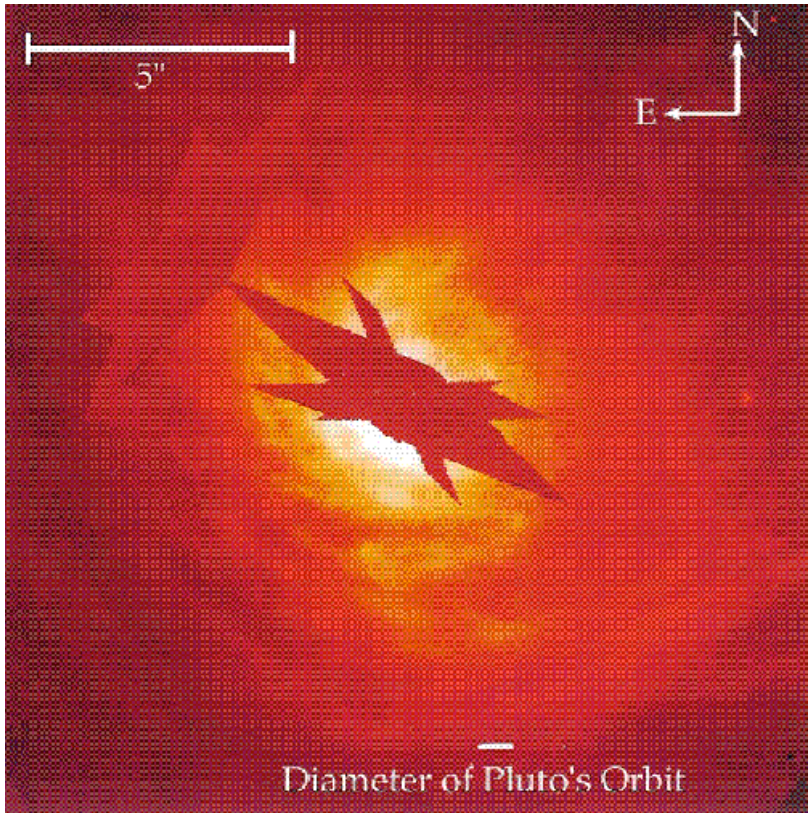
some weak evidence that M(disk) ∝ M_*; what is the other factor??

What drives disk accretion?

If M(disk) > 0.1 M(star), then self-gravity can drive angular momentum transport by spiral waves
⇒ build up star by gravity

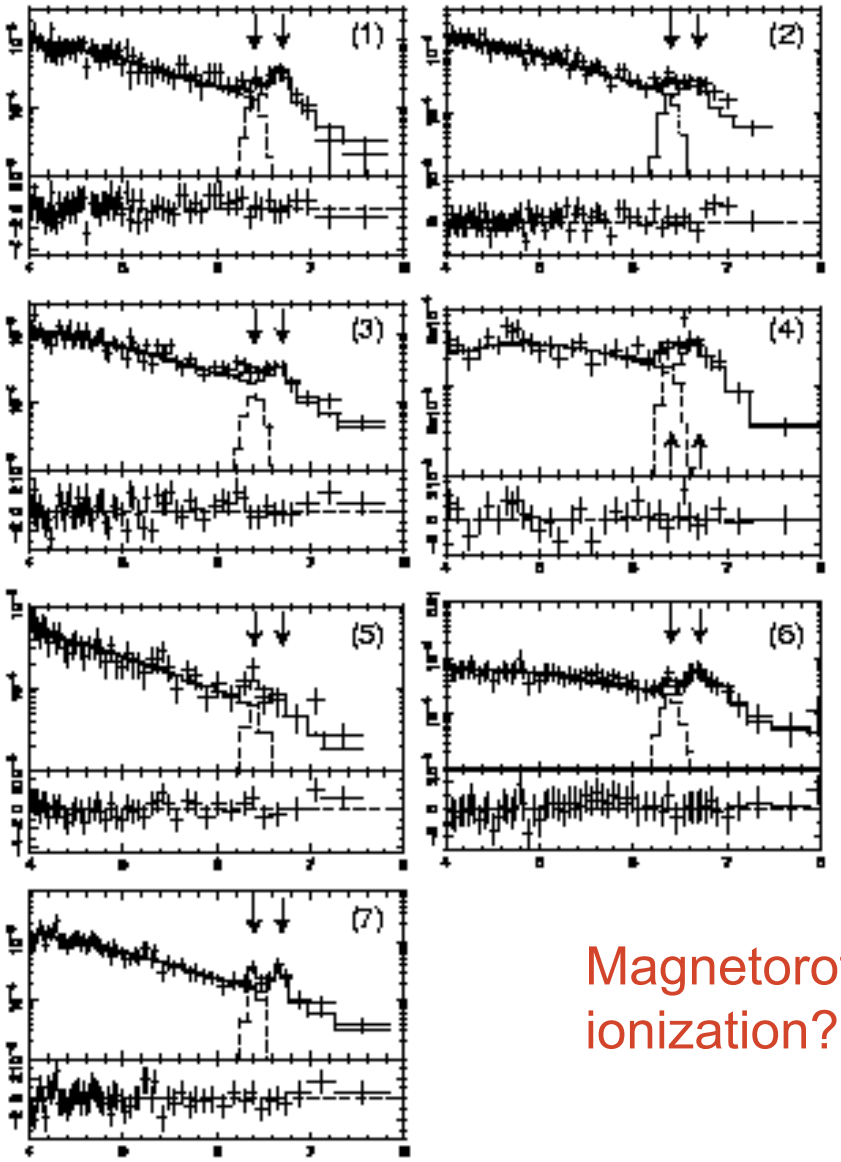
What drives accretion in lower-mass disks?

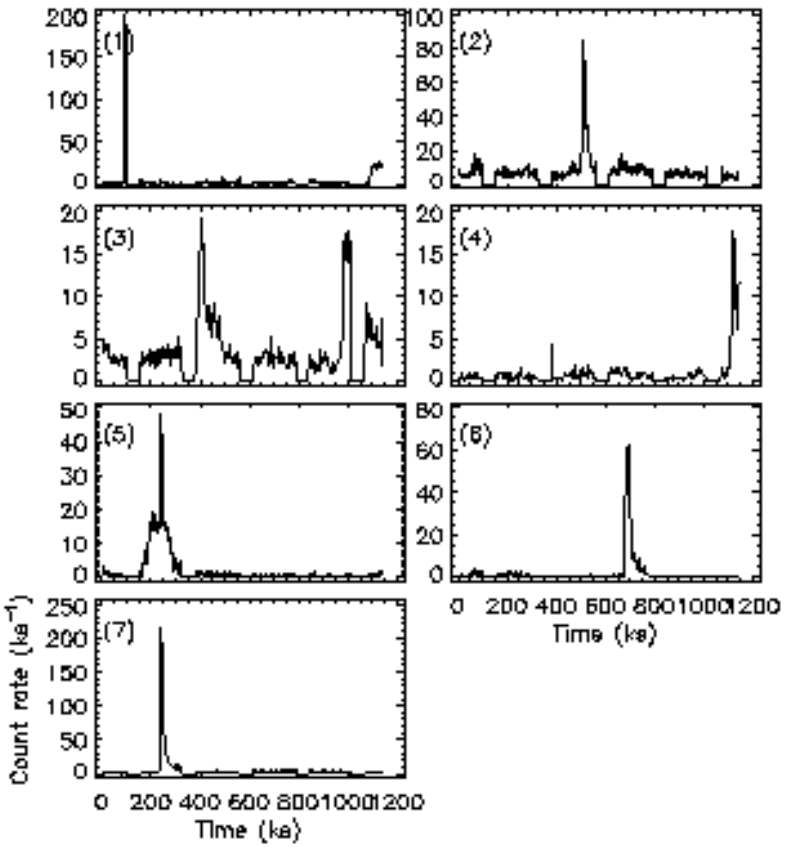
MRI - needs (low) ionization to couple B to gas
⇒ X rays (?)



Grady et al. 1999; STIS 0.2-1.1μm coronagraphic image of AB Aur (two position angles)

COUP - Xray ionization of disks

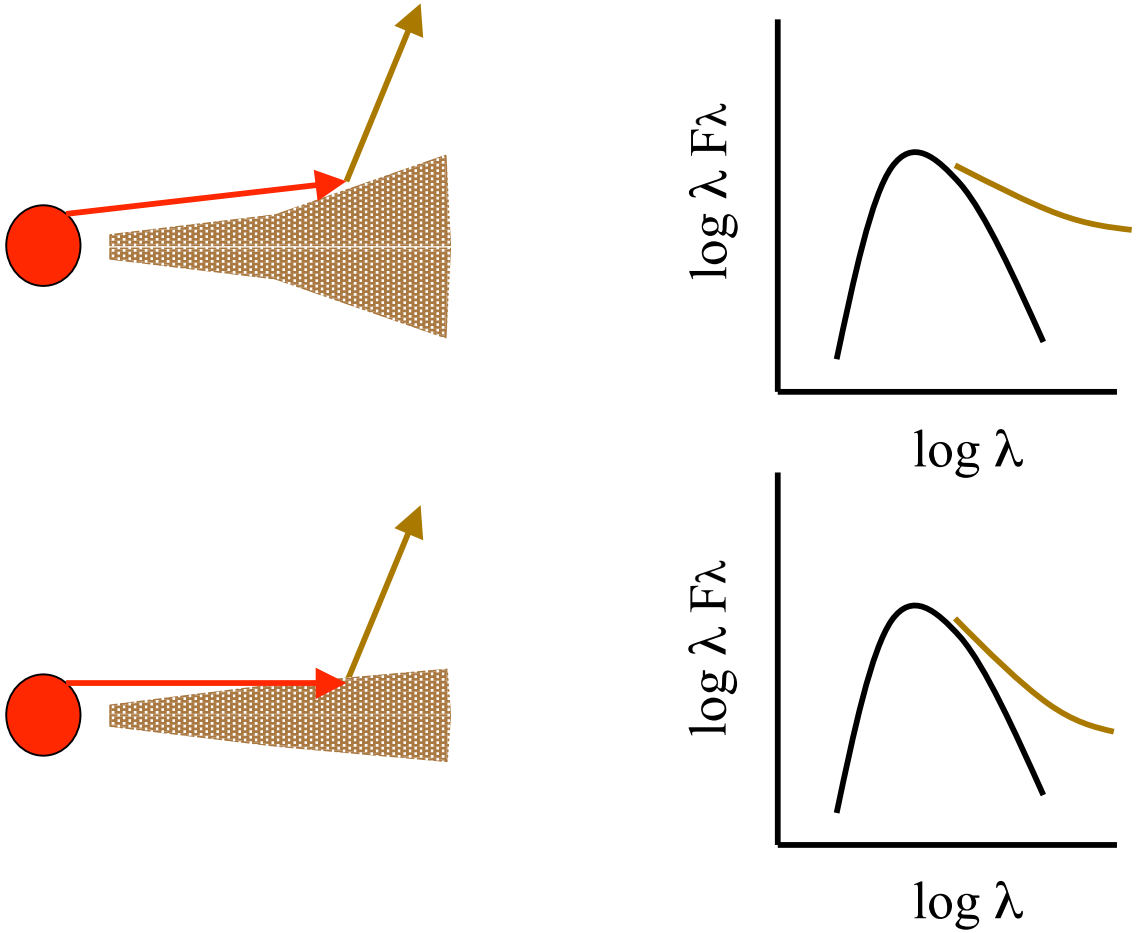




Magnetorotational instability (MRI); X-ray ionization? but highly time-variable...

Tsujimoto et al

Inner disk; dust settling, grain growth
⇒ first stage of planet formation (core acc.)

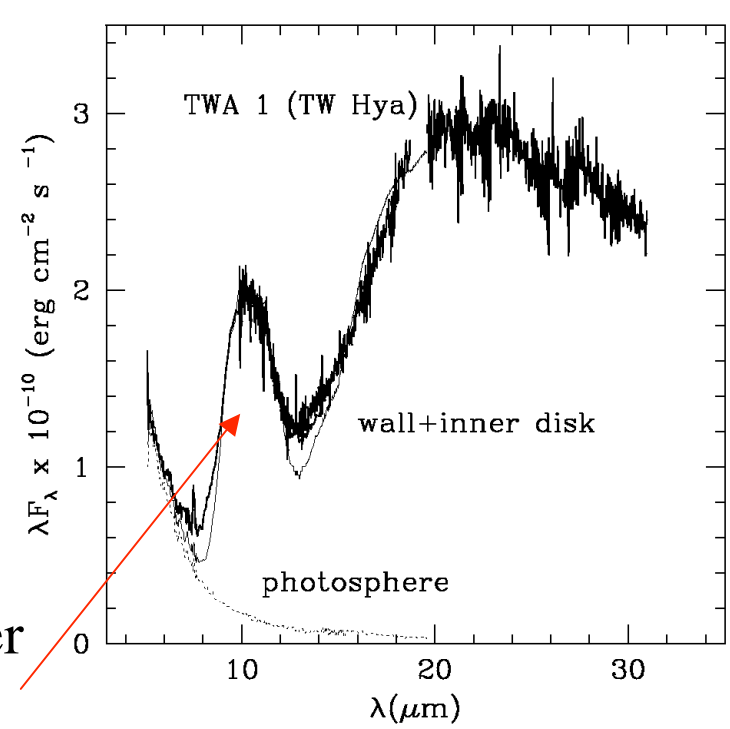


Sicilia-Aguilar et al. 2005; Spitzer results

Inner disk clearing

Spectra from IRS on SPITZER

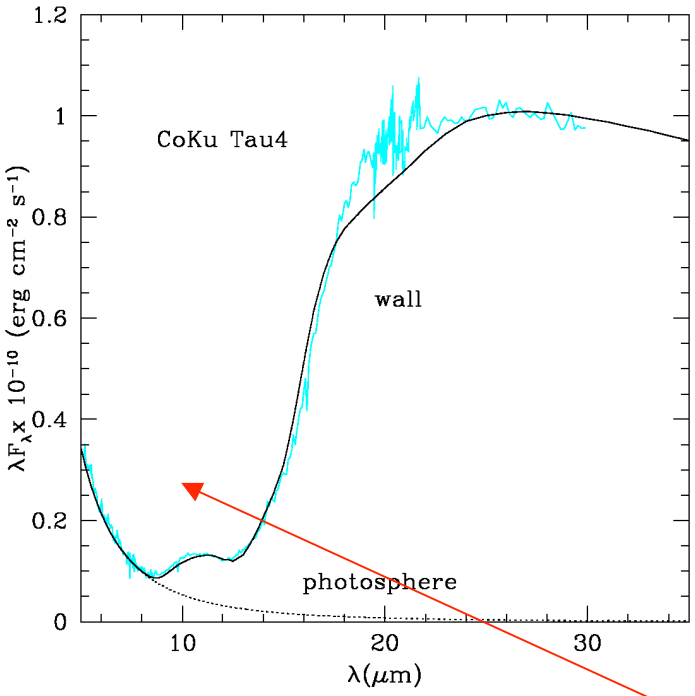
TW Hya, ~ 4 AU
~ 10 Myr



Inner disk

Uchida et al. 2004

CoKu Tau 4, ~ 10 AU
~ 2 Myr



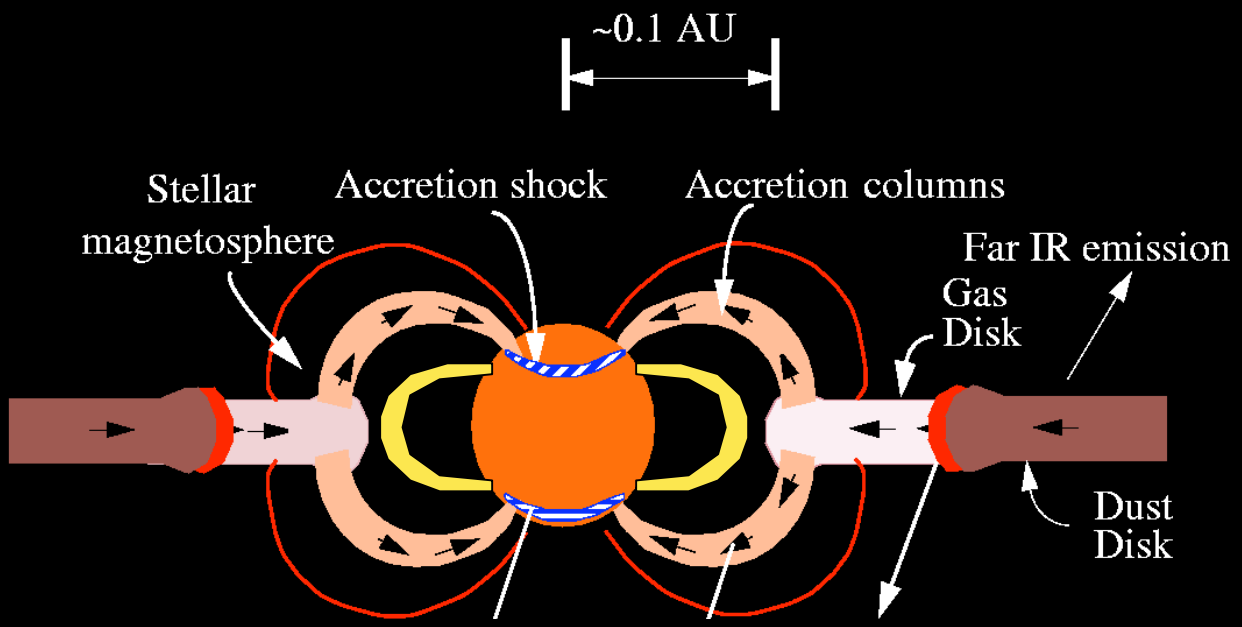
No inner disk, WTTS

Forrest et al. 2004;
D'Alessio et al. 2004

Some problems…

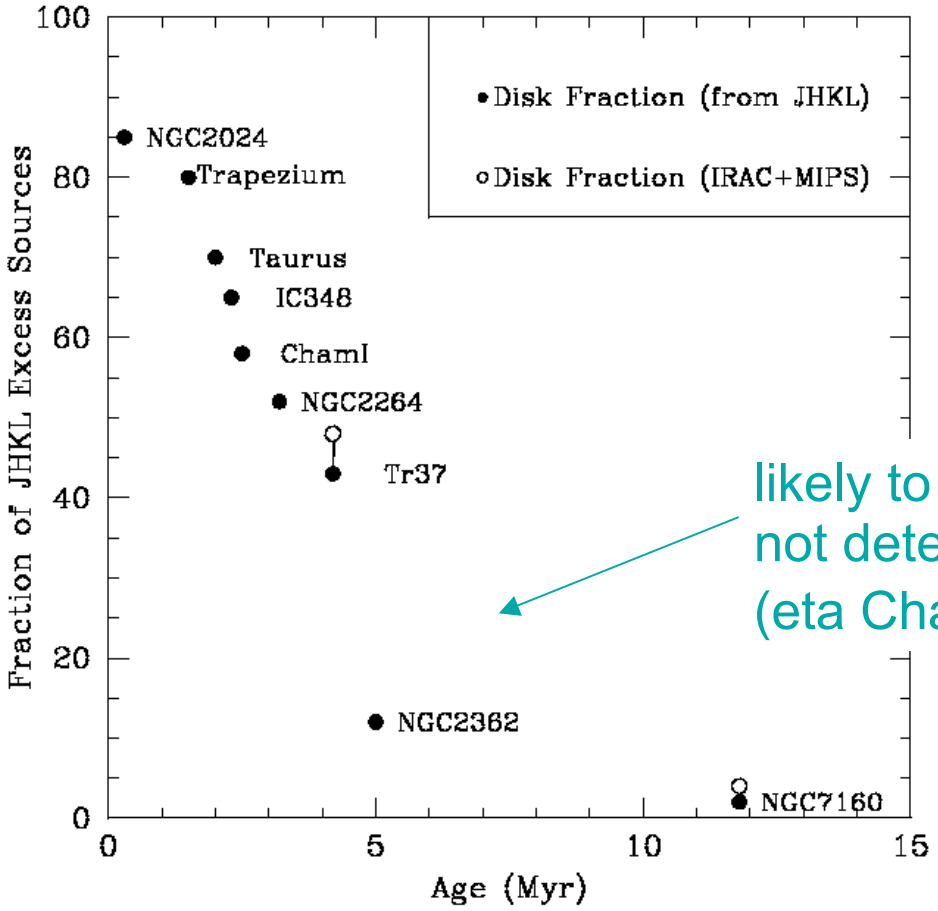
- Formation of protostellar cores - BD formation (Spitzer); high-mass stars (HST) $\Rightarrow$ IMF
- Disk accretion $\Leftrightarrow$ ionization by X-rays? (Chandra)
- Disk evolution; dust settling/growth; planet formation(?) (Spitzer, HST)

T Tauri star - magnetospheric accretion



X-ray emitting coronal gas

Disk frequencies



likely to have outer disks not detected at short λ (eta Cha?)

Haisch et al. 2001; Sicilia-Aguilar et al. 2005