# The Implications of Binary Stars for Star-Disk Interactions

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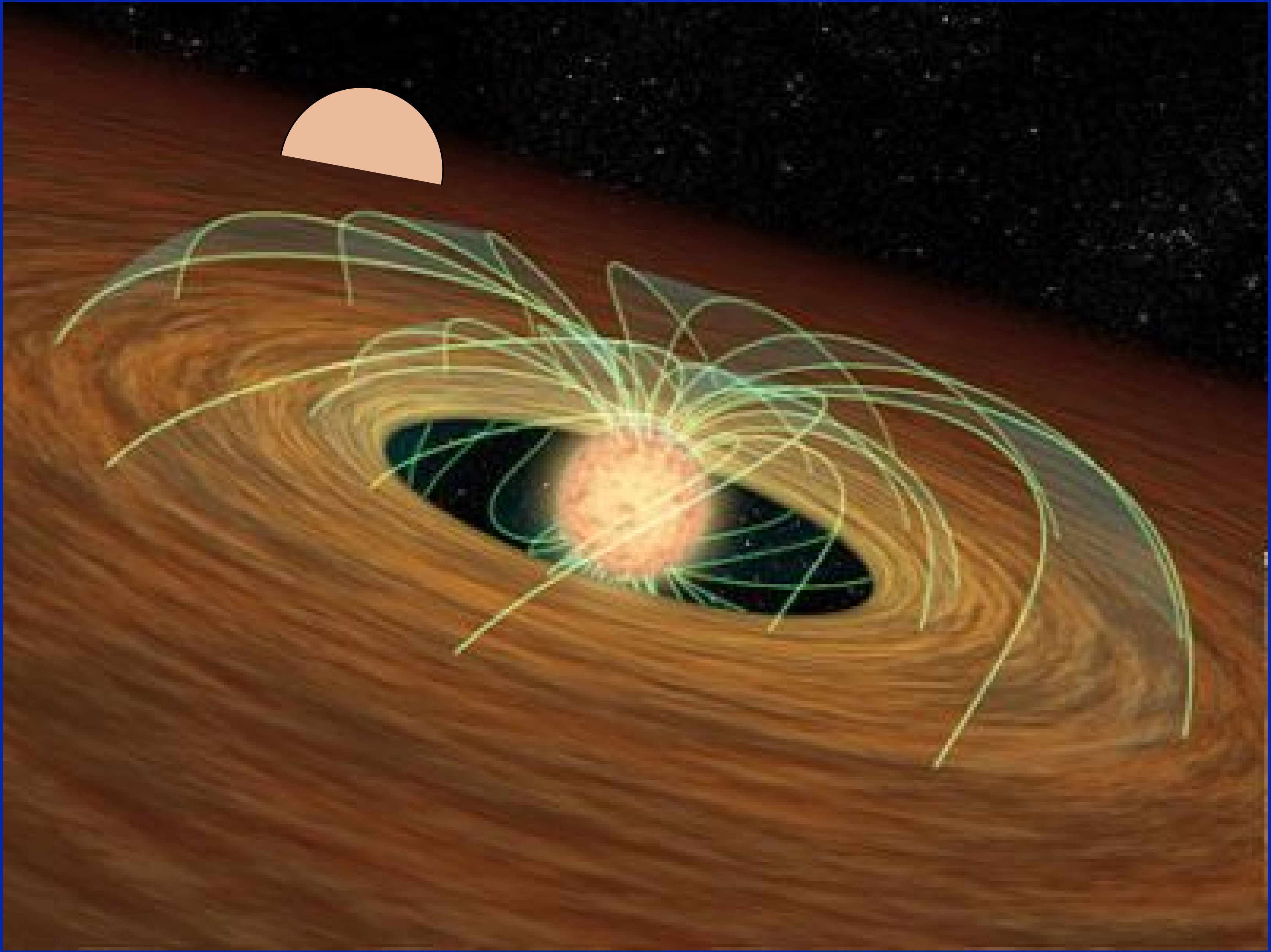
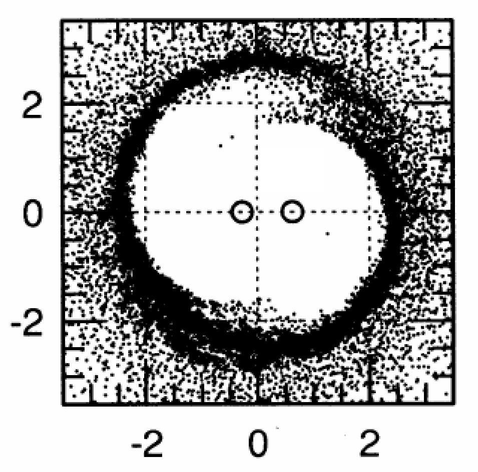
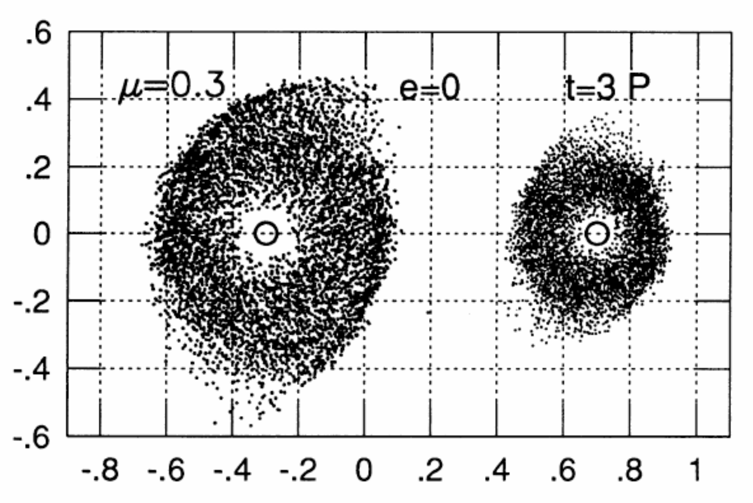
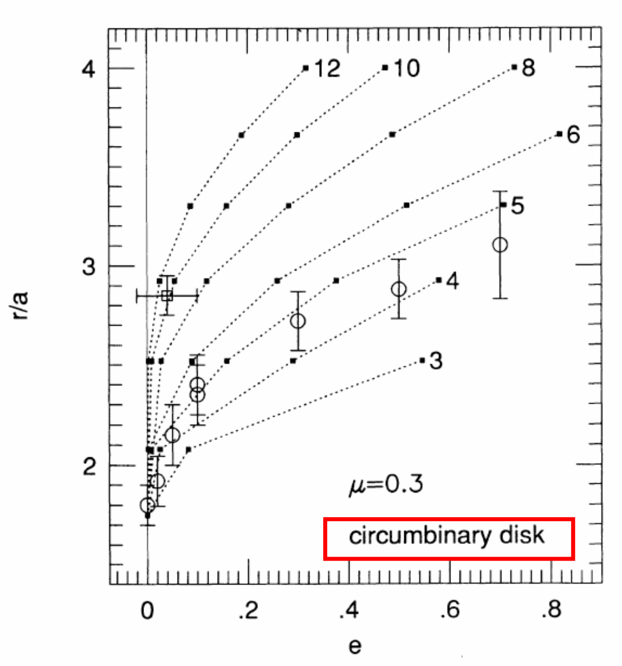
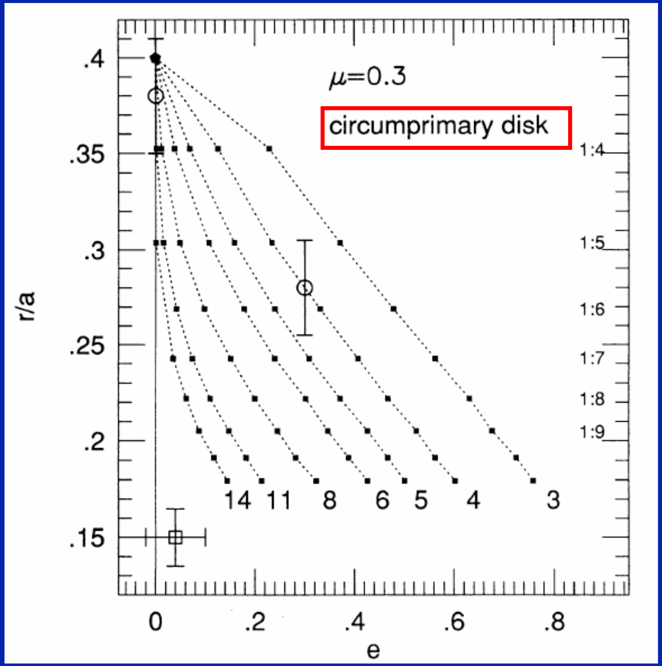


# Disk Truncation

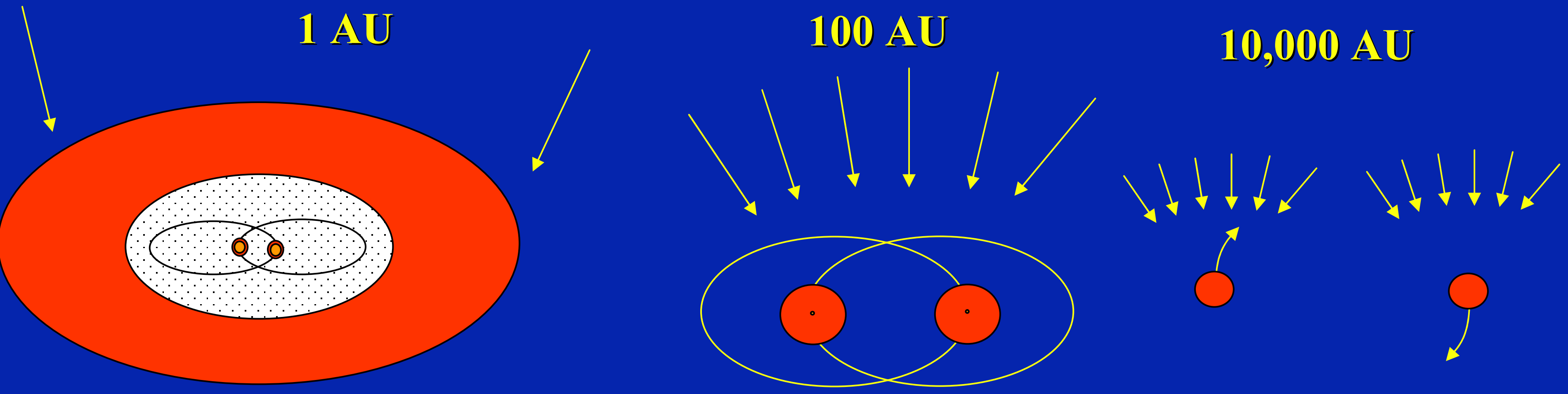


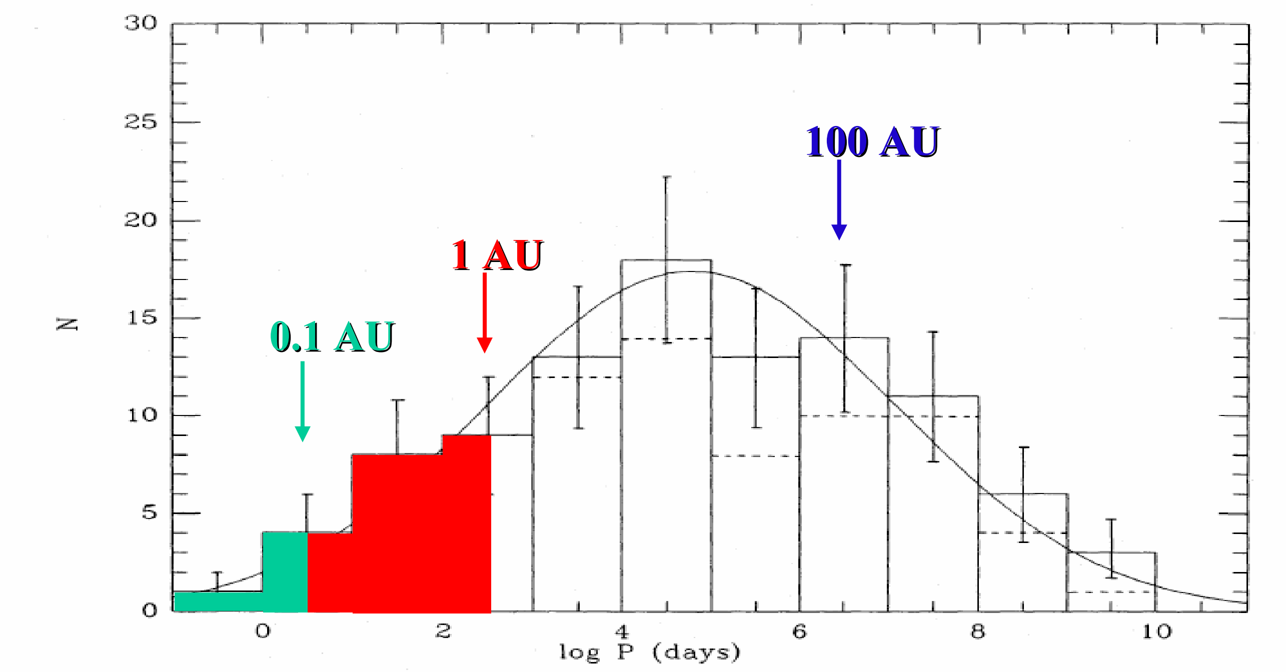




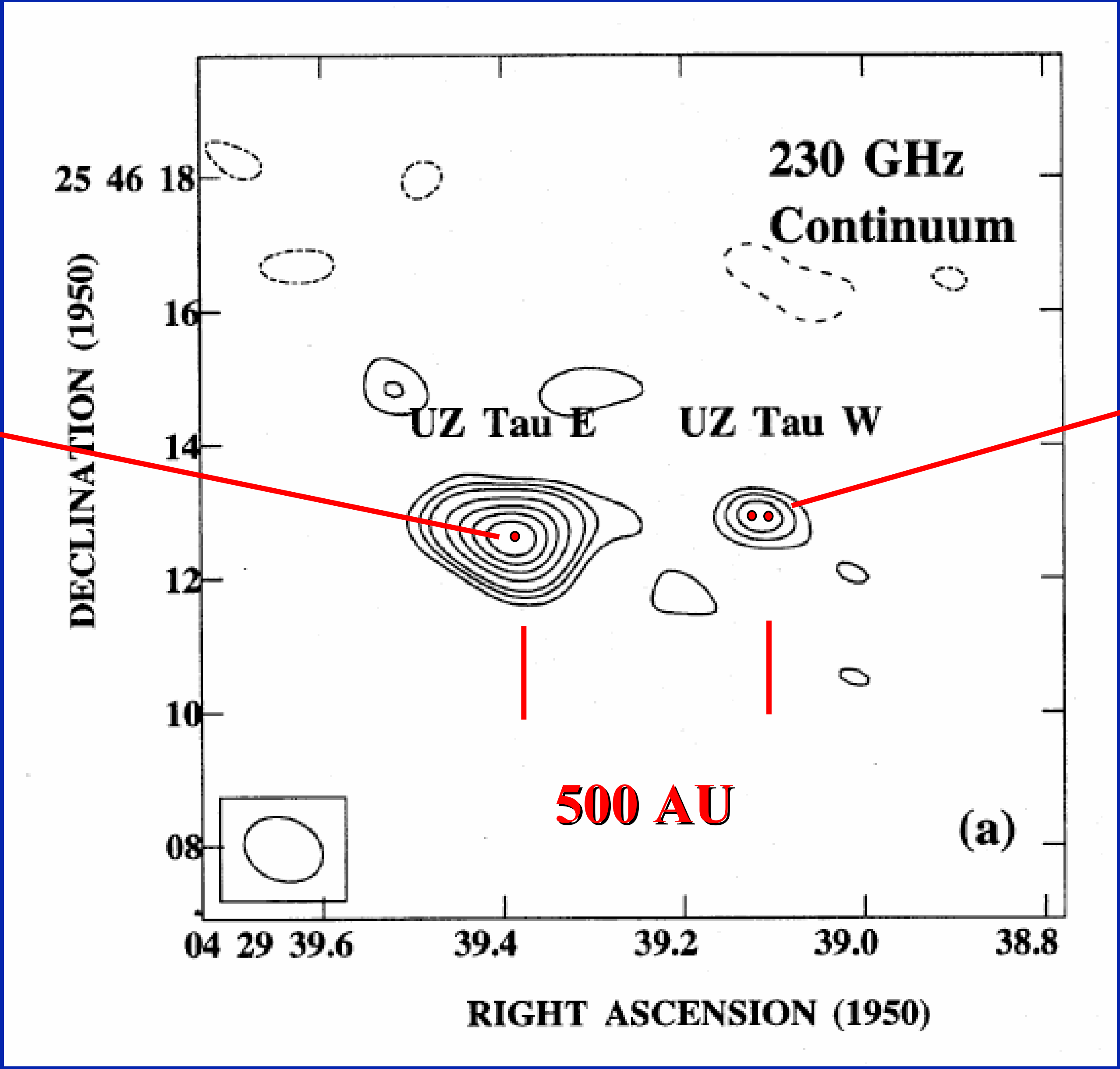


# Scales


1 AU
100 AU
10,000 AU


N
log P (days)
0
2
4
6
8
10
0
5
10
15
20
25
30
0.1 AU
1 AU
100 AU

# Accretion in Close Binaries



0.02 AU

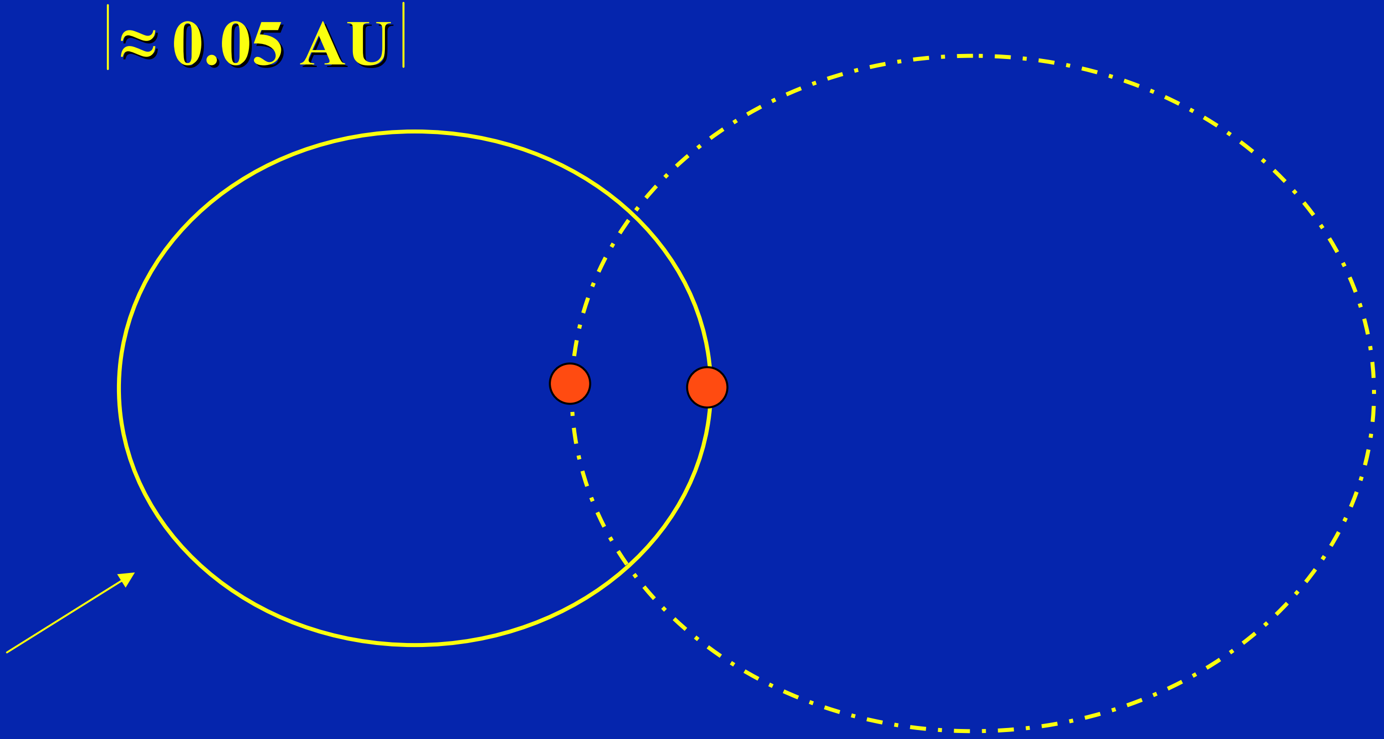
50 AU

Hα = 80 Å

# Accretion in Close Binaries

## UZ Tau E

### “The $19.1^{d}$ Period Binary Star”



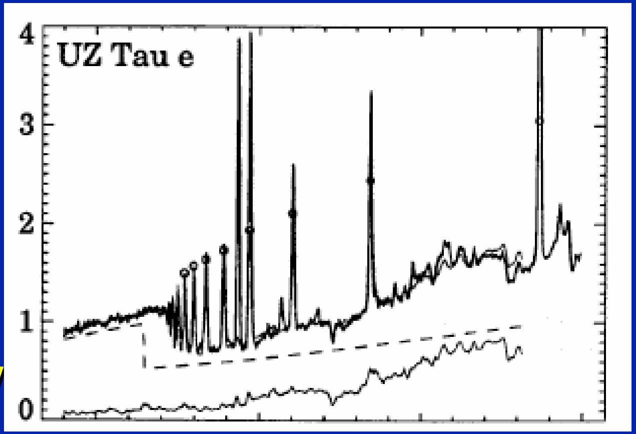
|≈ 0.05 AU|

e = 0.3

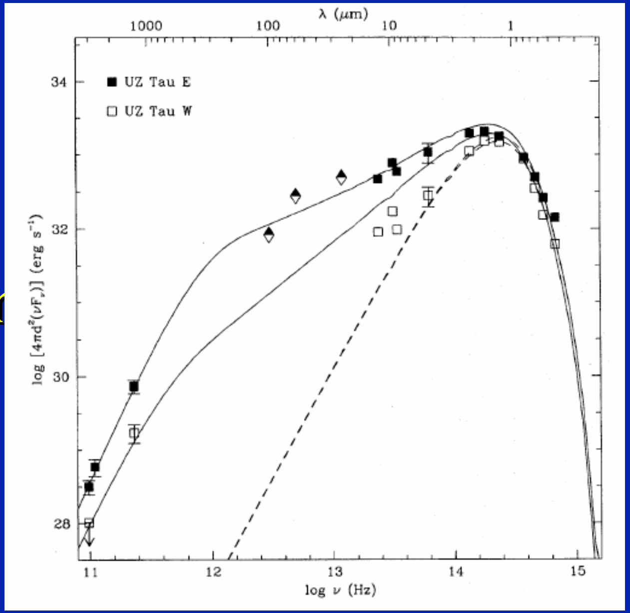
# Accretion in Close Binaries

## UZ Tau E

### "The Classical T Tauri Star"



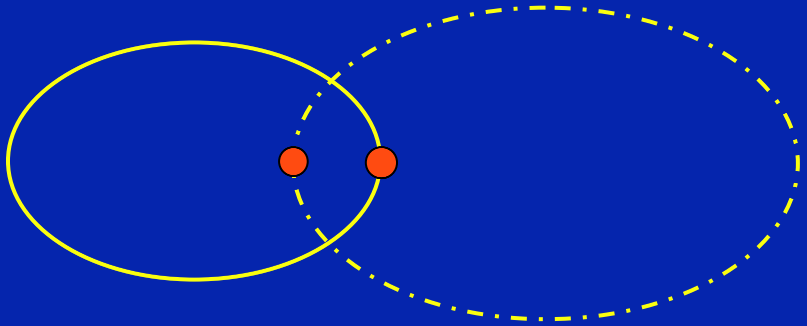
- "Eruptive T Tauri star" - Herbig 1977
- Hα > 50 Å
- Heavily veiled spectrum
- Large ultraviolet excess
- $M \approx 10^{-7} M_o/yr$
- Power-law spectral energy distributio
- Massive disk 0.06 $M_o$
- Outflow $M \approx 10^{-8} M_o/yr$
- Microjet



# Accretion in Close Binaries

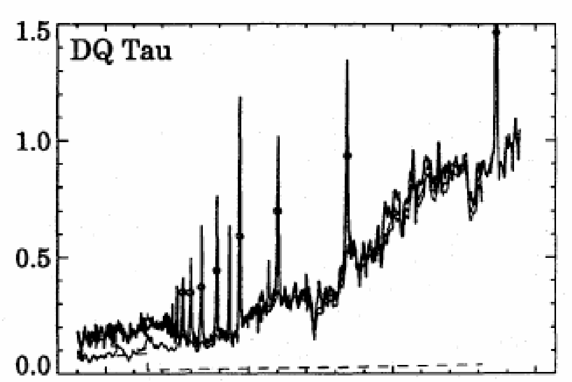
**Question 1:**

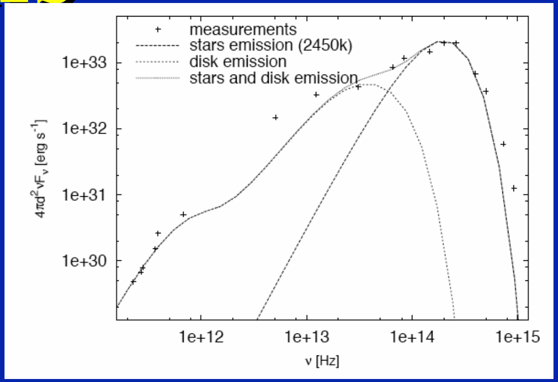
Given every diagnostic of circumstellar accretion (and disks?), what is the source of the accreting material?

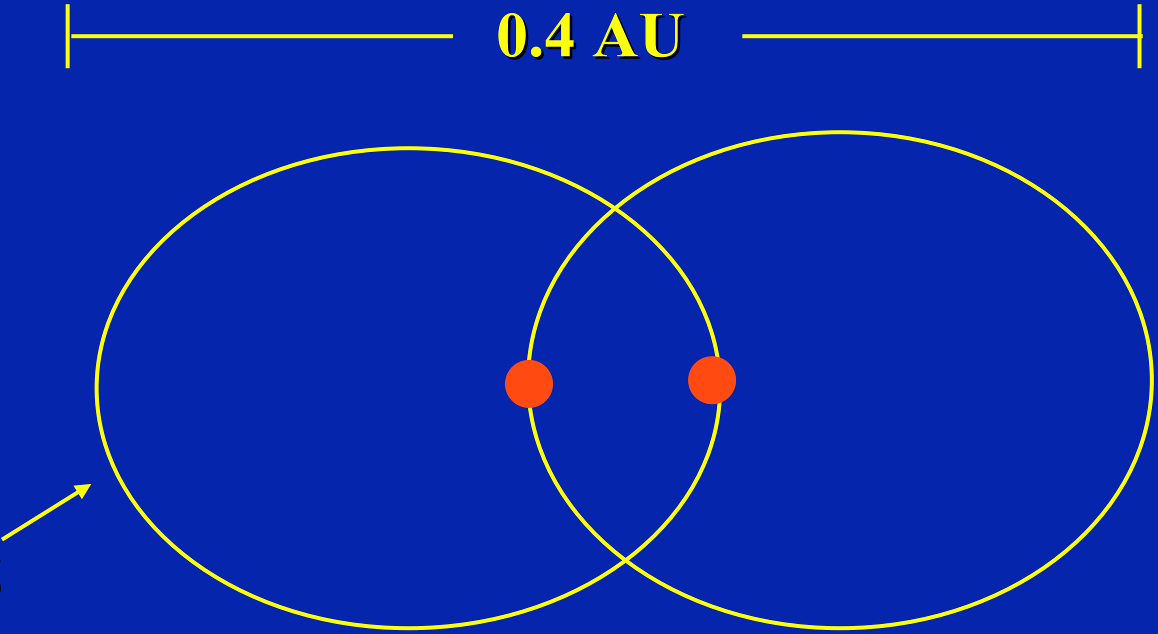


# Accretion Streams

## DQ Tau





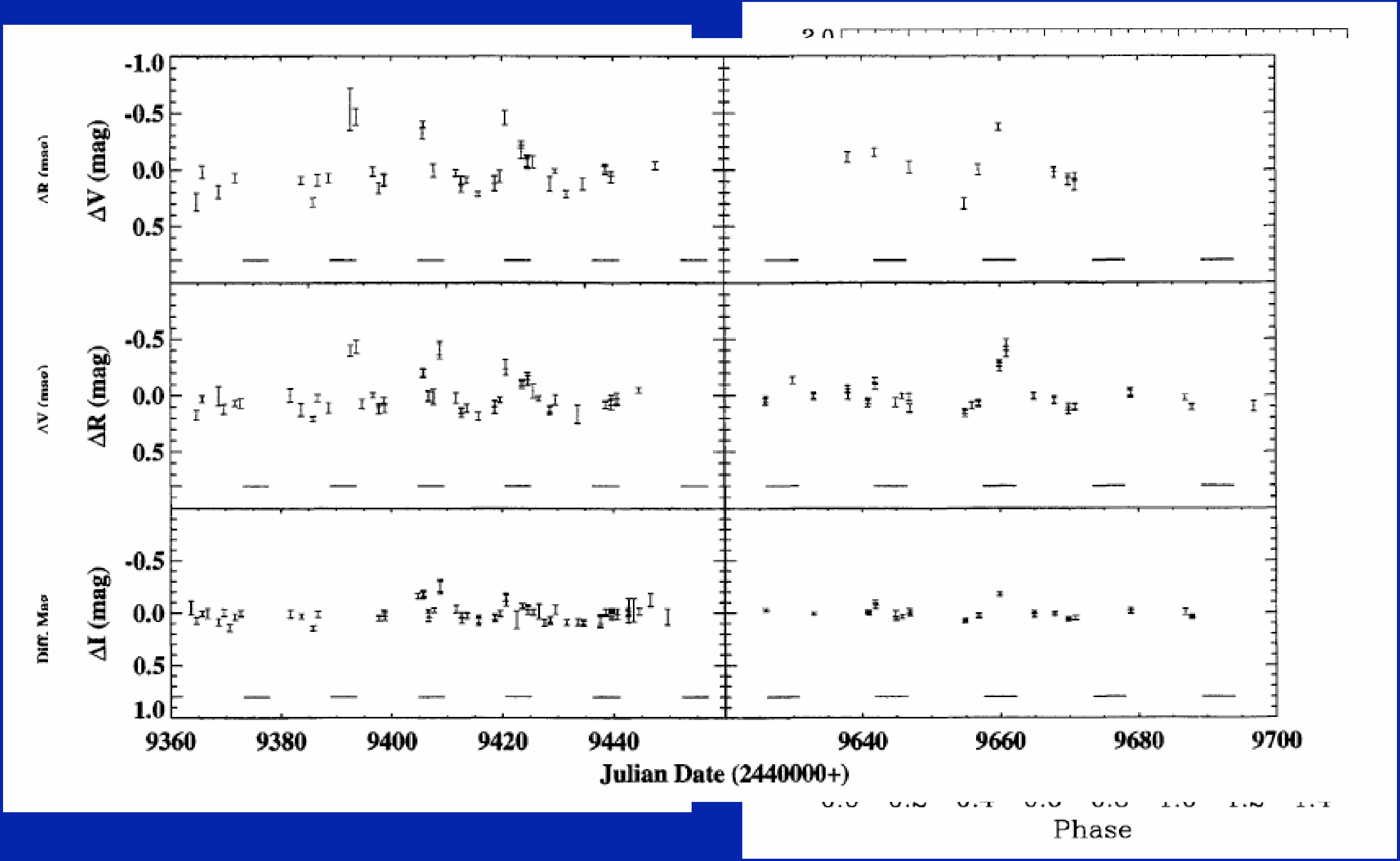


0.4 AU

e = 0.5

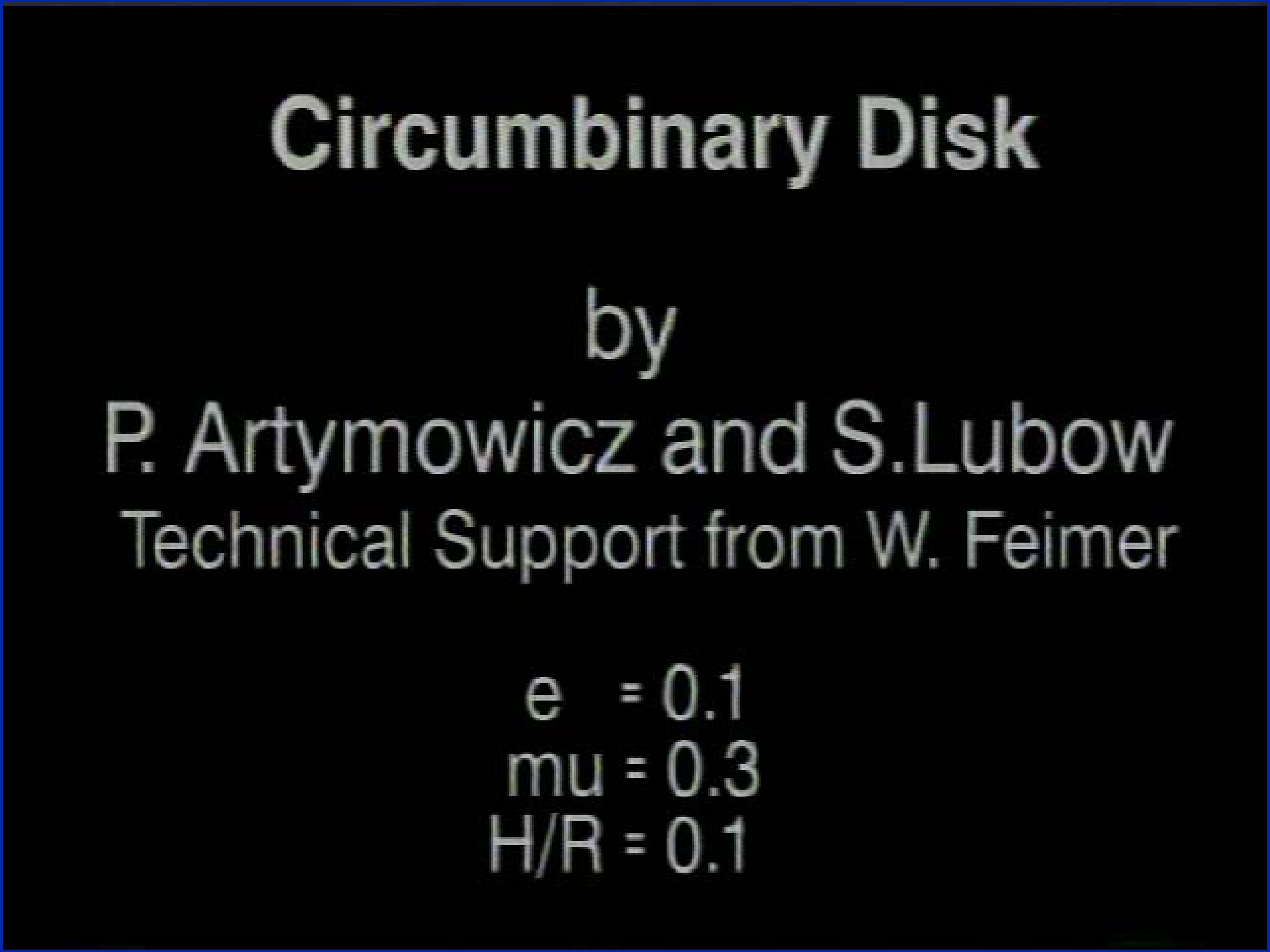
P=15.80 days

# Accretion Streams



Mathieu et al. 1997, Basri, Johns-Krull & Mathieu 1997

# Accretion Streams



Circumbinary Disk

by

P. Artymowicz and S.Lubow

Technical Support from W. Feimer

e = 0.1

mu = 0.3

H/R = 0.1

# Accretion Streams

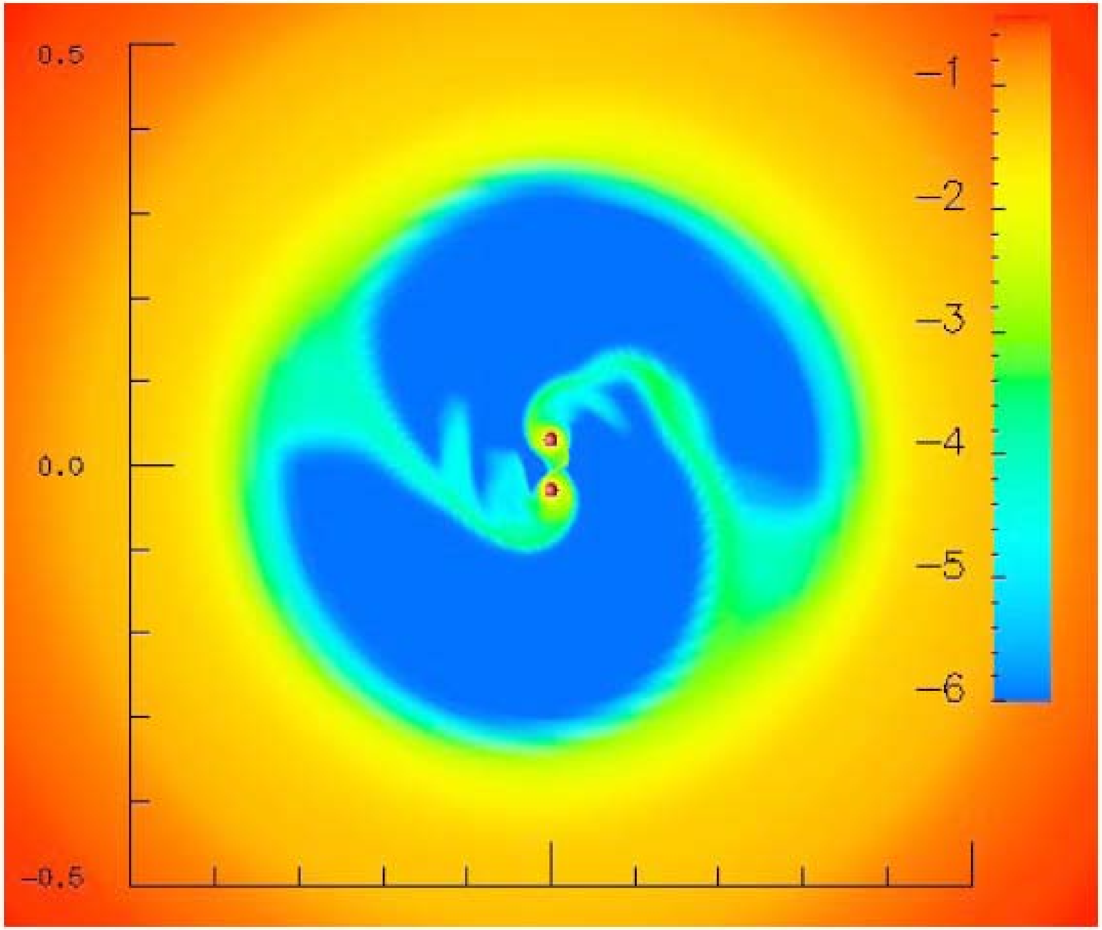
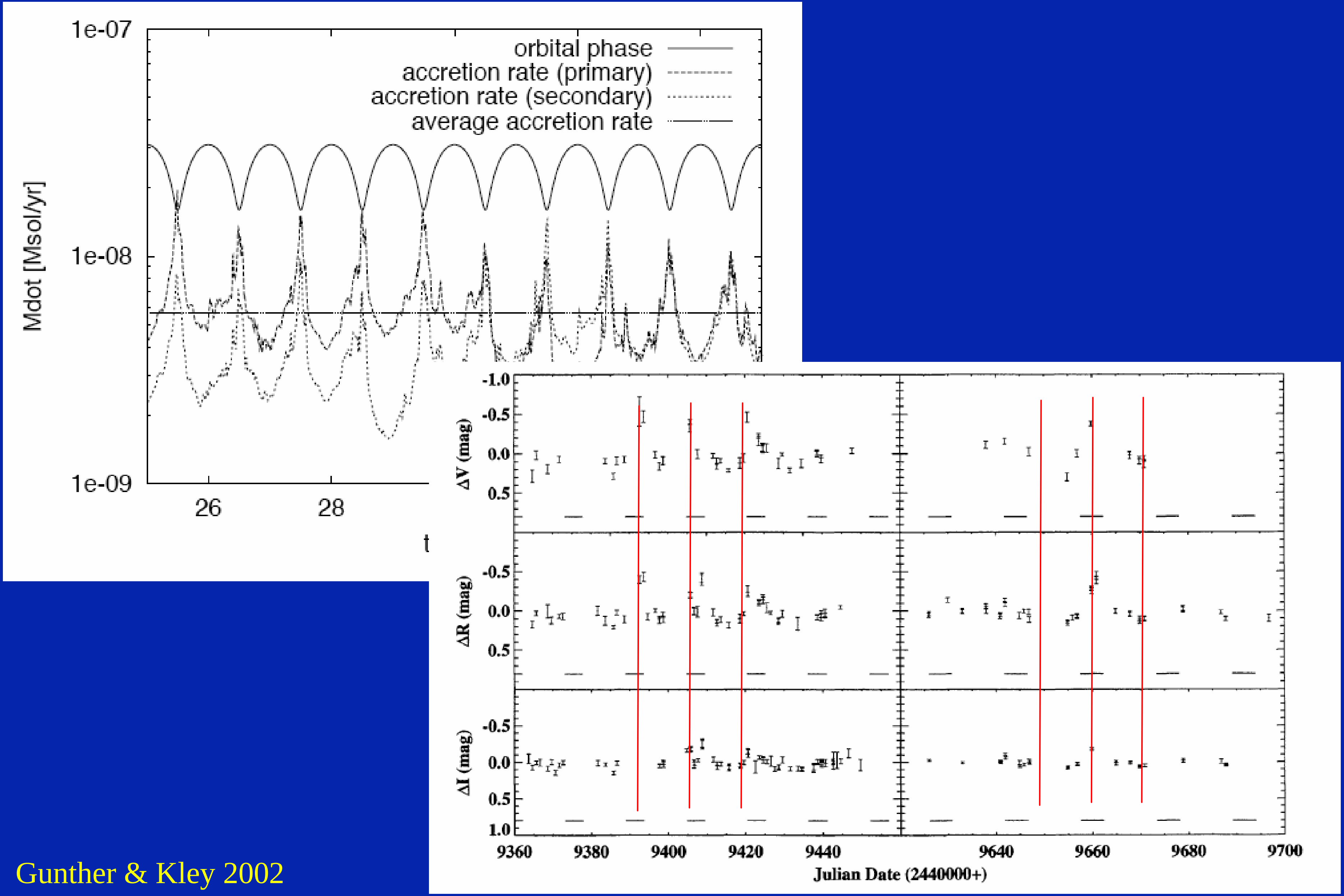


**Fig. 10.** DQ Tau circumbinary disk after 85.5 orbital periods in periastron. Color coding is log(Σ), the size of the stars reflects the actual stellar radii, the length scales are in AU.

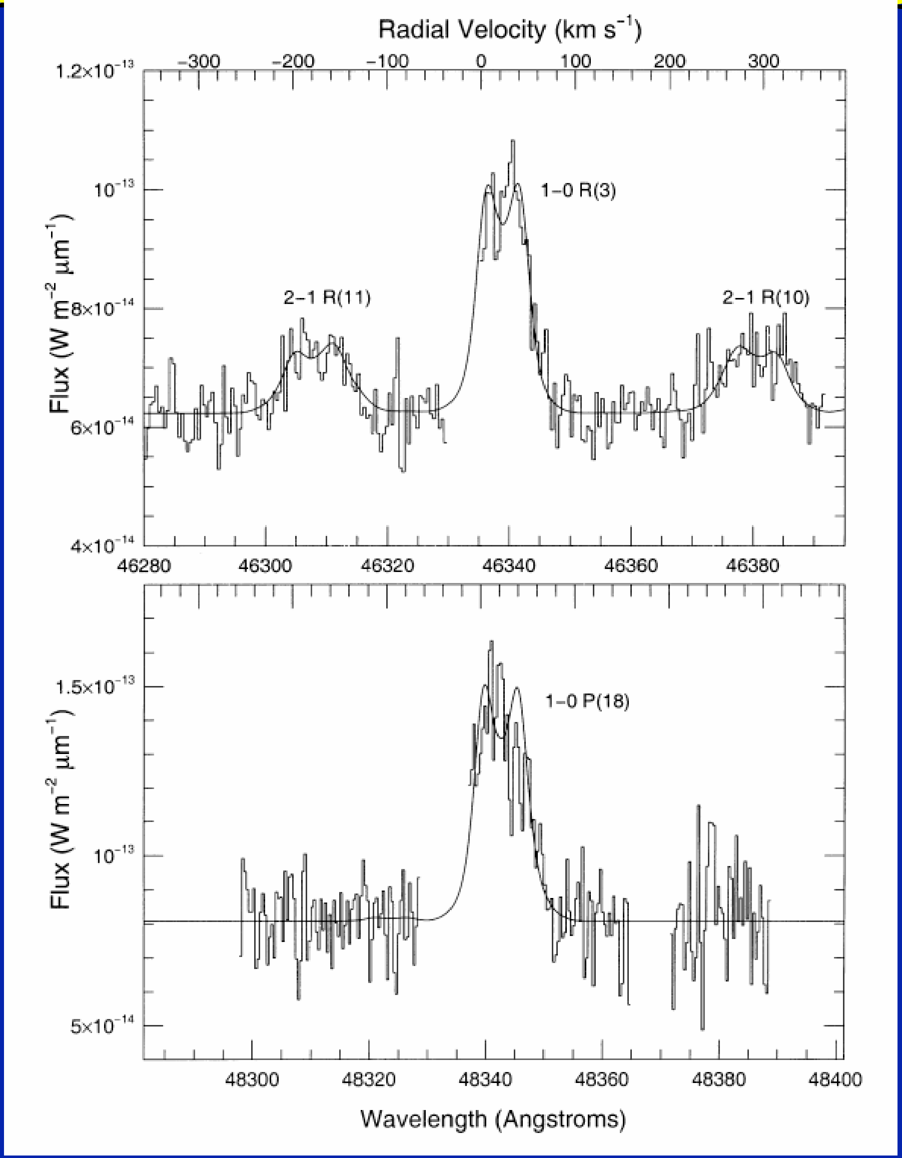
Gunther & Kley 2002

# Accretion Streams

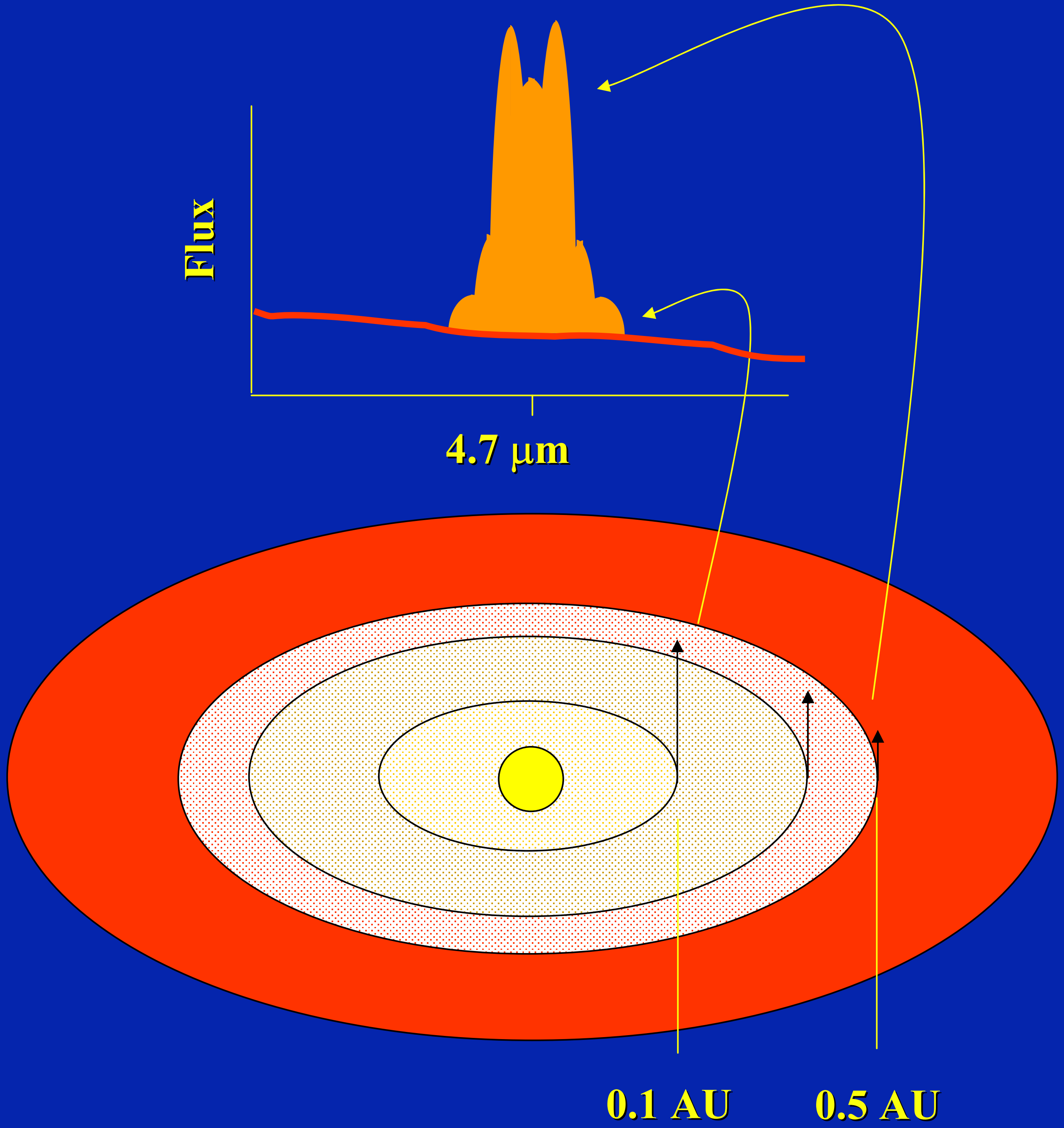


Gunther & Kley 2002

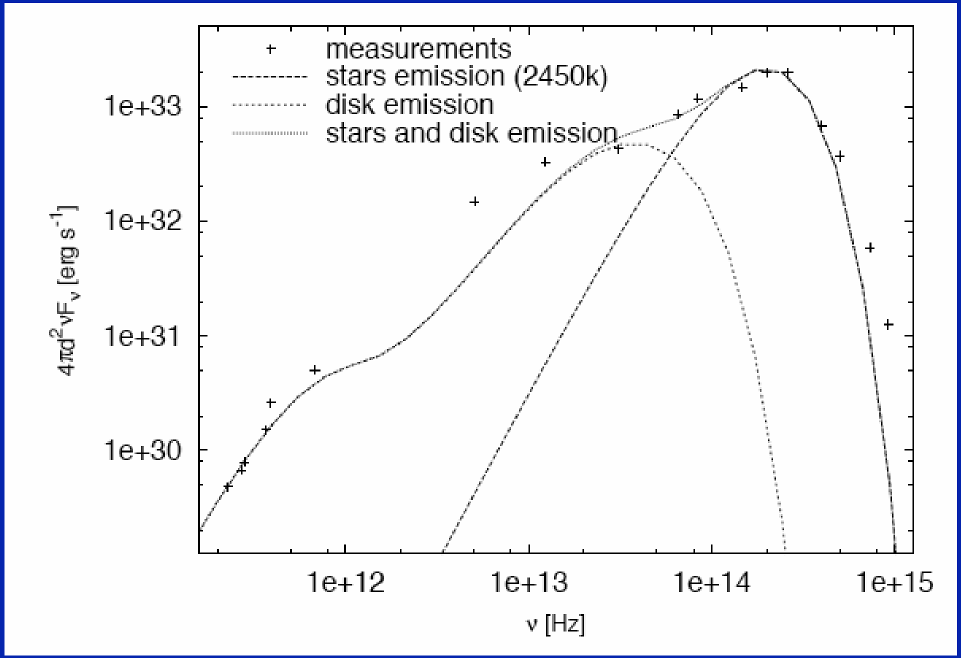
# Accretion Streams



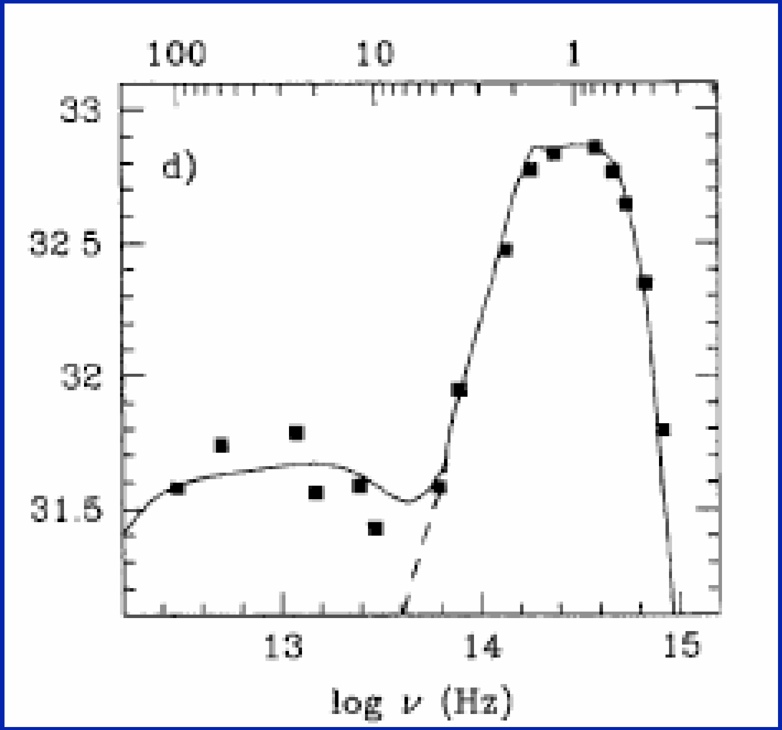
Carr, Mathieu & Najita 2001


Flux
4.7 μm
0.1 AU
0.5 AU

# Accretion Streams



**V4046 Sgr**



**DQ Tau**

# Accretion Streams

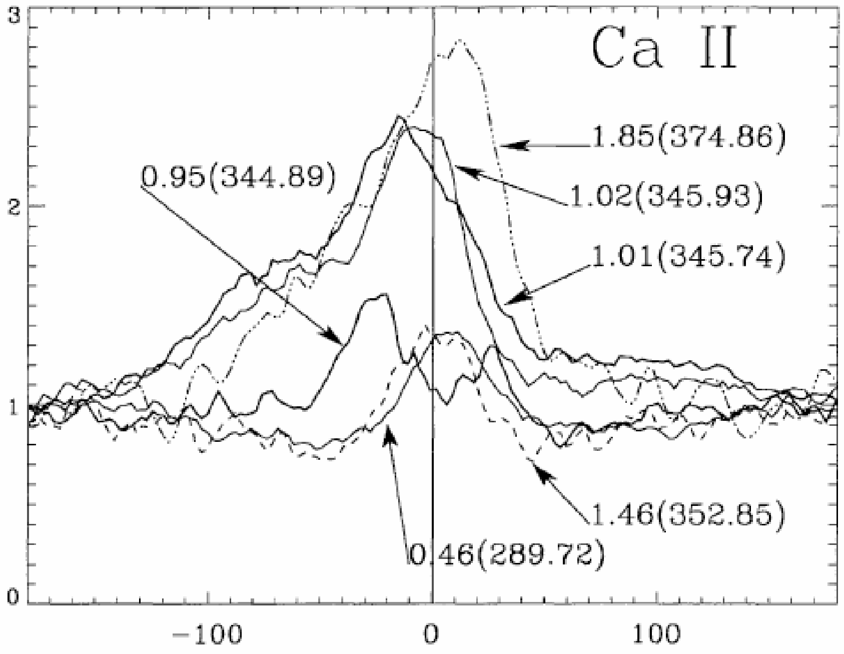


FIG. 4. Same as Fig. 1 but for the Ca II line at 866.2 nm.

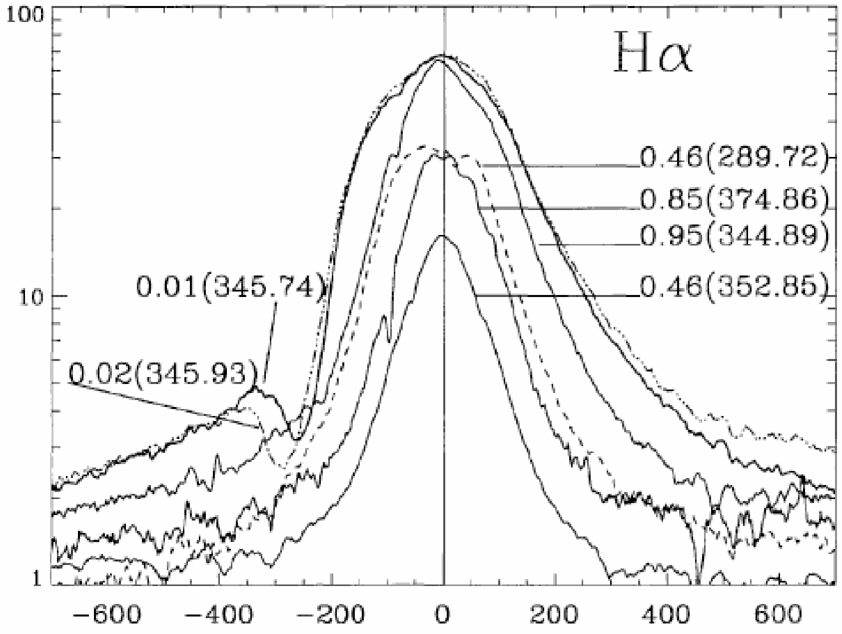
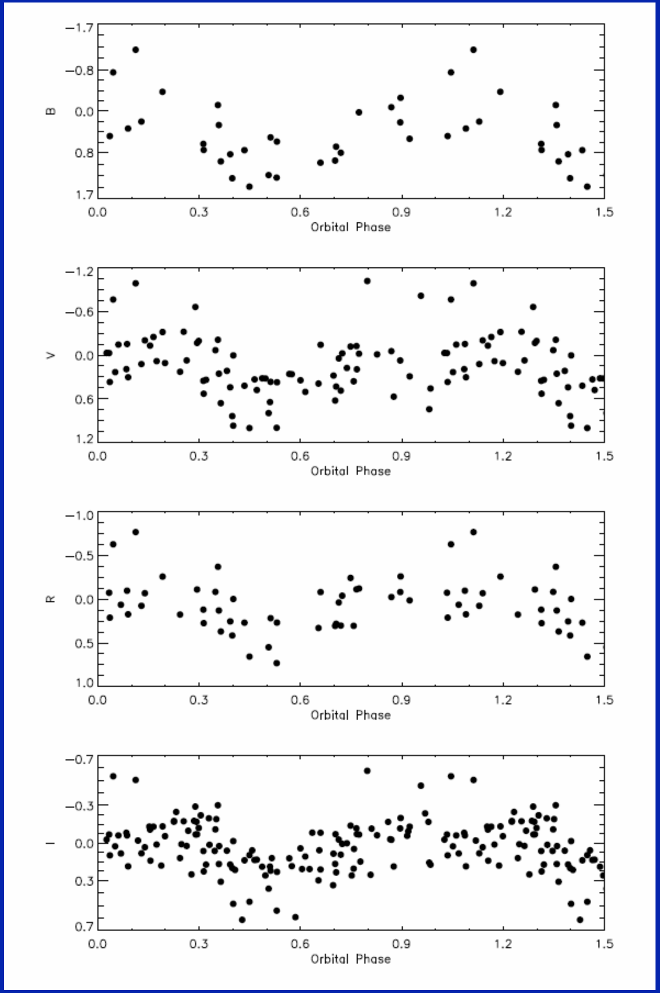


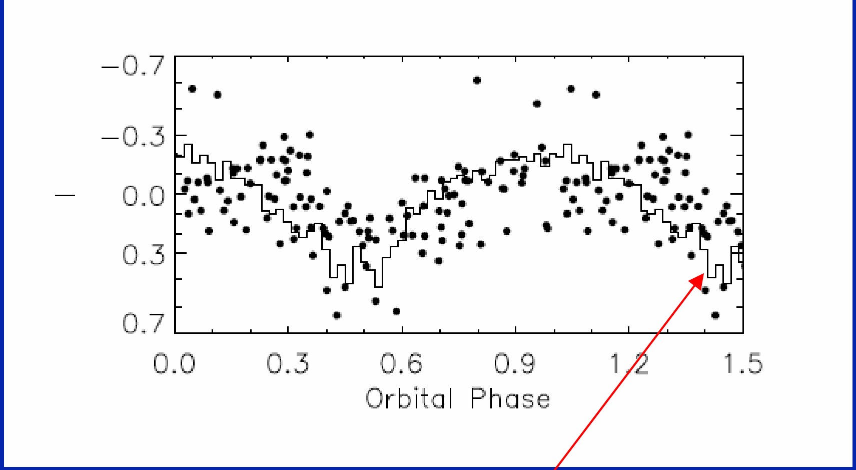
FIG. 5. Same as Fig. 1 but for the Hα line at 656.3 nm. Note that the intensity scale is logarithmic.

Basri, Johns-Krull & Mathieu 1997

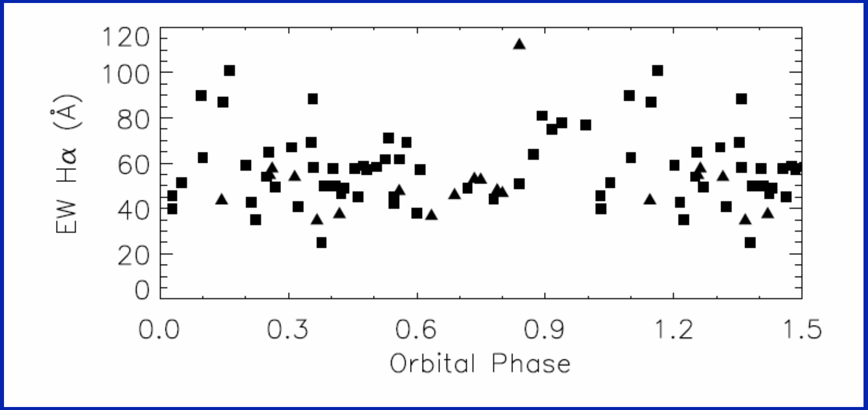
# Accretion Streams

## UZ Tau E





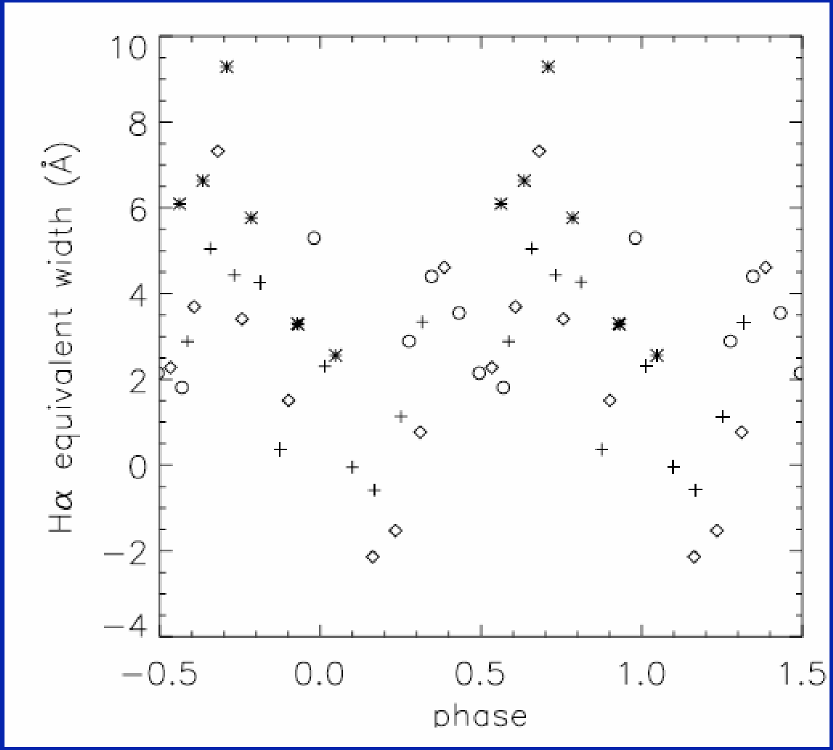
Theory (SPH)

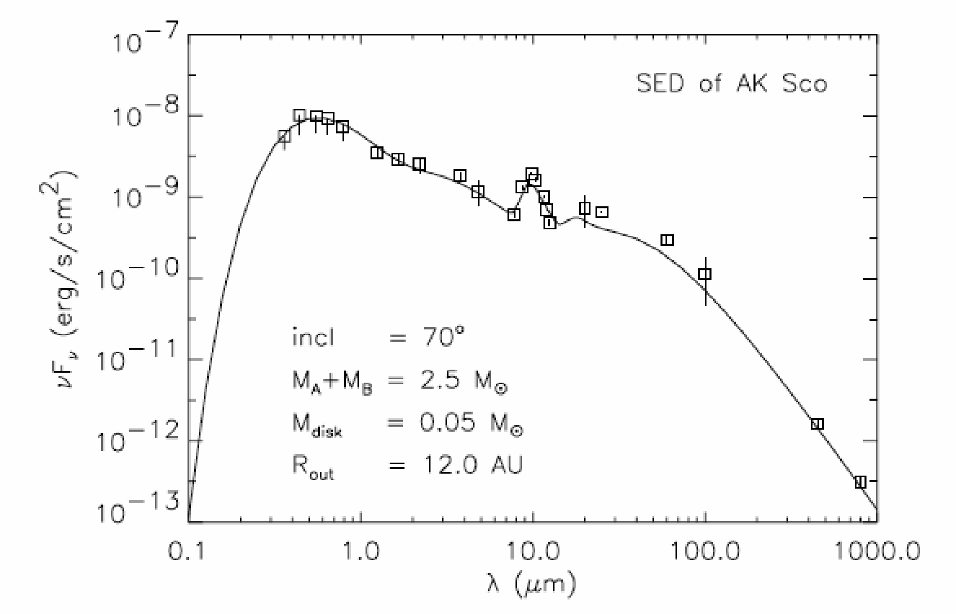


Jensen et al. 2007

# Accretion Streams

## AK Sco





Alencar et al. 2003

**P=13.6 days**

# Presence of Accretion

**Question 1:**

Given every indicator of circumstellar accretion (and disks?), what is the source of the accreting material?

**Possible Answer:**

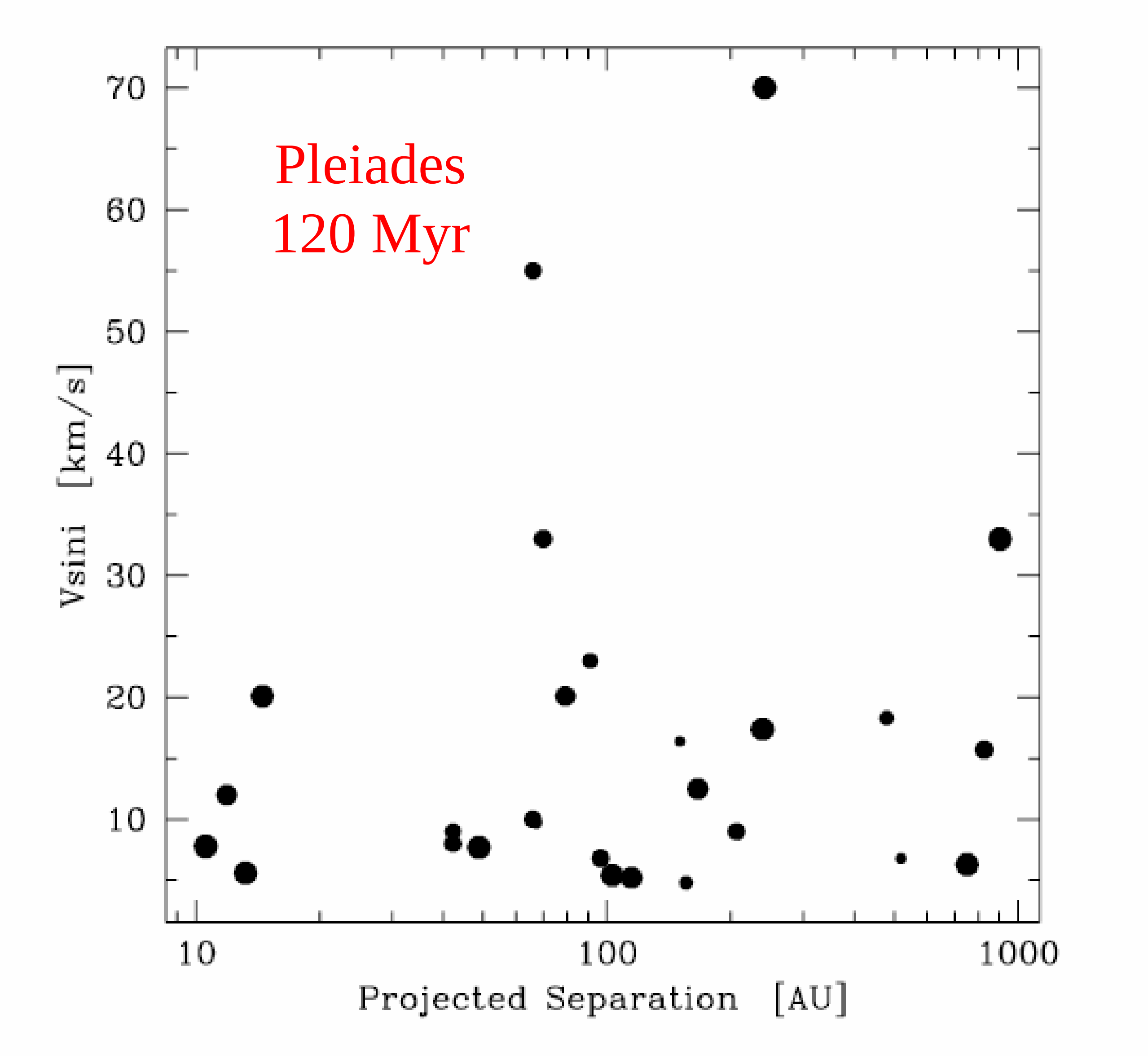
Accretion streams carrying circumbinary disk material to circumstellar region.

# Angular Momentum Regulation

**Question 2:**

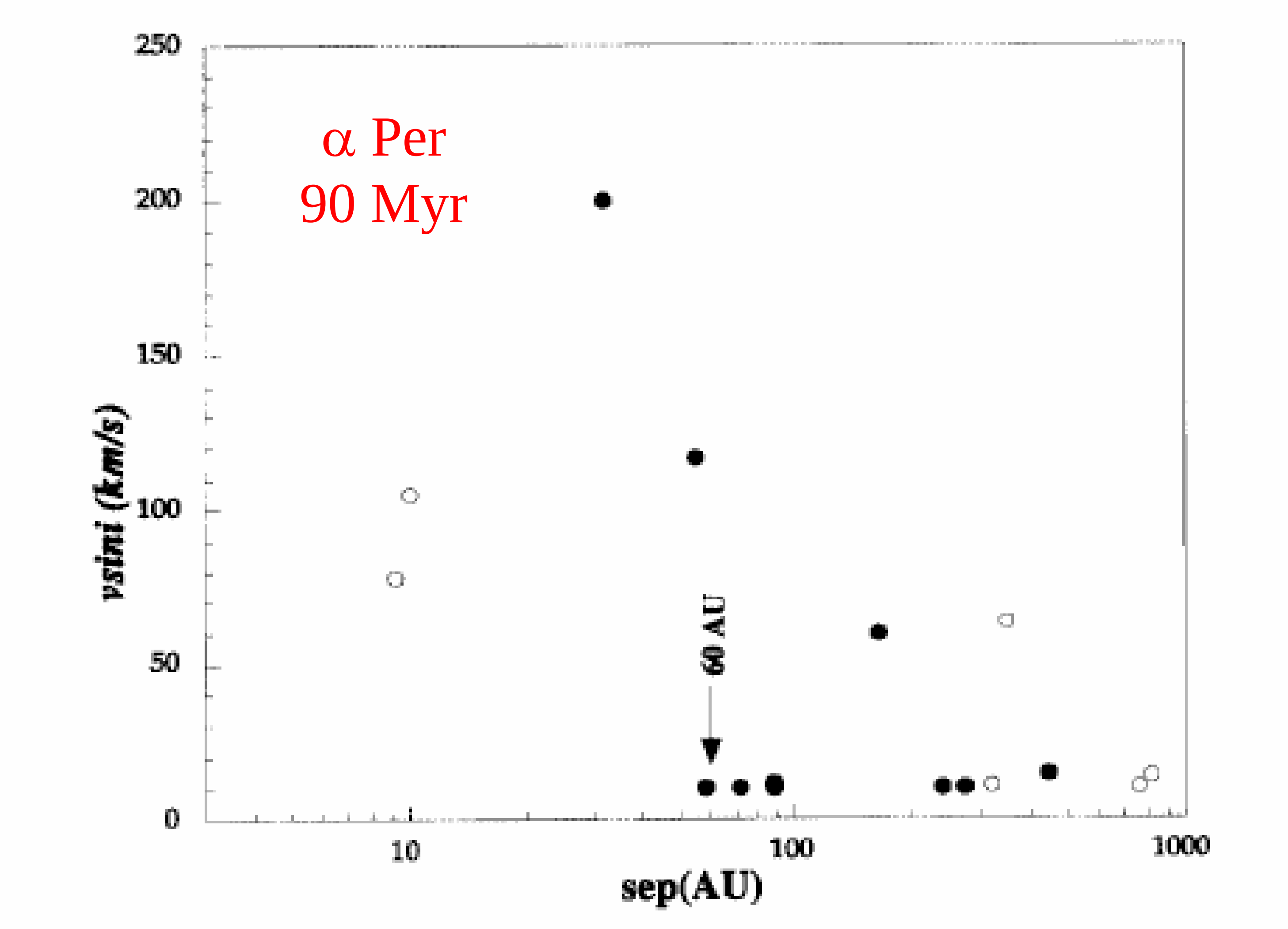
Given severe (complete?) circumstellar disk truncation, what is the impact on angular momentum evolution?

# Stellar Rotation in Binaries



Bouvier et al. 1997

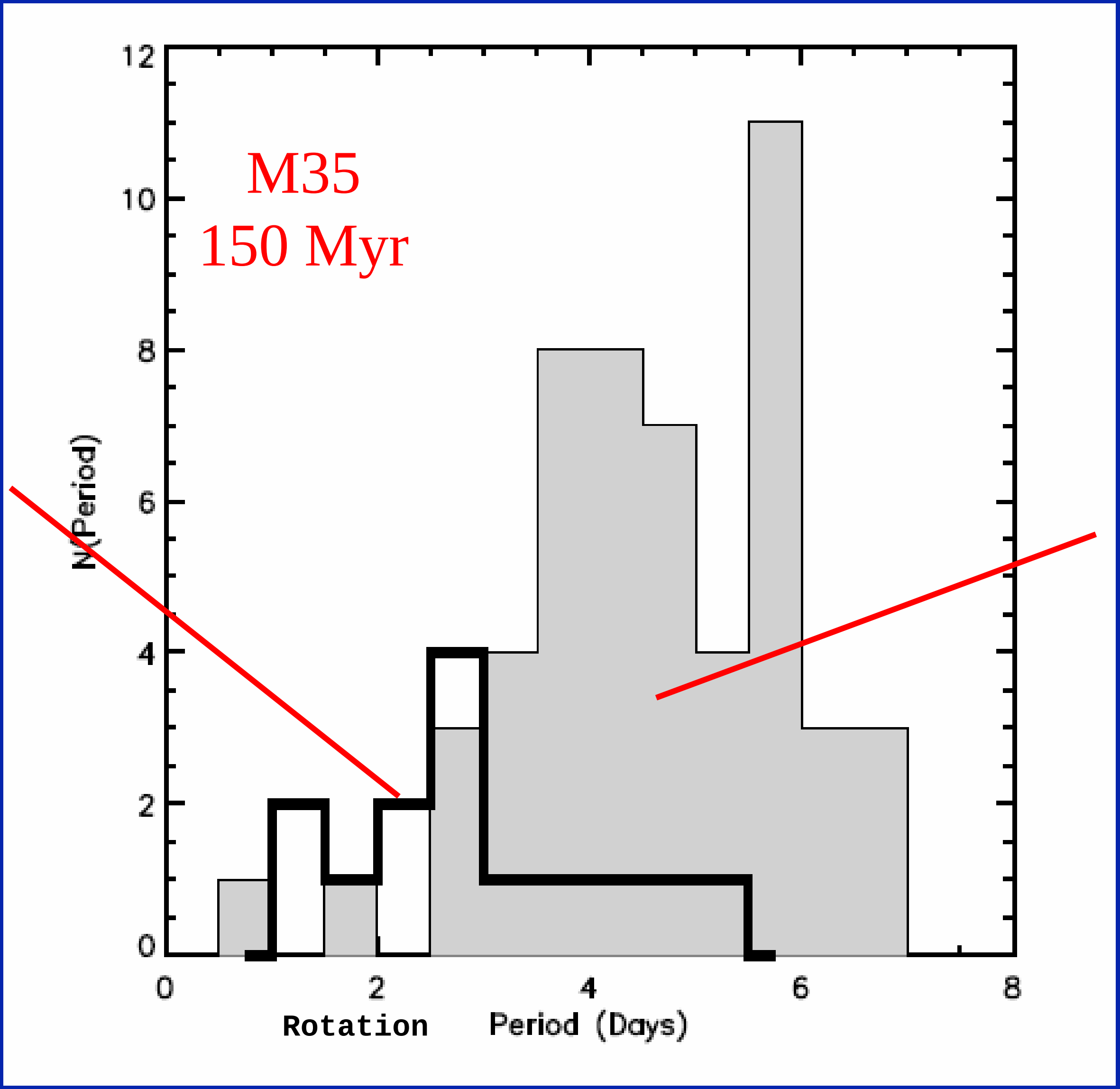
# Stellar Rotation in Binaries



Patience et al. 2002

# Stellar Rotation in Binaries

**0.1 < a < 5 AU**



**a > 5 AU**

Meibom, Mathieu & Stassun 2007

**Different at 99.9% confidence**

# Angular Momentum Regulation

**Question 2:**

Given severe (complete?) circumstellar disk truncation, what is the impact on angular momentum evolution?

**Possible Answer:**

Reduced angular momentum regulation for the closest binaries ("disk locking picture")

**Possible Answer:**

Stars in close binaries form with higher angular momentum ("formation picture")

# Star-Disk Interactions in Young Binaries

1. At least 15% of T Tauri stars are binaries with companions within 1 AU.

2. The presence of close (≈ 0.02 AU) companions does not change spectroscopic accretion diagnostics and SED disk diagnostics.

3. Gap-crossing streams may feed accretion.

4. Stars in young, short-period binaries rotate more rapidly than wide binary primaries or single stars.

# Outstanding Question

**Given that every indicator of circumstellar accretion survives in the face of severe (complete?) circumstellar disk truncation, what does this tell us about star-disk physics?**