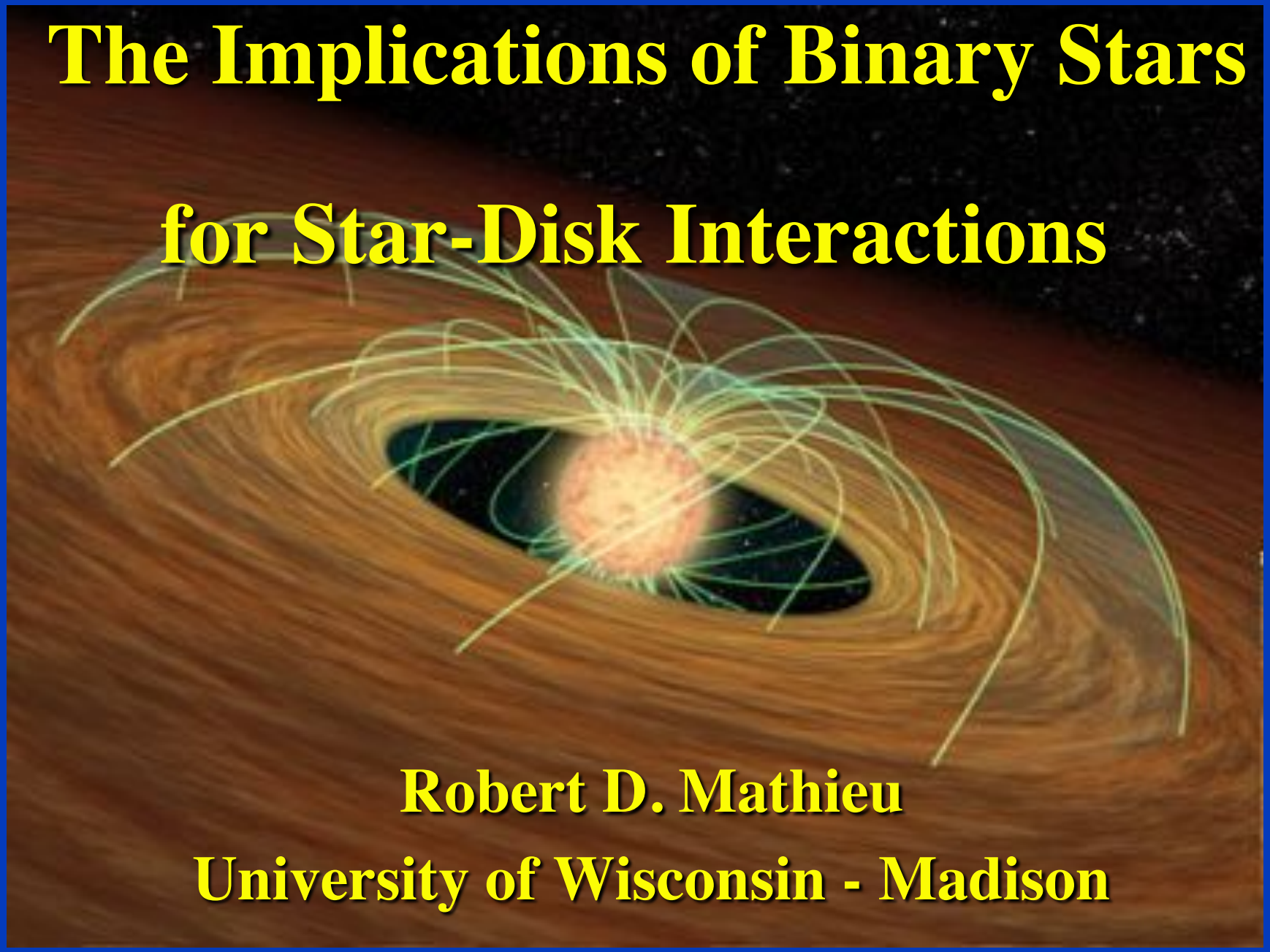
The Implications of Binary Stars for Star-Disk Interactions



Robert D. Mathieu
University of Wisconsin - Madison

Phil as a Star!

Beichman *et al*. 1986

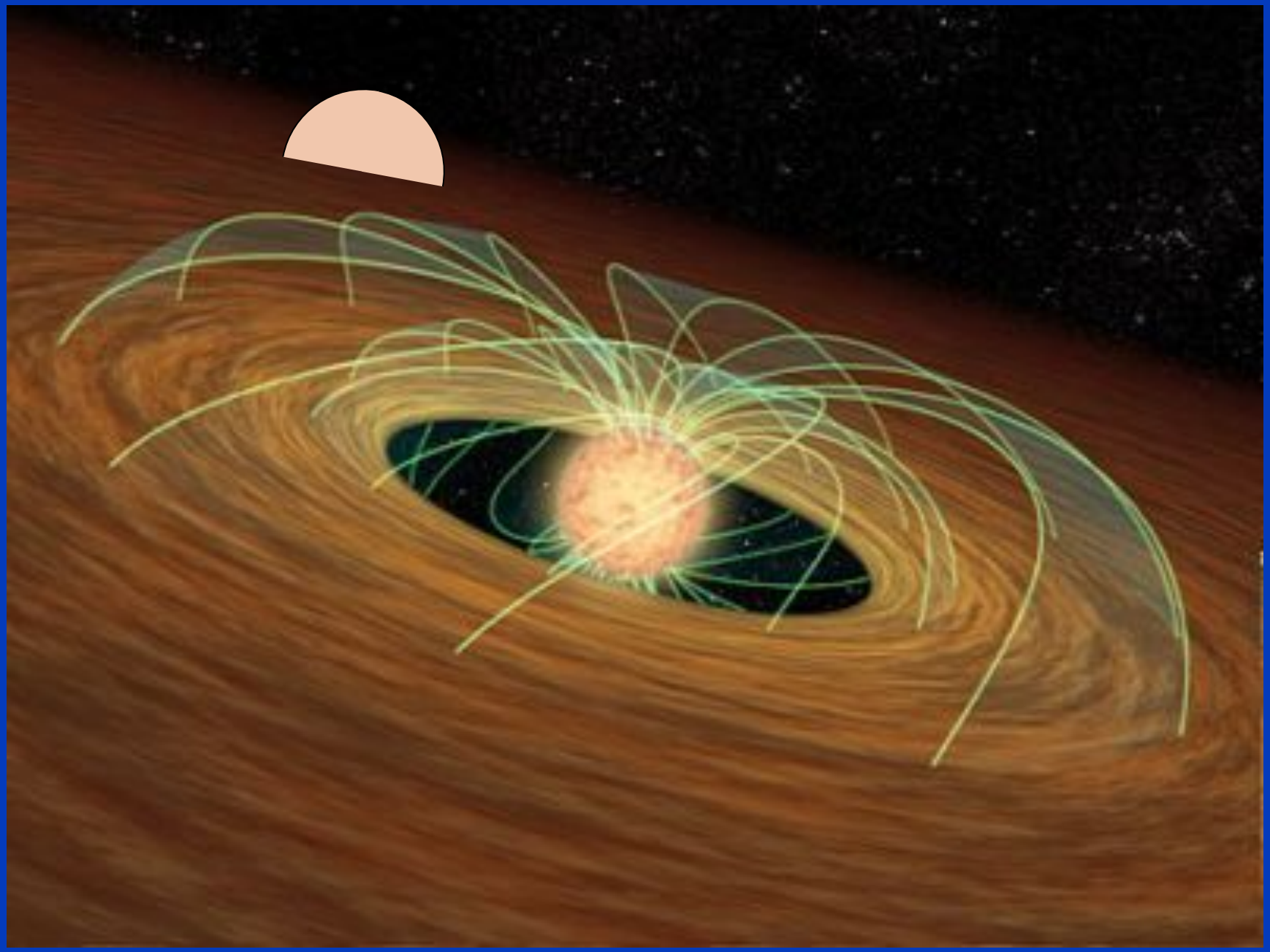
Myers *et al*. 1987

Feigelson *et al*. 1987

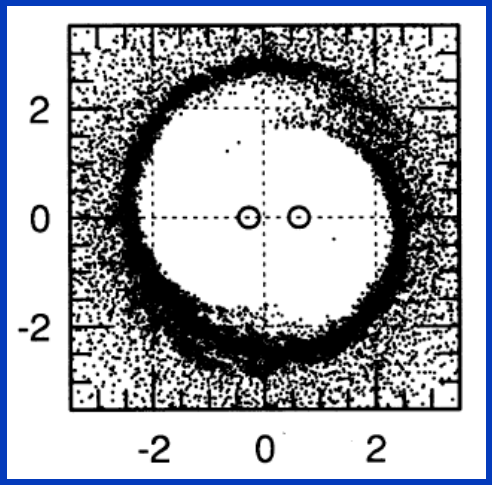
Walter *et al*. 1988

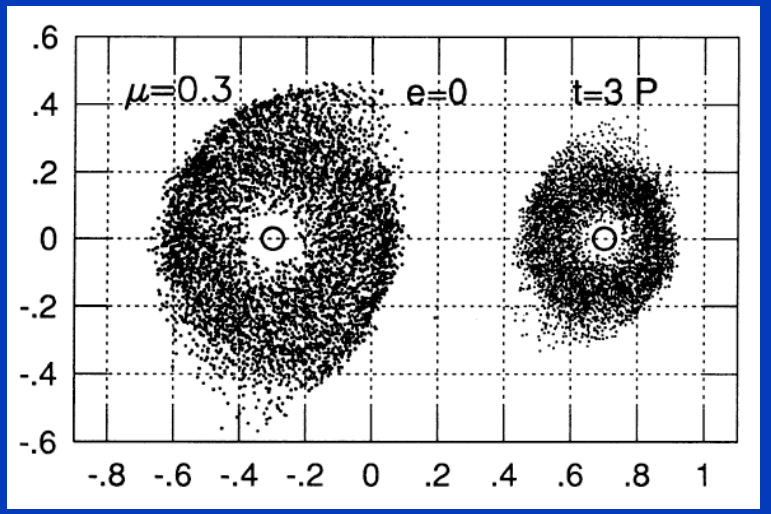
Mathieu *et al*. 1988

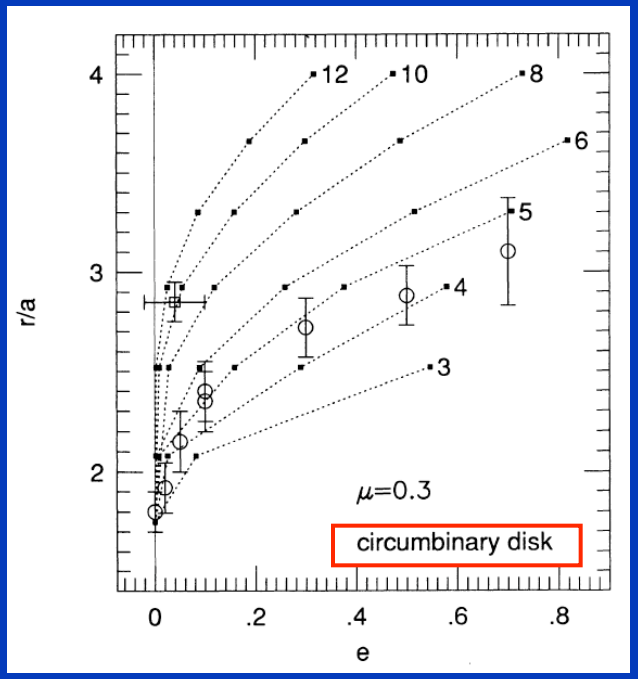
Mathieu *et al*. 1989

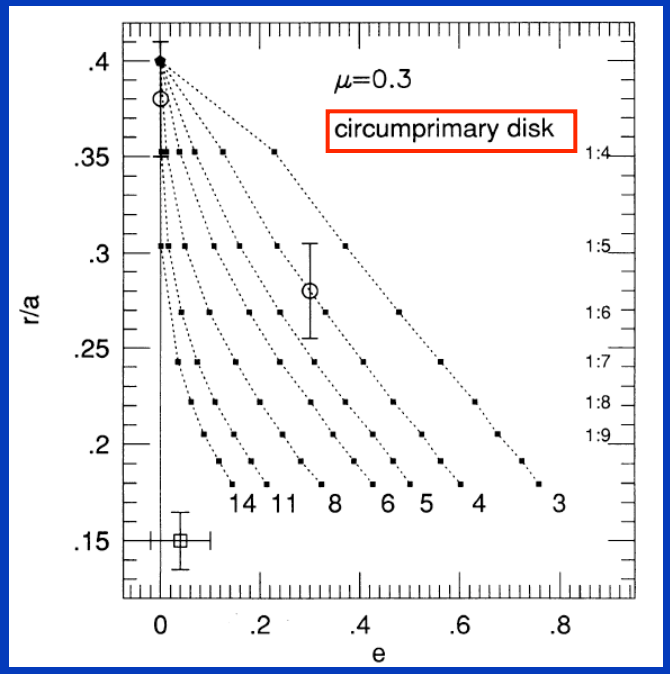


Disk Truncation

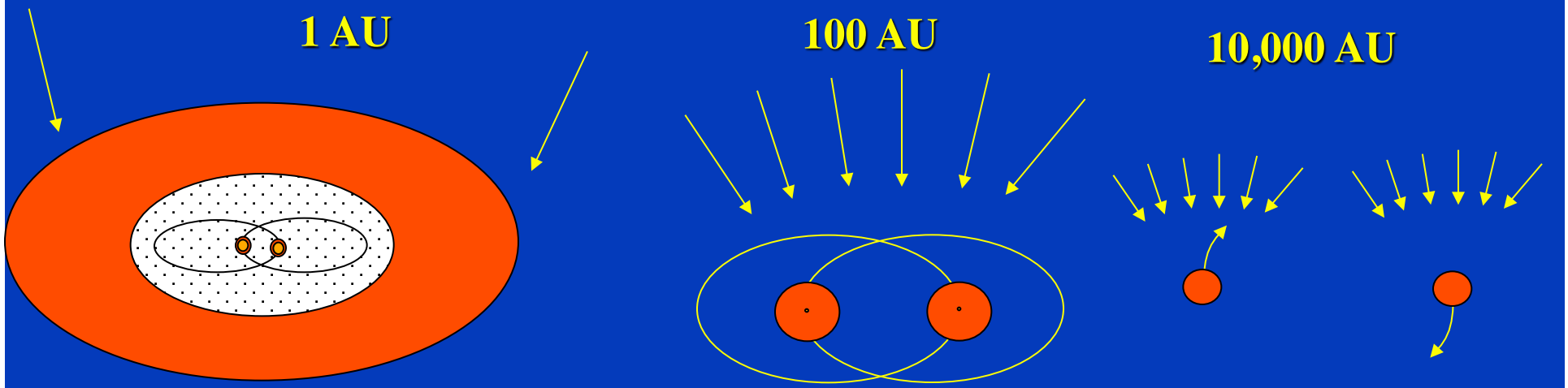


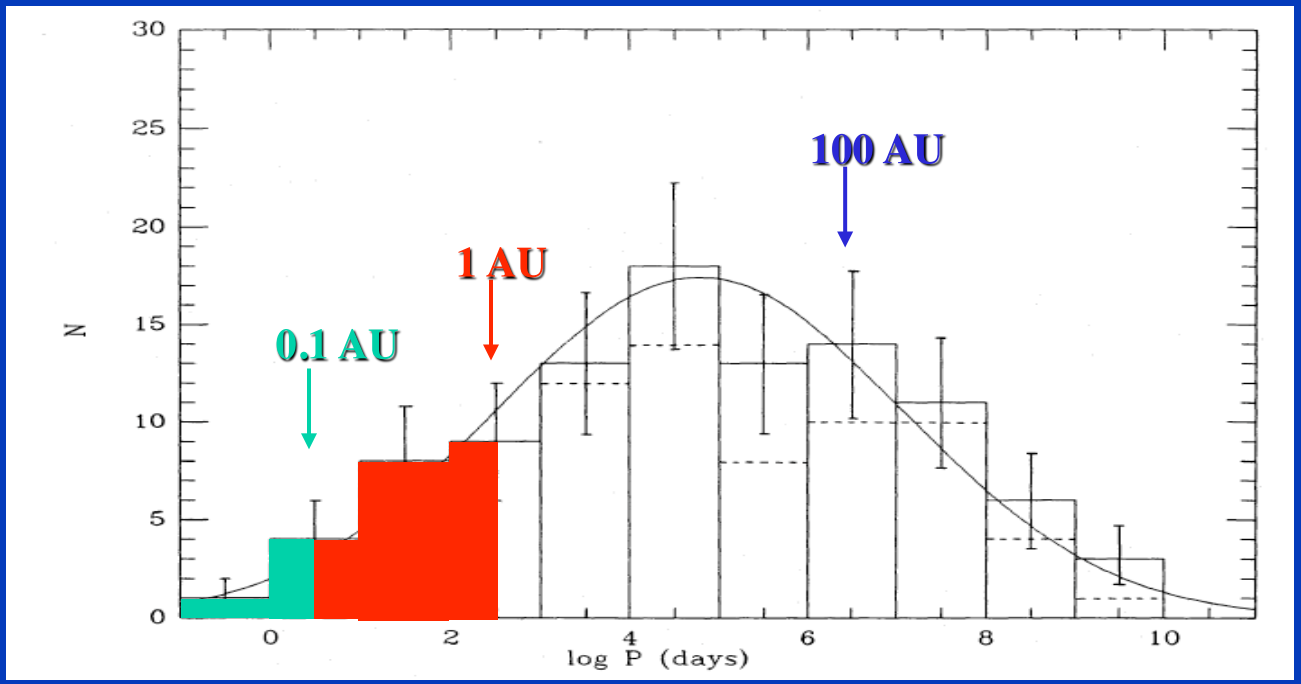






Scales


1 AU
100 AU
10,000 AU

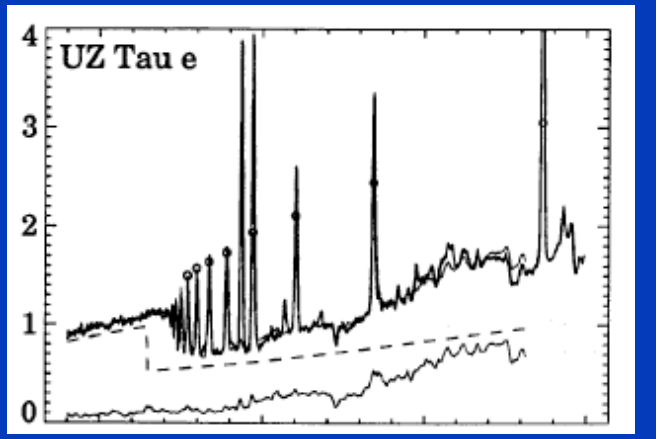

100 AU
1 AU
0.1 AU
N
log P (days)
0
5
10
15
20
25
30
0
2
4
6
8
10

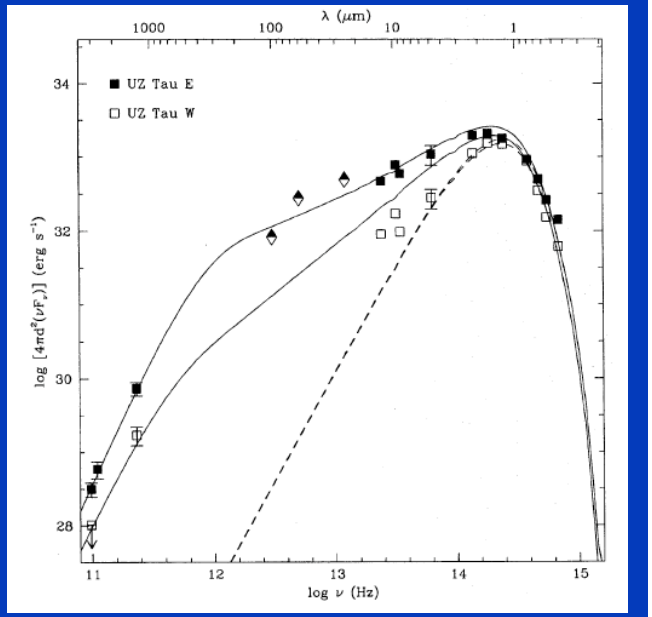
Accretion in Close Binaries

UZ Tau E

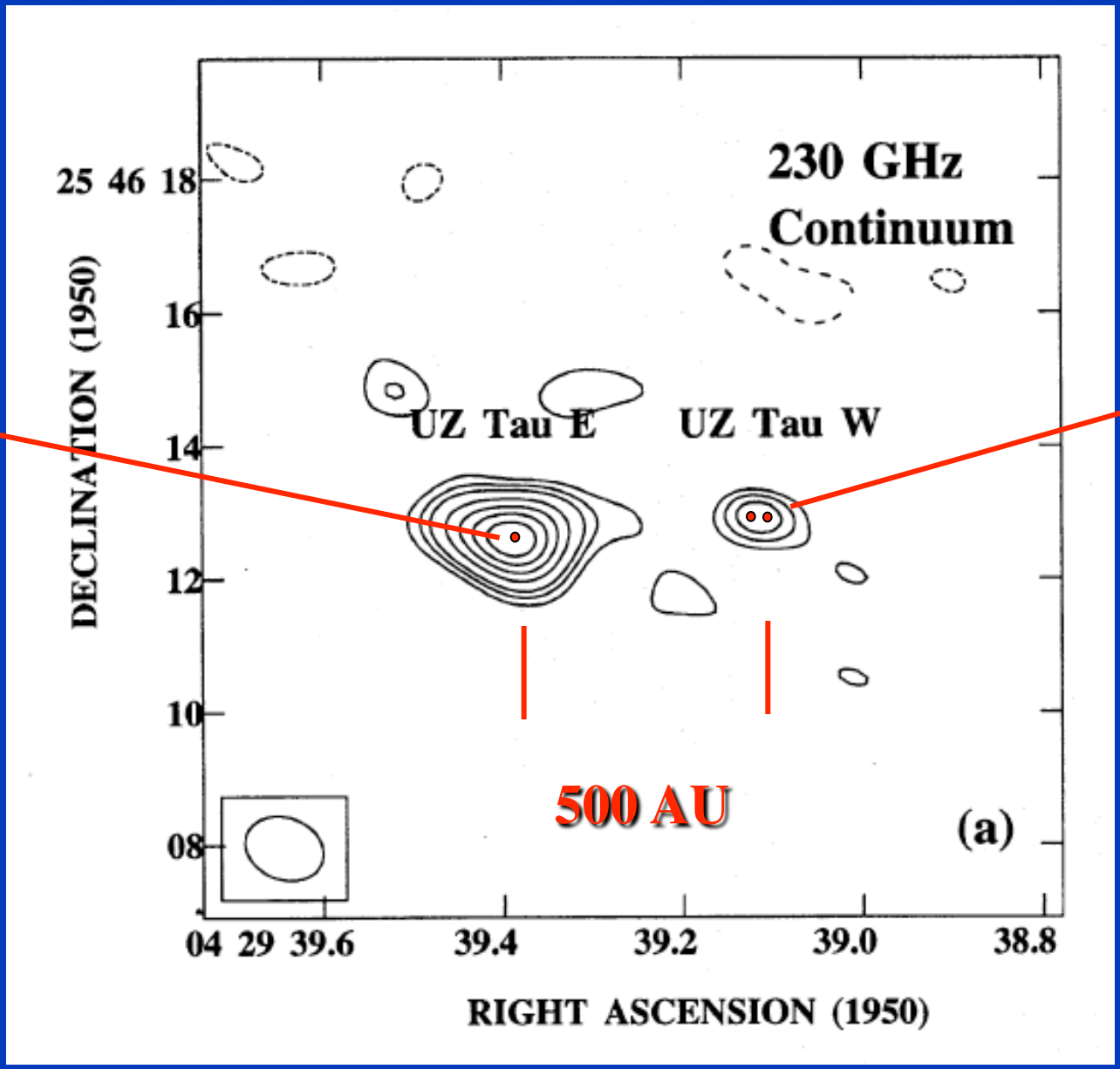
"The Classical T Tauri Star"

- "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 distribution
- Massive disk 0.06 M_o
- Outflow $M \approx 10^{-8}\ M_o/yr$
- Microjet





Accretion in Close Binaries



0.02 AU

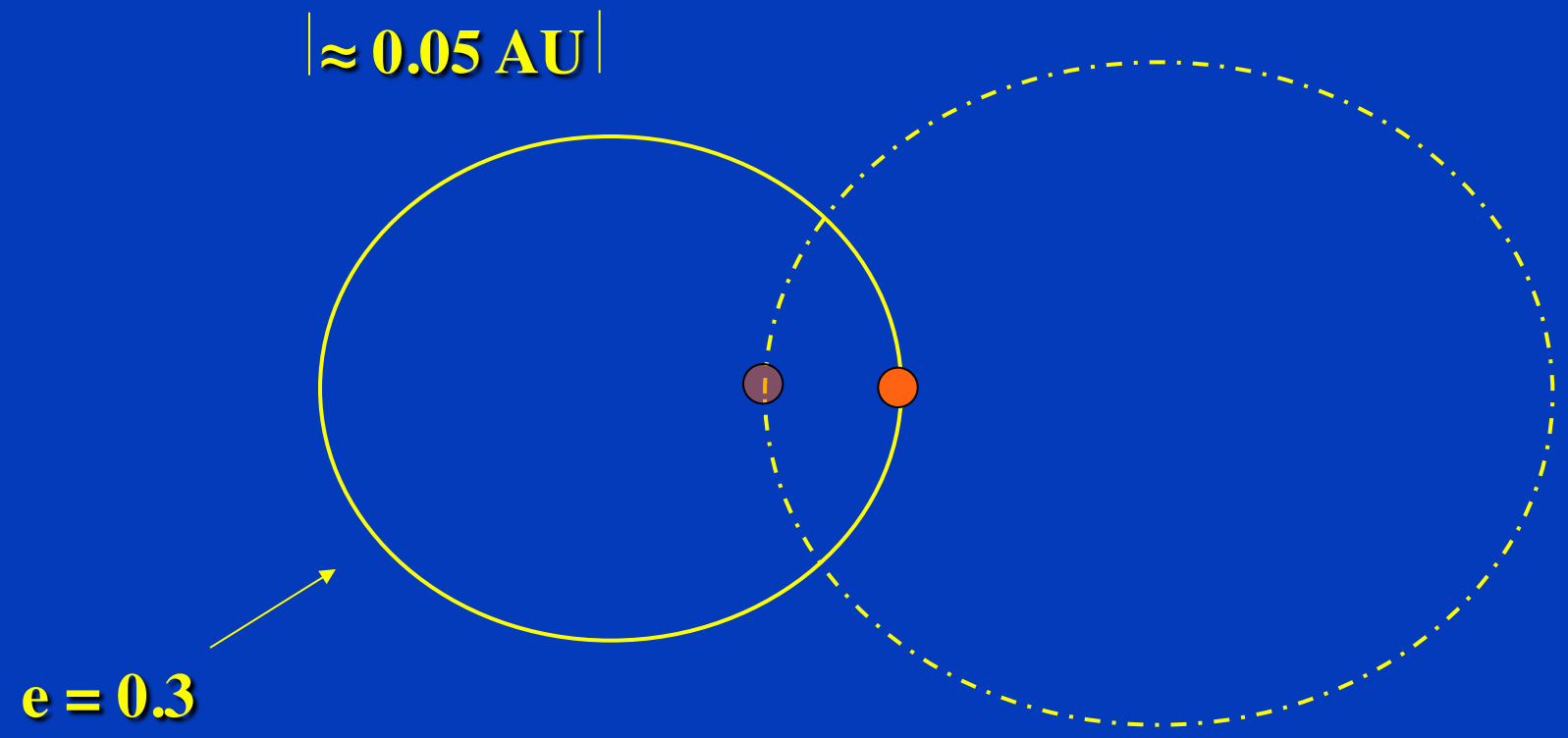
50 AU

Hα = 80 Å

Accretion in Close Binaries

UZ Tau E

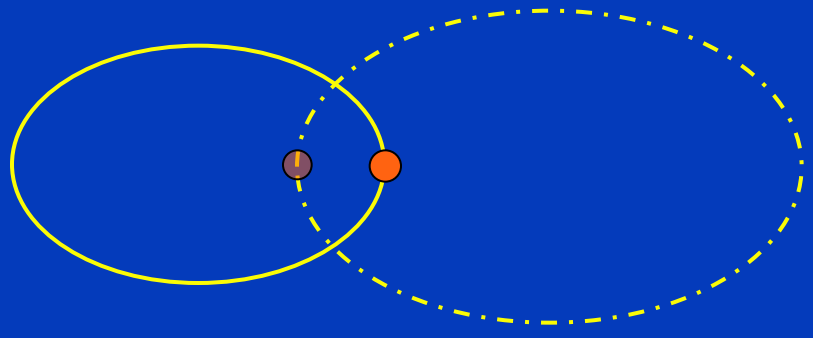
"The 19.1^{d} Period Binary Star"



Accretion in Close Binaries

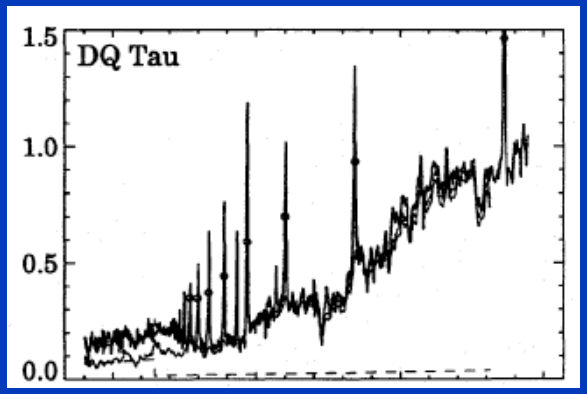
Question 1:

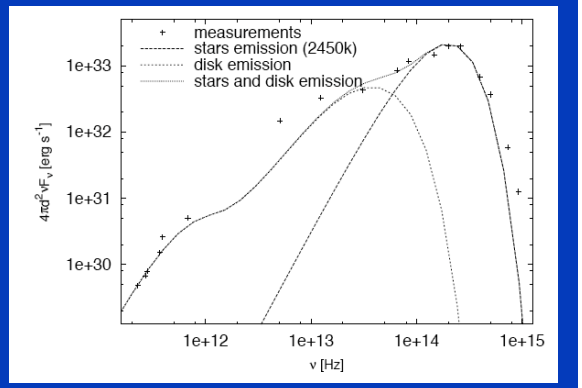
Given every diagnostic of circumstellar accretion (and disks?), what is the source of the accreting material?

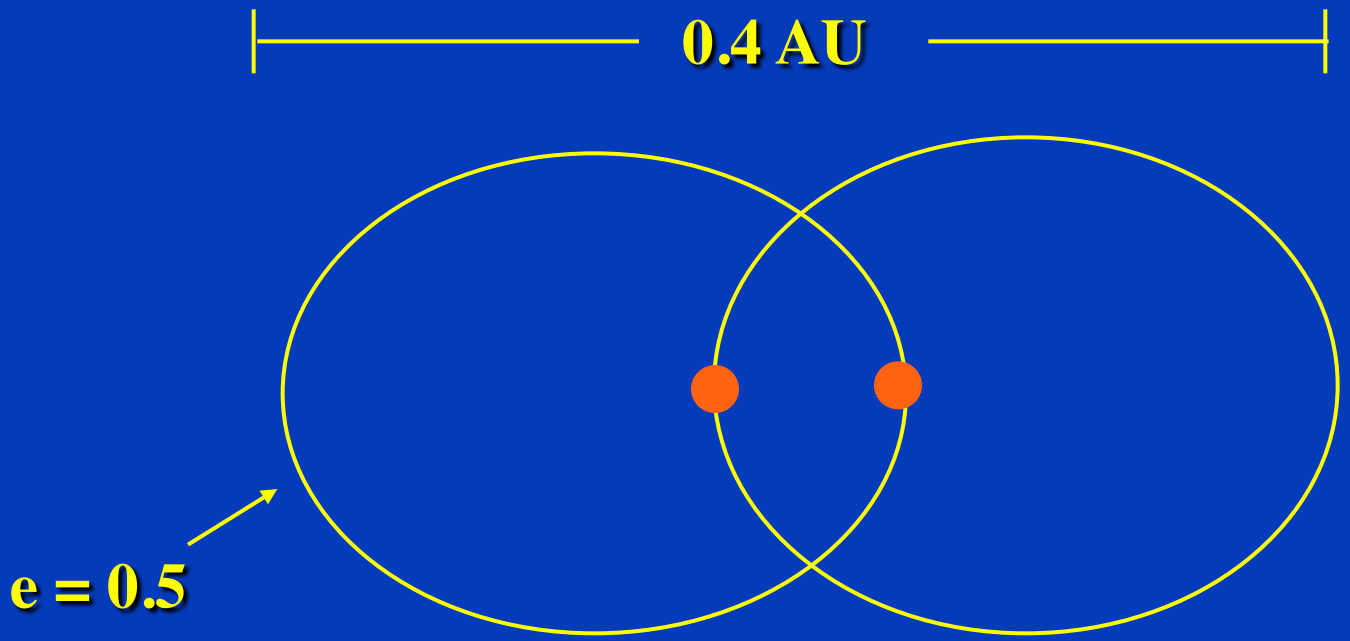


Accretion Streams

DQ Tau

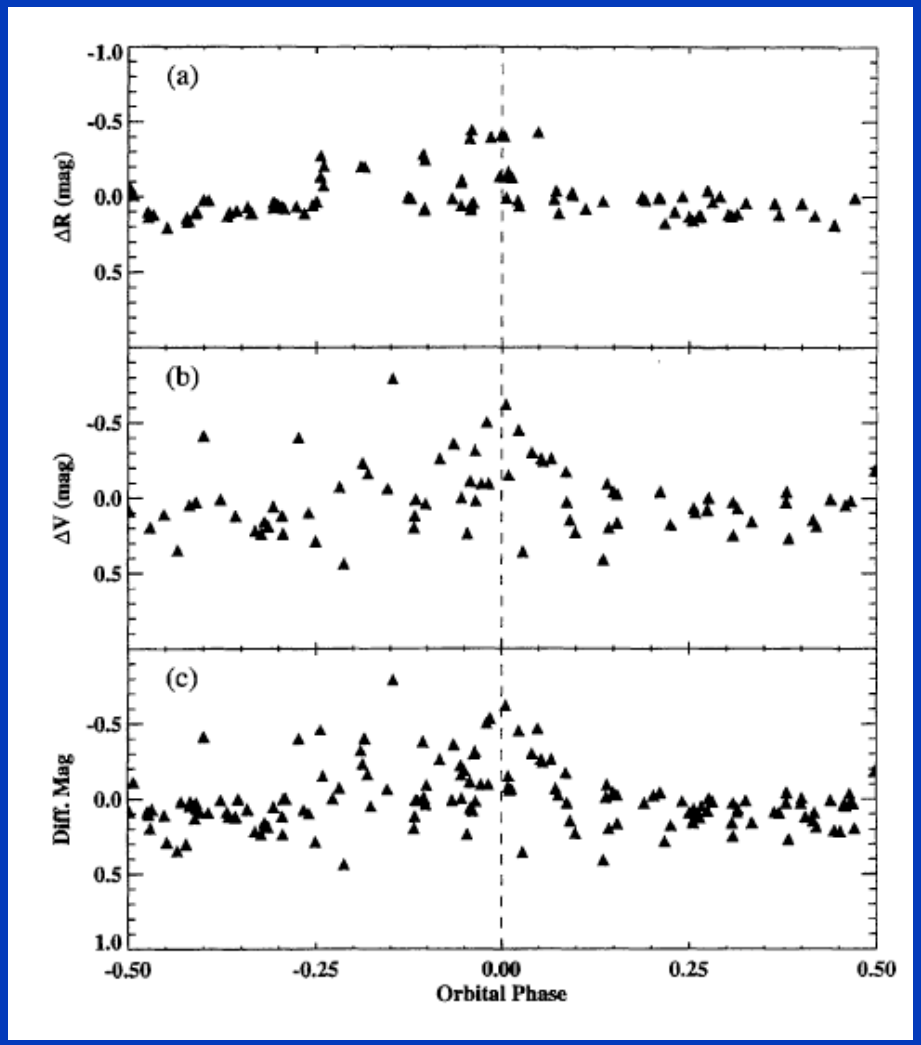


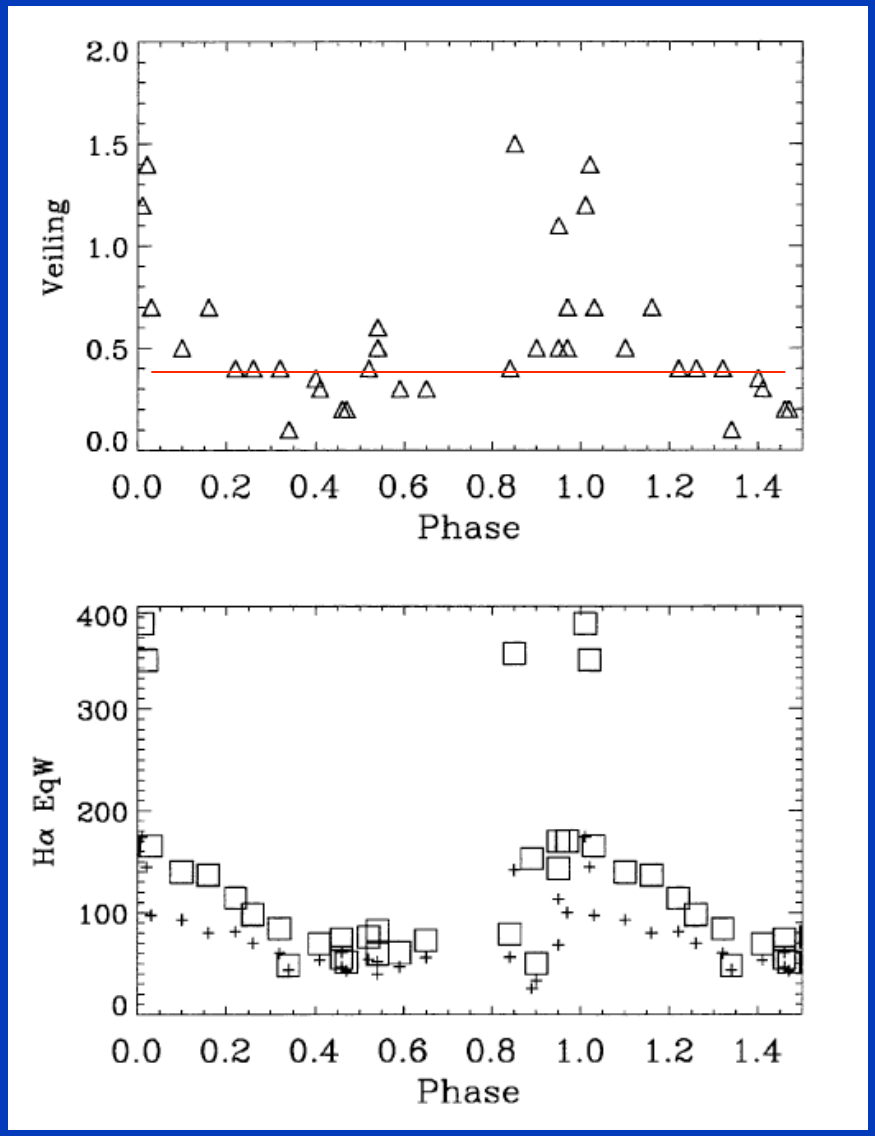




P=15.80 days

Accretion Streams





Accretion Streams

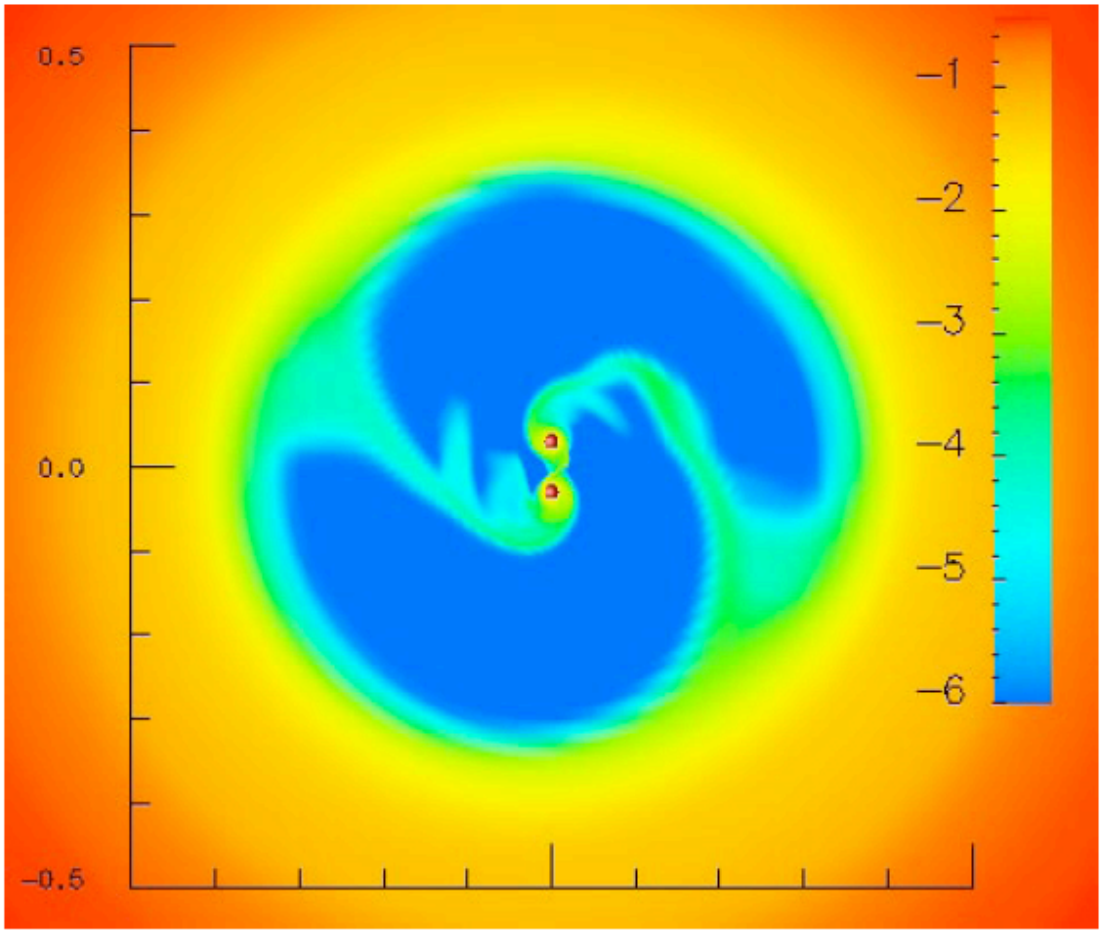
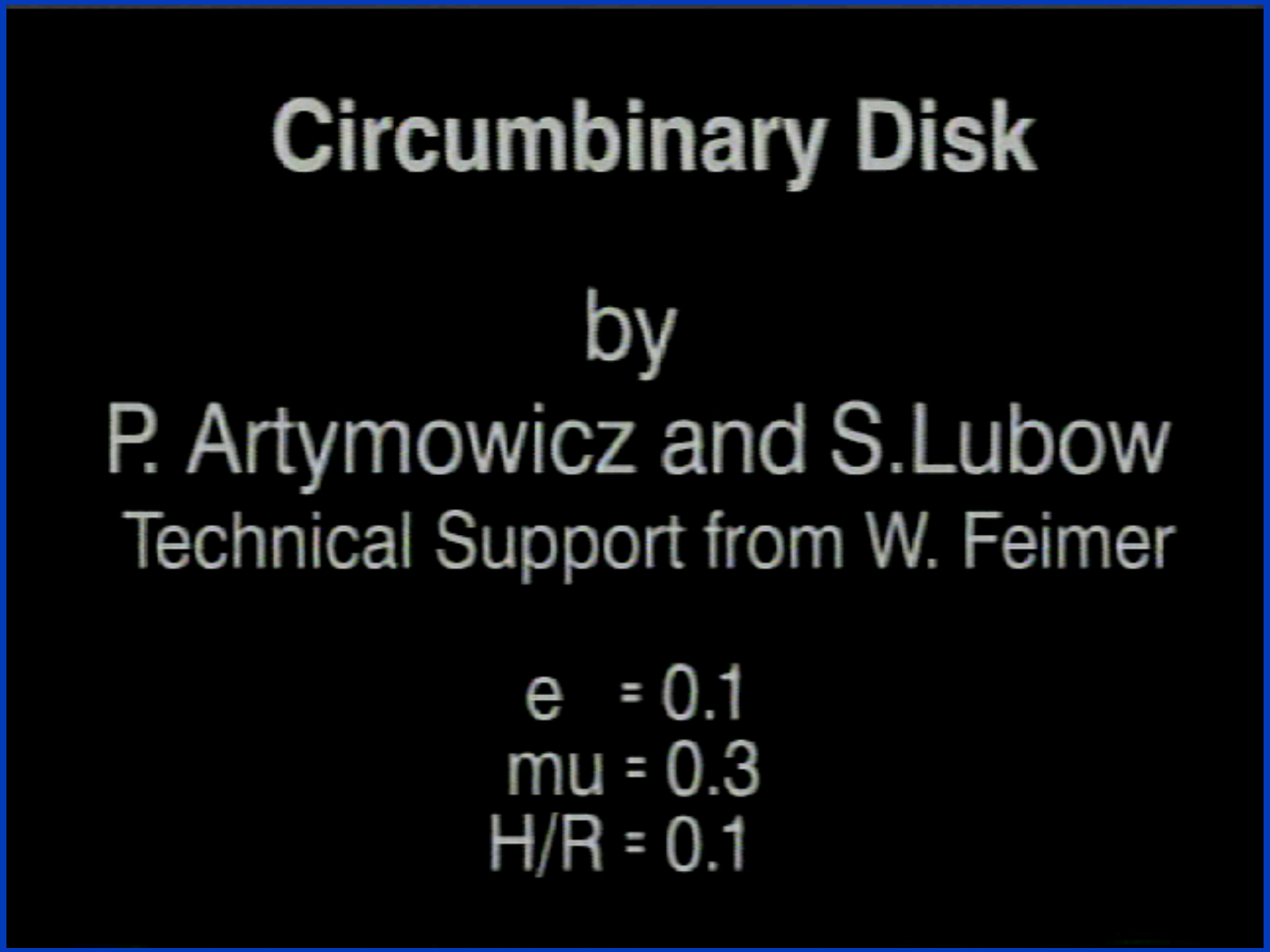


Fig. 10. DQ Tau circumbinary disk after 85.5 orbital periods in periastron. Color coding is $\log(\Sigma)$, the size of the stars reflects the actual stellar radii, the length scales are in AU.

Gunther & Kley 2002

Accretion Streams



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.

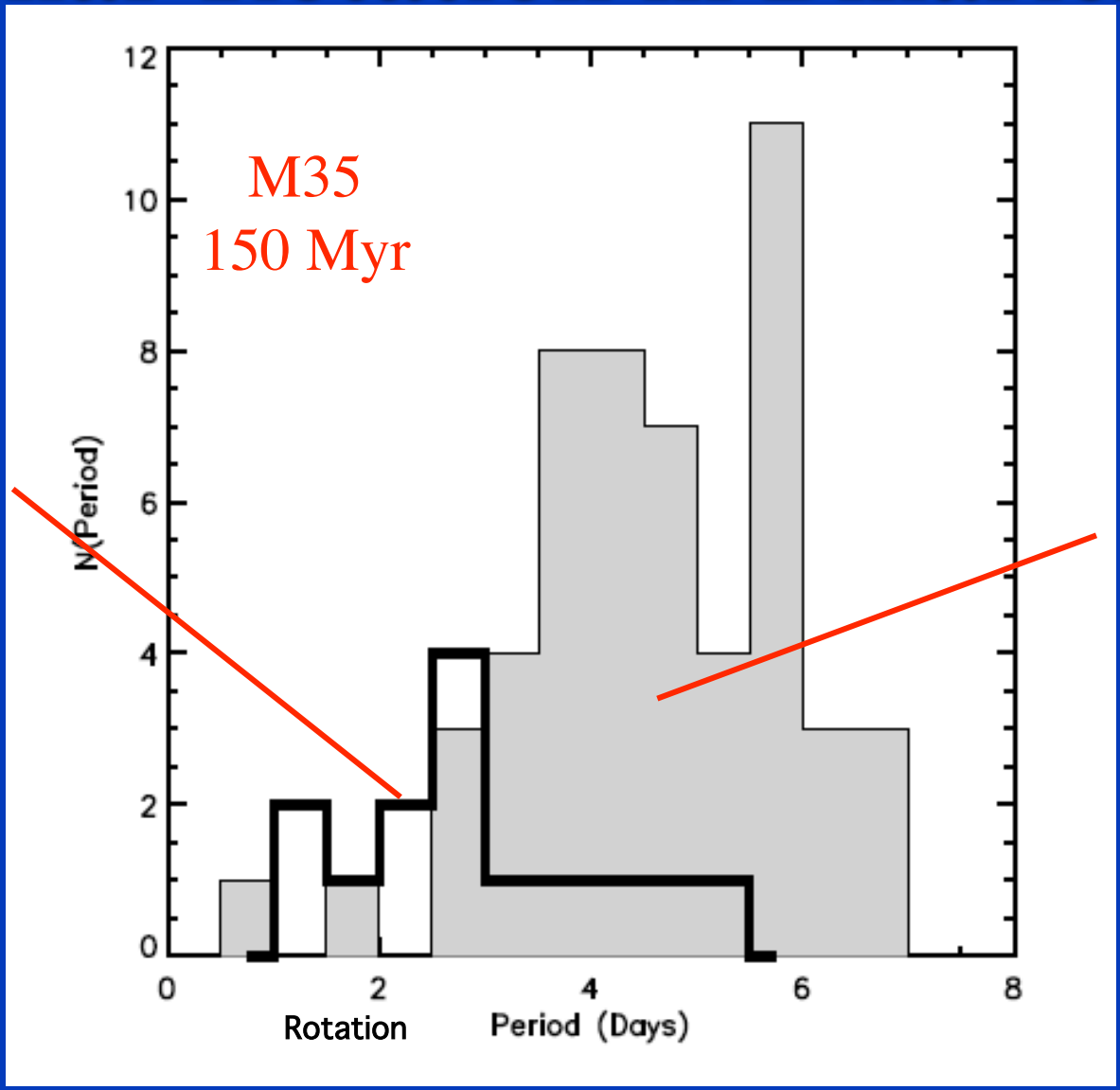
Angular Momentum Regulation

Question 2:

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

Stellar Rotation in Binaries

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:

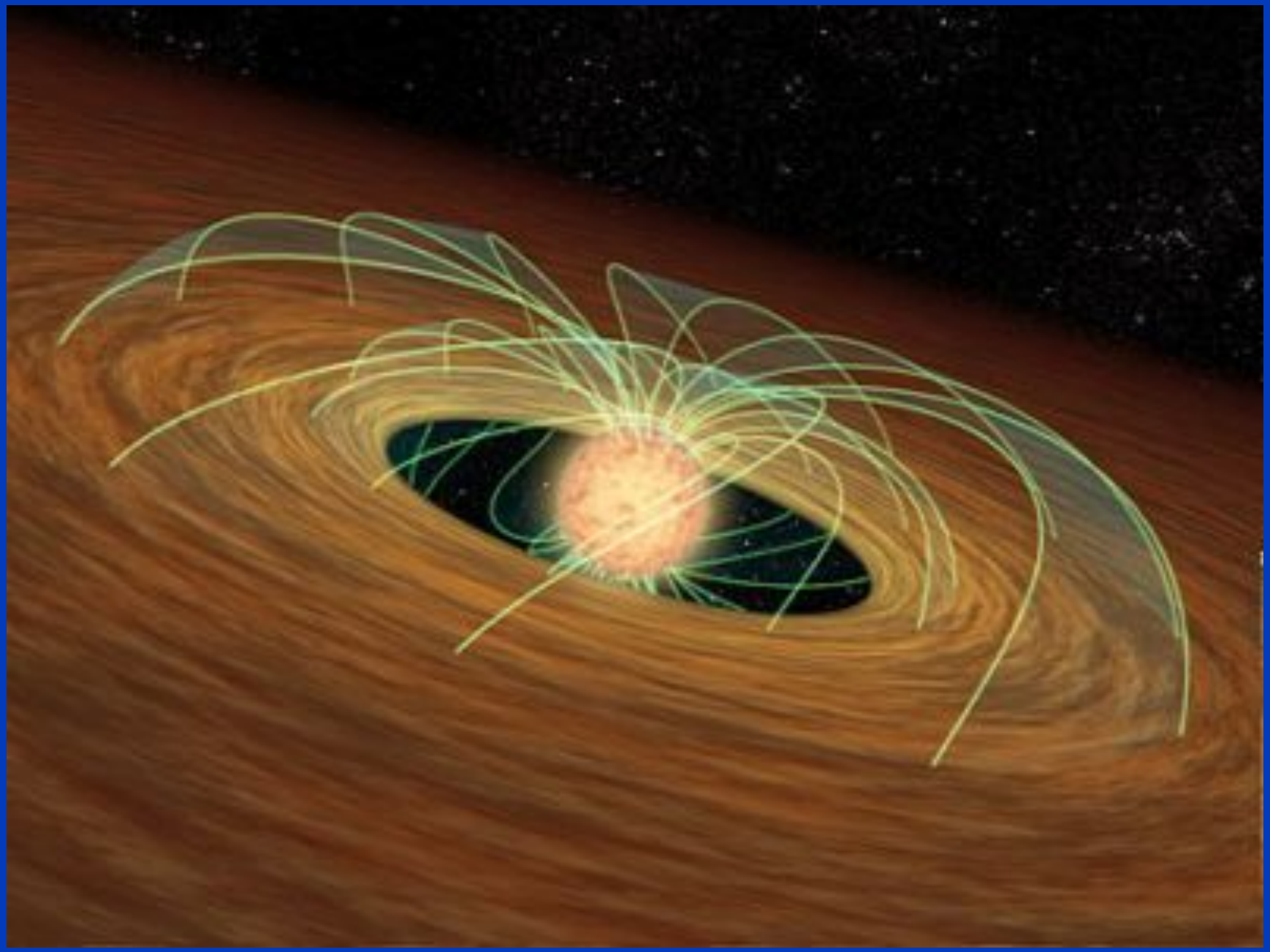
Reduced angular momentum regulation for the closest binaries ("disk locking picture")

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?