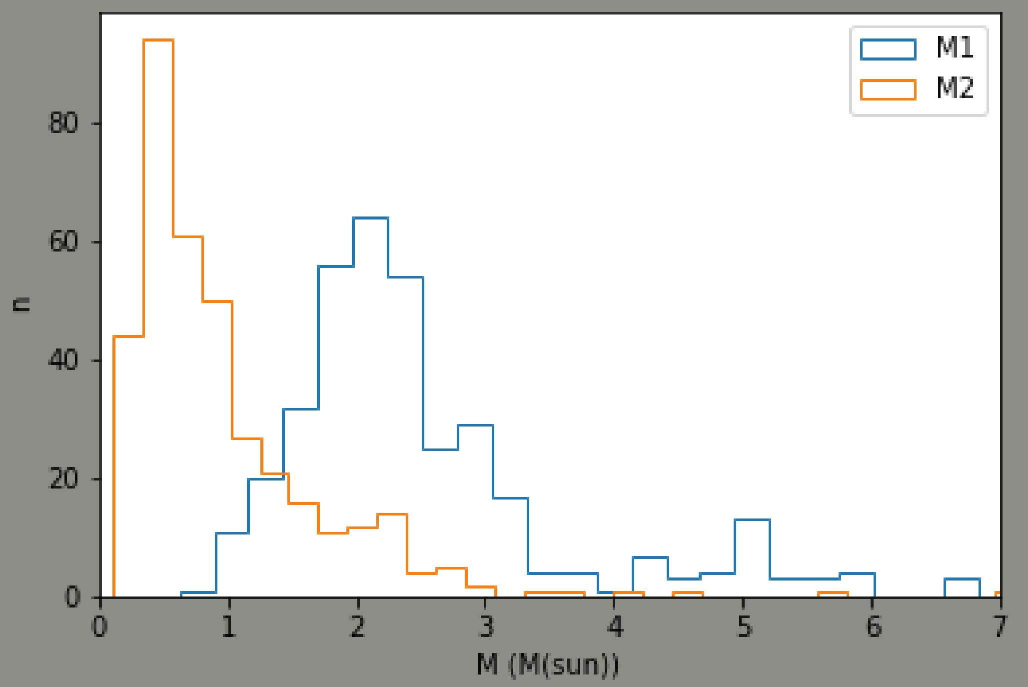
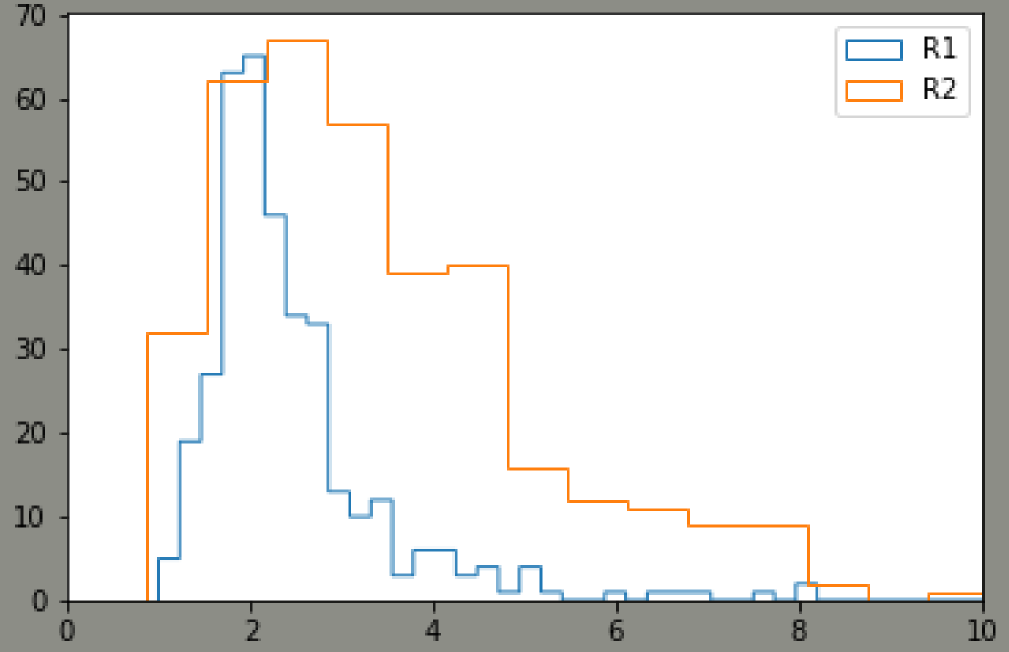
ALGOL-TYPE BINARY SYSTEMS

Basics

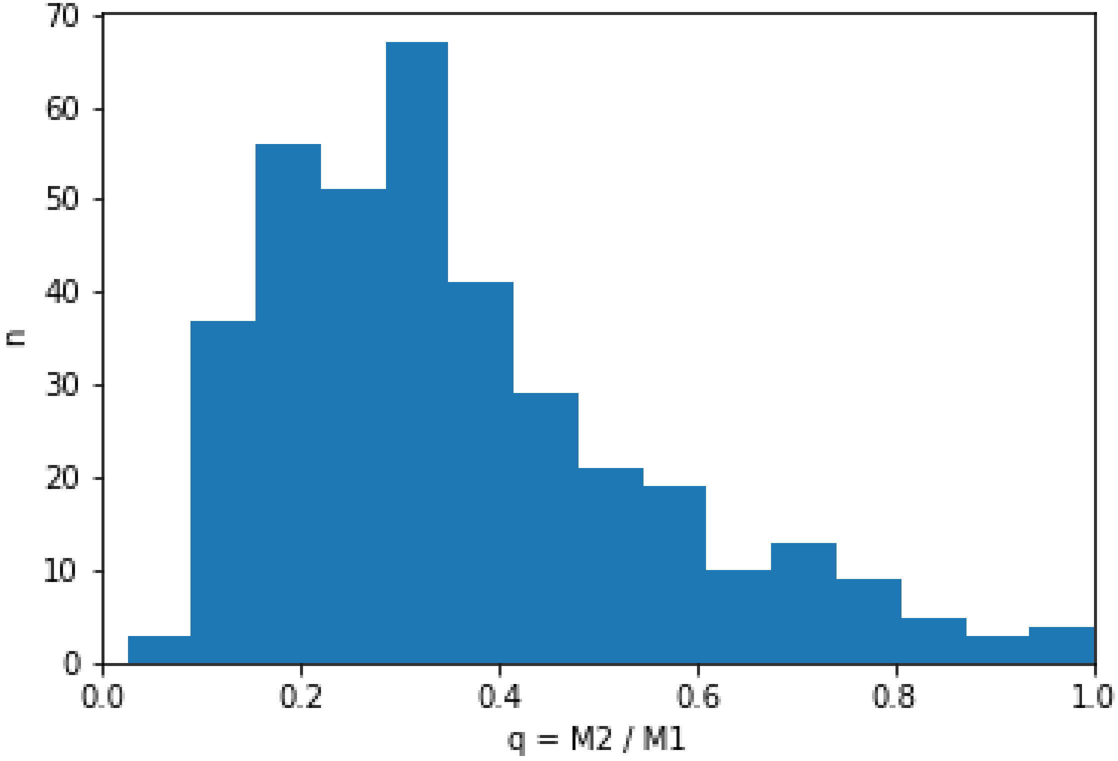
- Algol type binary is
  1. Semi-detached
  2. Secondary fills its Roche lobe but primary does not
  3. Primary is still in MS and is more massive than secondary
  4. Secondary is larger, fainter and cooler than primary

- Typical mass transfer rate between 10^-7 – 10^-11 solar masses / yr
- Mass transfer rate depends on
  - How fast the core of the secondary subgiant contracts (how fast the secondary can expand)
  - How fast angular momentum can be removed from the system





- Masses of primaries typically some solar masses, secondaries less massive.
- Radii can be quite similar; however, secondaries are statistically larger.
- Data for plots from Budding et al. (2004)



Periods and accretion mechanisms

P > 4.5 d

- Size of the system significantly larger than primary radius
  - Accretion disks may occur

2.5 d < P < 4.5d

- Transient accretion disks may occur

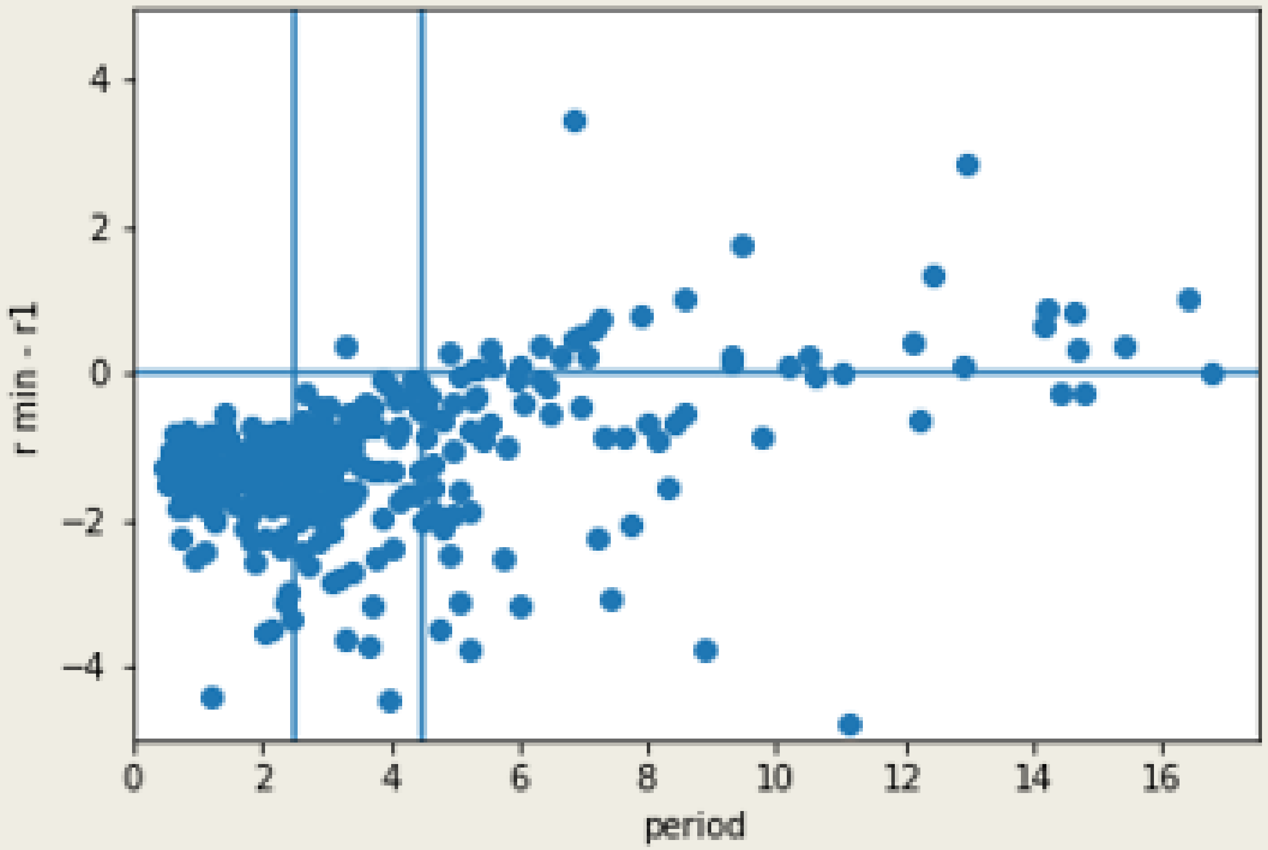
P < 2.5 d

- Stream hits the surface of the star
  - More complicated accretion structures

- Minimum accretion disk radius from

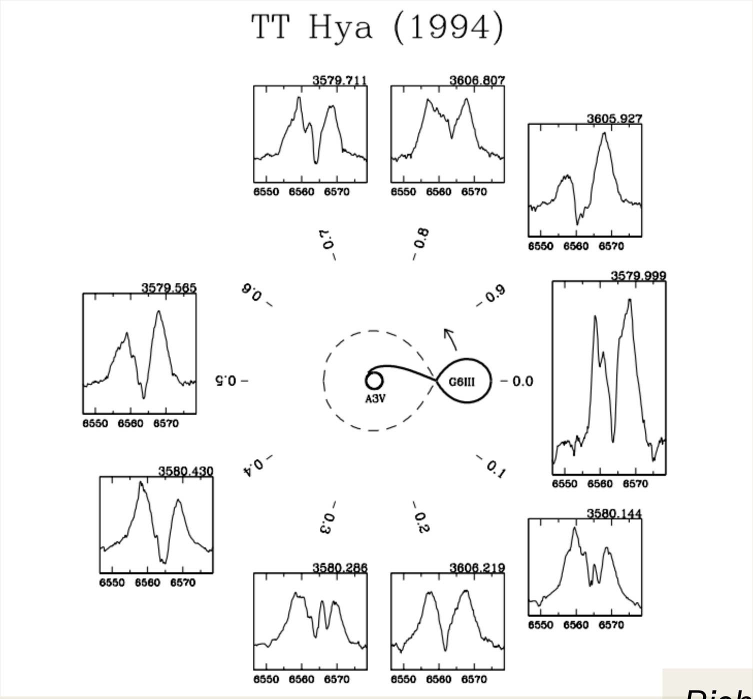
  $R_{min} = 0.0488\, a * q \wedge (-0.464)$

  – If primary radius larger than this, the accretion stream hits the surface of the star



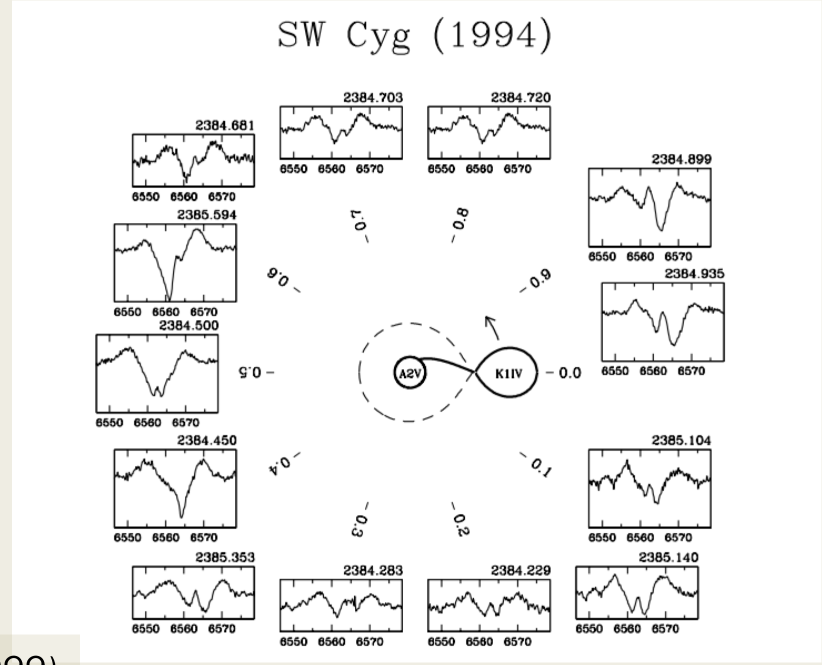
Classical disk

- Emission strong compared to combined flux of the system
- Lines broadened by Keplerian motion
- Permanent structures



Transient disk

- Emission weak compared to combined flux of the system
- Lines broadened by supersonic turbulence
- Highly variable – may disappear in less than one orbital period



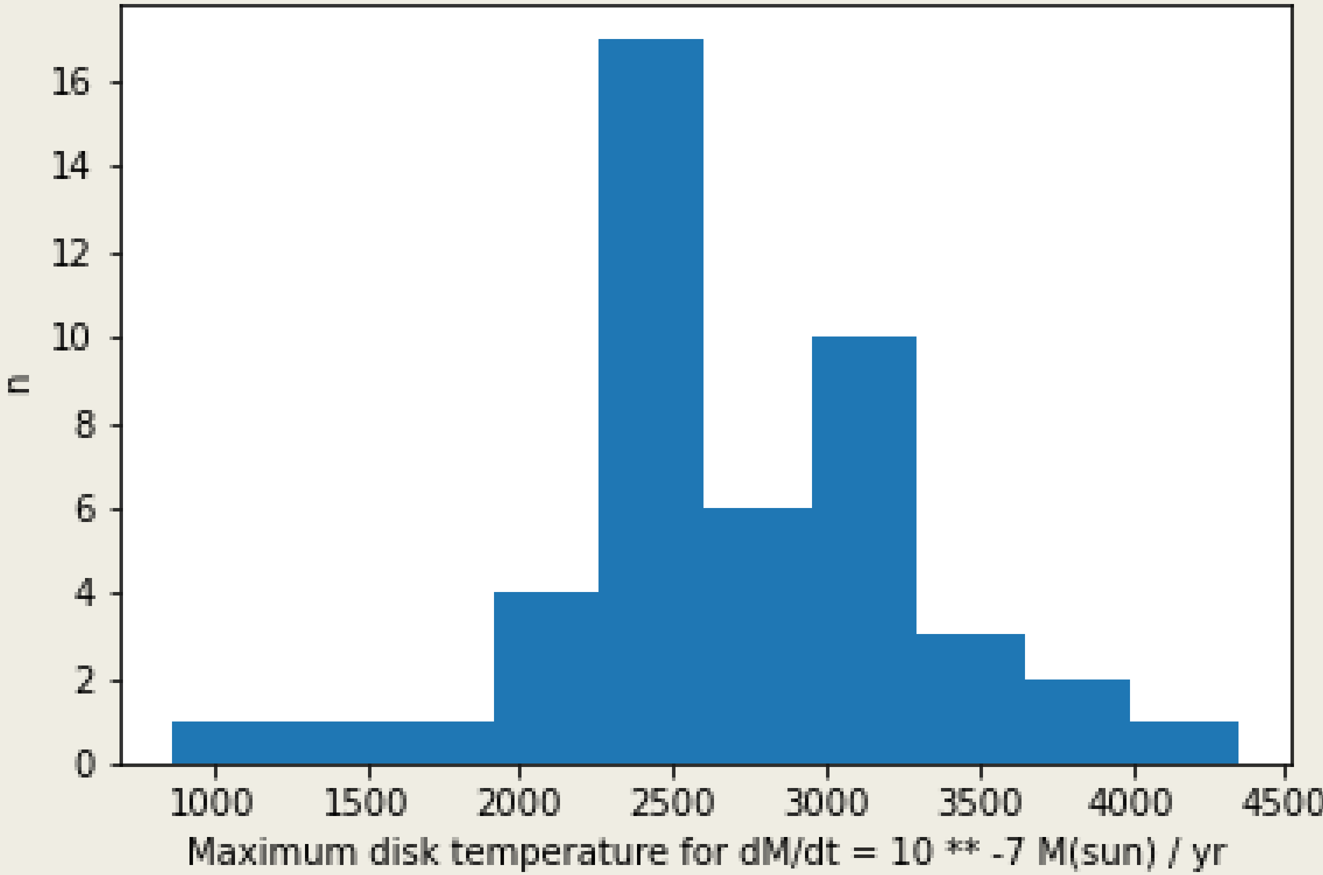
Richards & Albright (1999)

Disk temperatures

- Even for quite rapid mass transfer, the maximum disk temperature is quite low
  - no outbursts

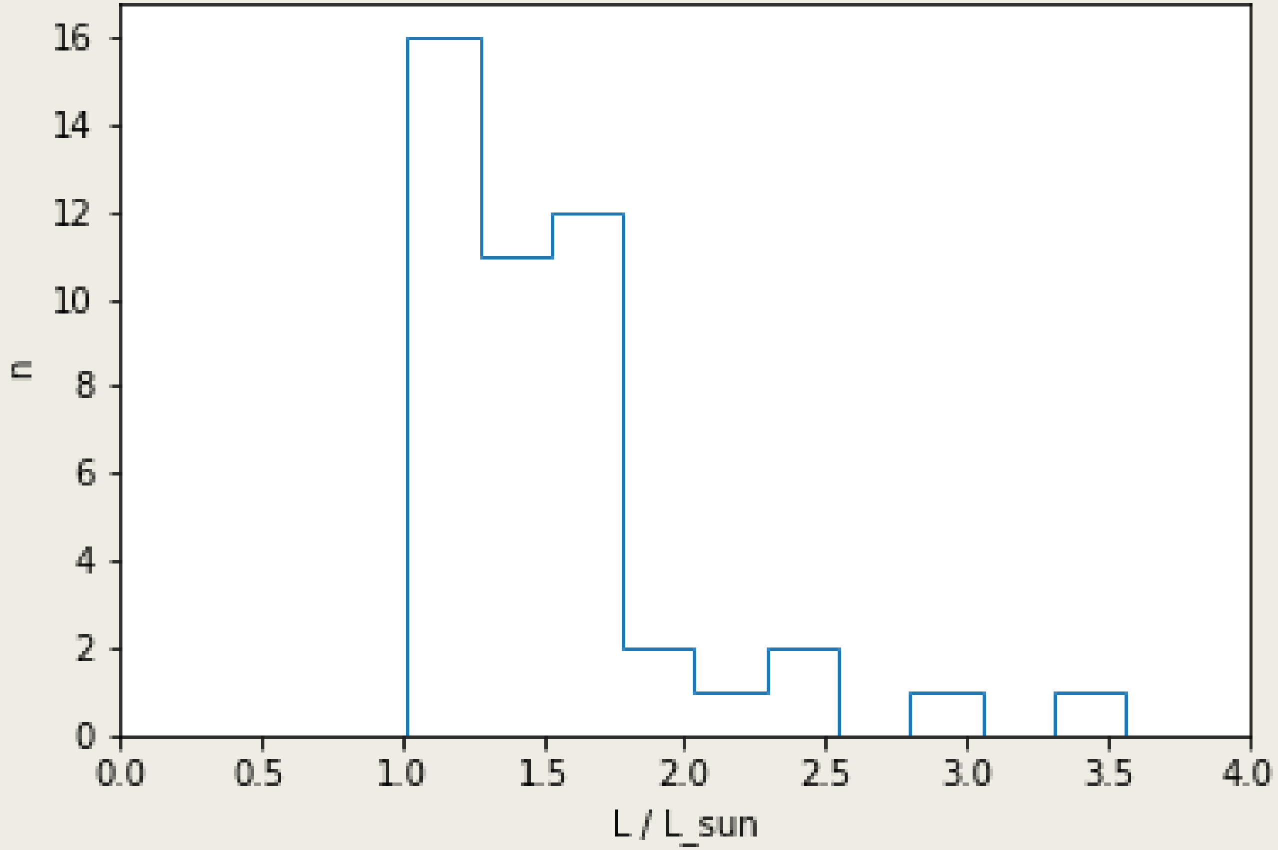
$$T_* = \left(\frac{3GM\dot{M}}{8\pi R_*^3 \sigma} \right)^{1/4}$$

$$T_{max} = 0.488\, T_*$$



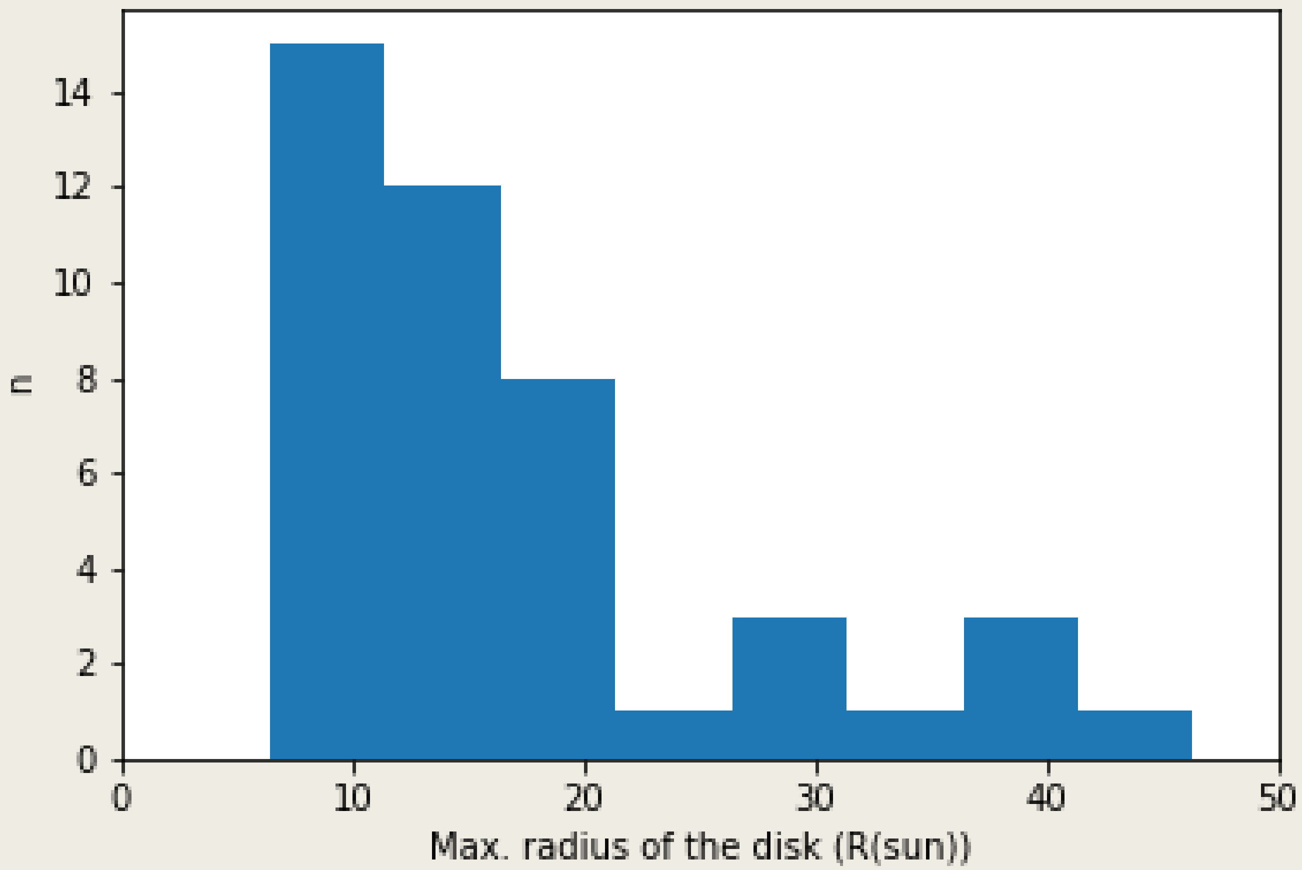
Disk luminosities

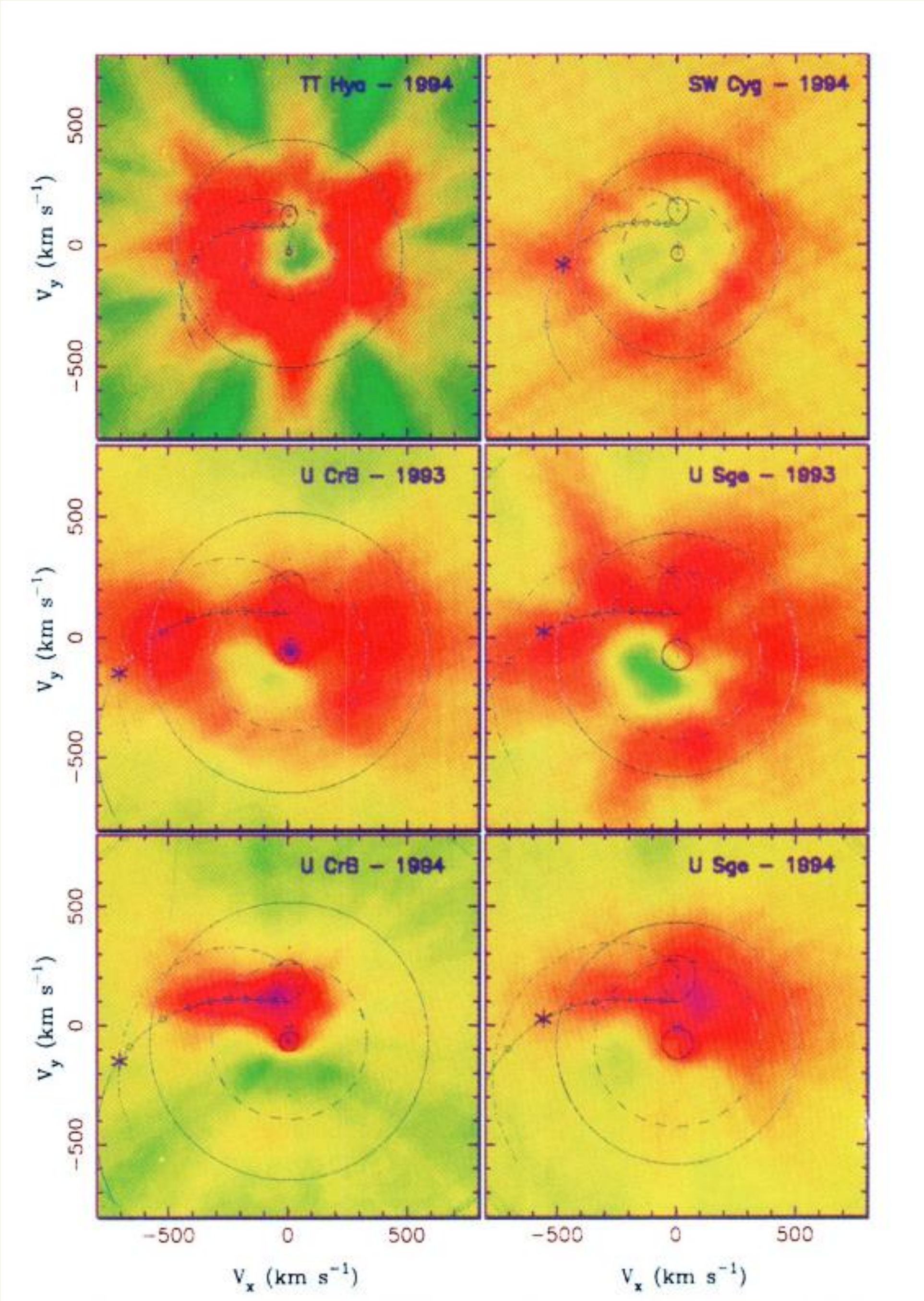
- Few solar luminosities
- Can be hard to detect, if stars are more luminous



Maximum disk radii

- Maximum disk sizes are some tens of solar radii.

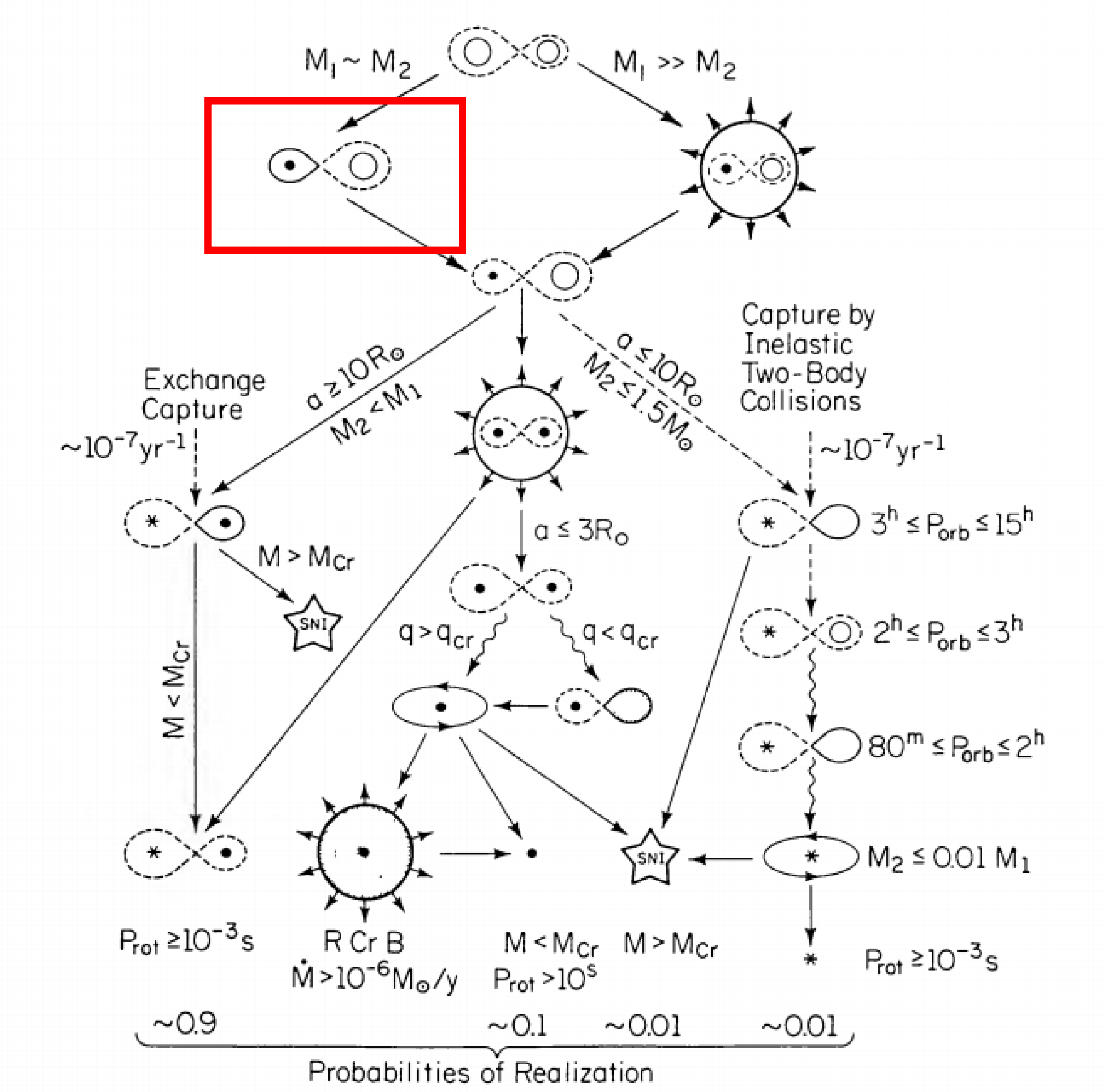




Albright & Richards 1996

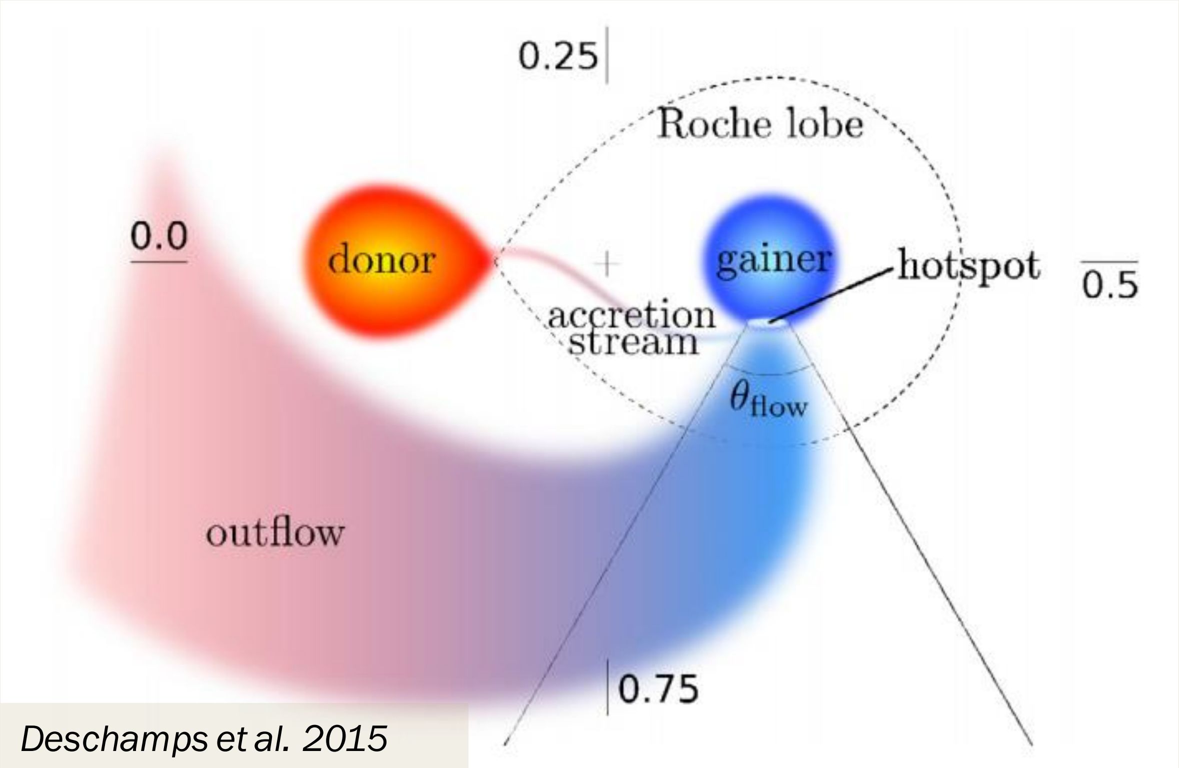
Evolution of Algols

- Originally more massive star (secondary) evolves faster
  - Moves away from the main sequence before the less massive primary
- Secondary then expands to fill its Roche lobe and begins transferring mass to the primary
- Post-Algol stage: Secondary evolves into a compact object and starts accreting mass from the primary.
- Evolution is non-conservative (mass-loss plays significant role in the evolutio n)



Mass loss

- Some mechanism of mass loss is needed to explain the loss of angular momentum needed for the evolution of observed Algols
  - Hotspot mechanism most promising *(van Rensbergen et al. 2011)*
  - Other possible methods include bipolar jets, enhanced winds, and losses through L3 point *(R. Deschamps et al. 2015)*
- However, direct detection has not been made



Deschamps et al. 2015

Thank you for listening!