Linking Herbig and T Tau stars with Linear Spectro-polarimetry

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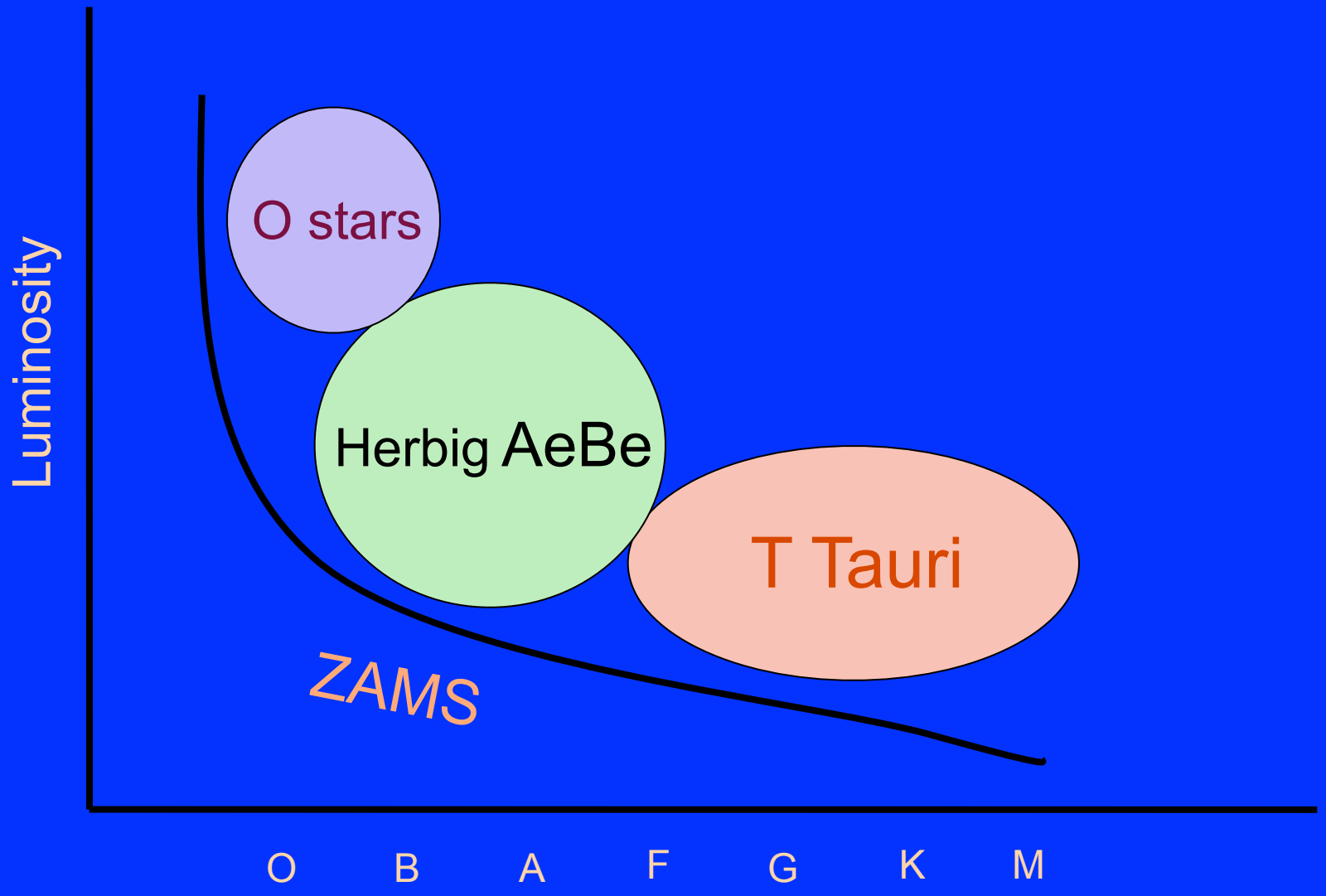
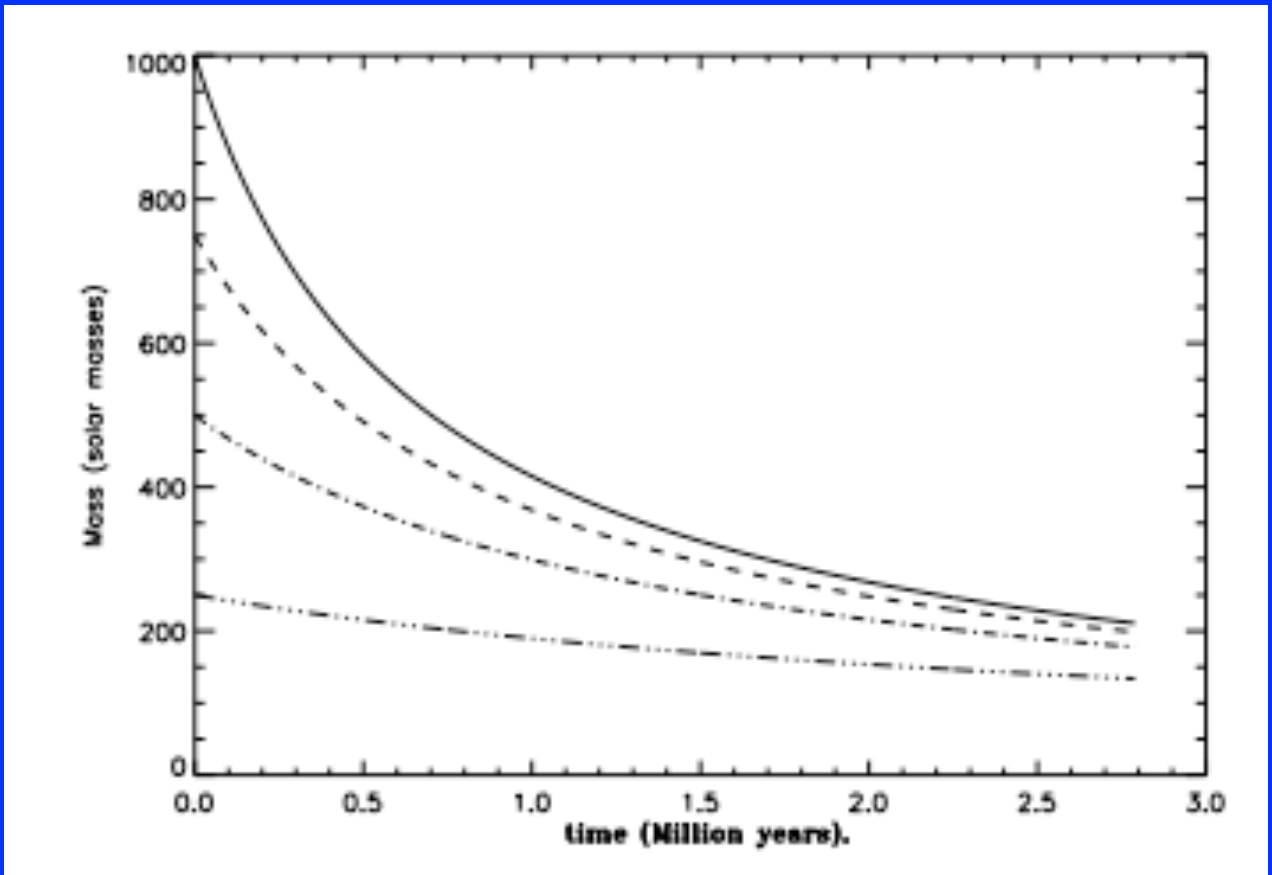
Oudmaijer, Drew, Harries, Mottram, Ababakr

Costigan, Scholz, Ray, Testi
Barentsen
Kalari


Luminosity
O stars
Herbig AeBe
T Tauri
ZAMS
O
B
A
F
G
K
M

Effective Upper Mass Limit

Mass



(Vink 2018)

Time (Myr)

Outline

- Intro on Accretion
- Intro on Polarimetry
- Data
- Disc scattering models
  - inner hole size
- Summary & Future

Z-dependent mass accretion?

$$\log \dot{M}_{\rm acc} = a' \times \log \frac{t}{\rm Myr} + b' \times \log \frac{m}{M_\odot} + c' \times \log \frac{Z}{Z_\odot} + d'.$$

(de Marchi et al. 2010, 2011, 2017)

Z-dependent mass accretion?

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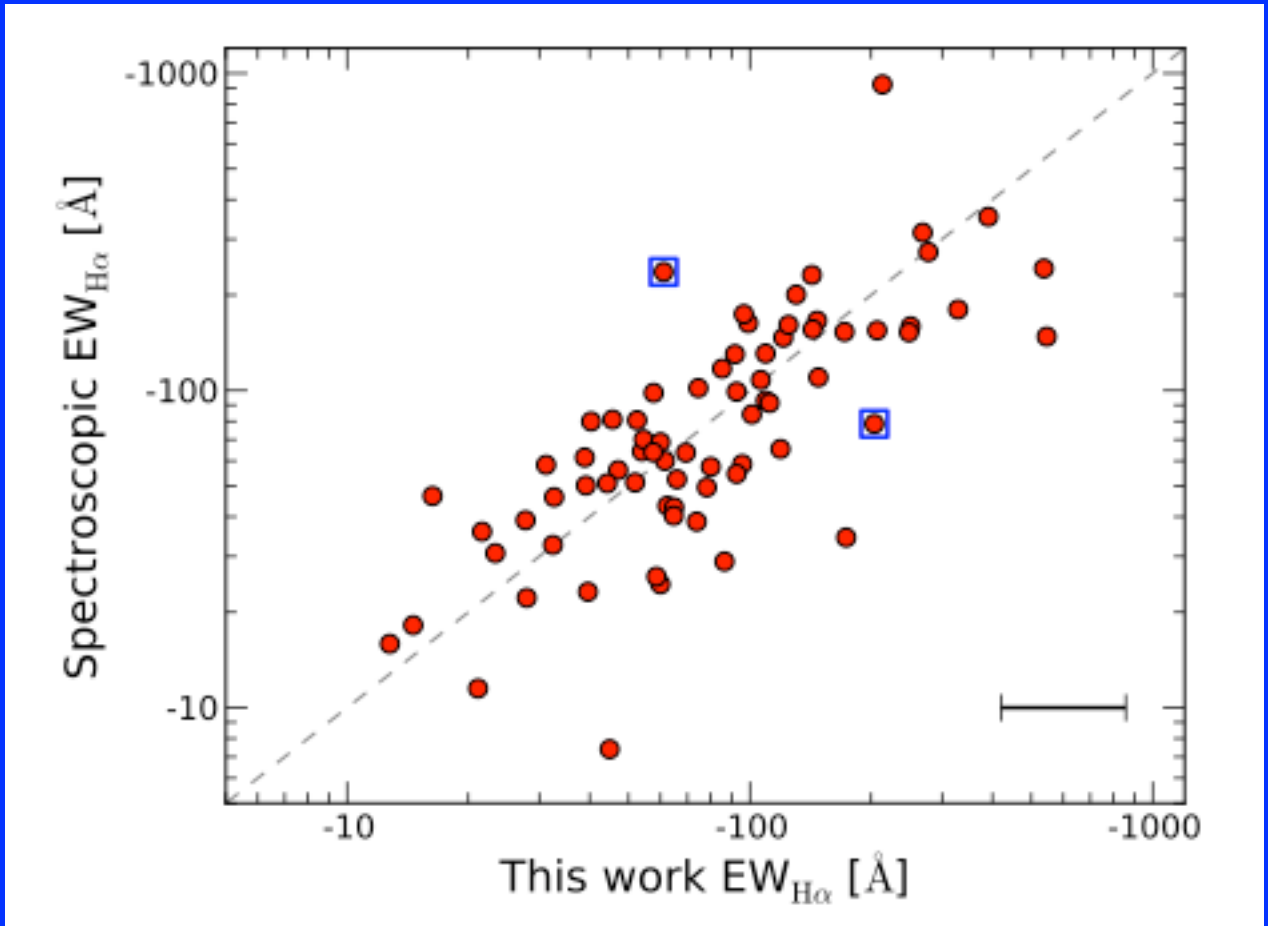
(de Marchi et al. 2010, 2011, 2017)

(BUT Kalari & Vink 2015: NO)

Photometric Halpha?



(Barentsen, Vink et al. 2011, 2013) + (Kalari, Vink et al., 2015)

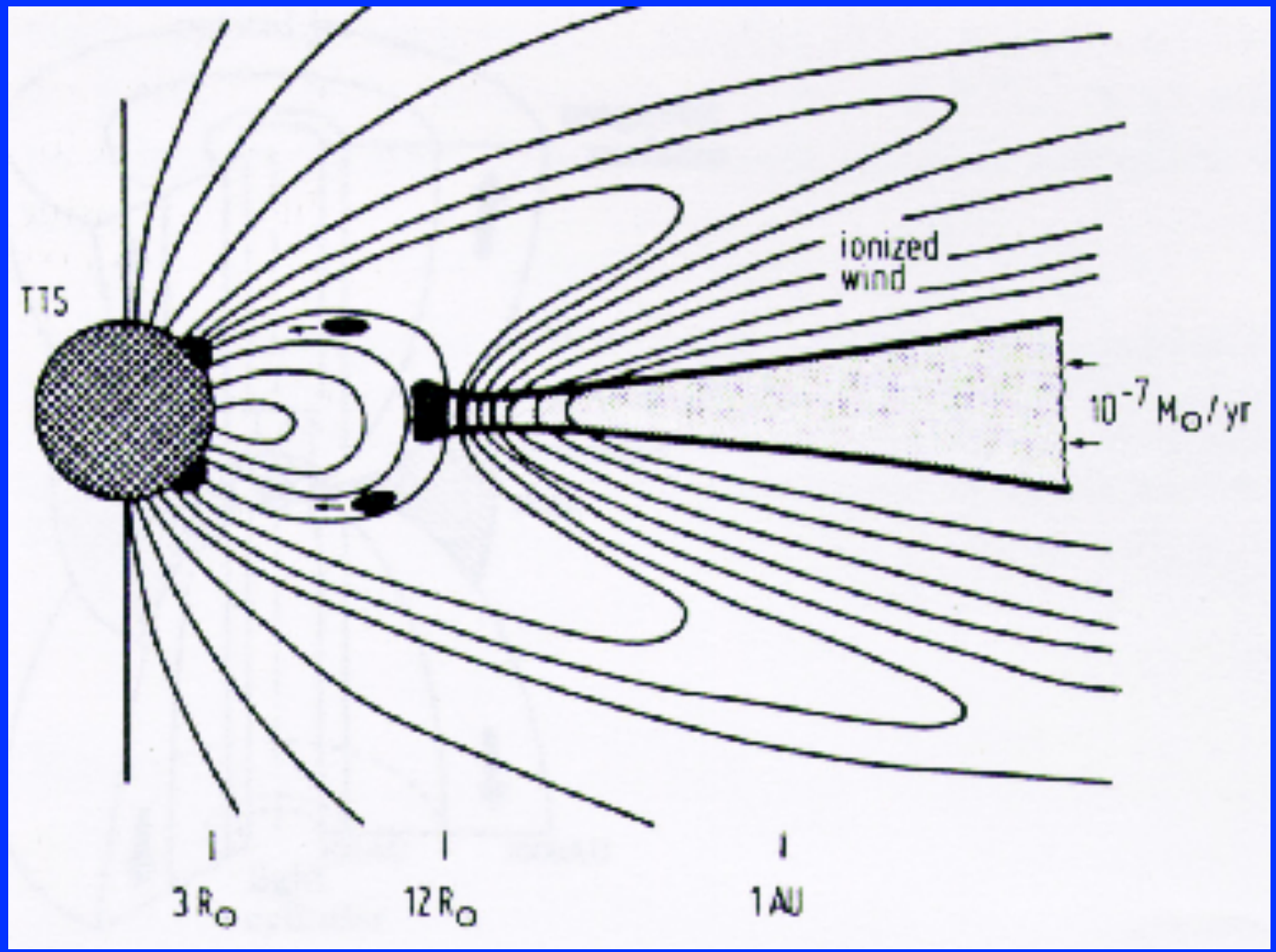
Z-dependent mass accretion?

$$\log \dot{M}_{\rm acc} = a' \times \log \frac{t}{\rm Myr} + b' \times \log \frac{m}{M_\odot} + c' \times \log \frac{Z}{Z_\odot} + d'.$$

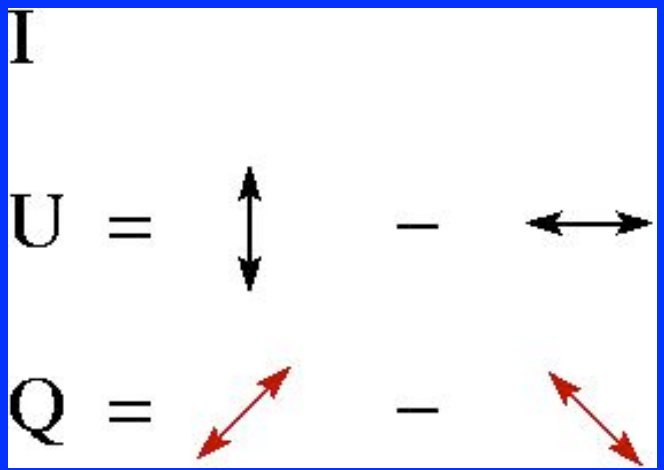
(de Marchi et al. 2010, 2011, 2017)

(BUT Kalari & Vink 2015: NO)

T Tauri stars: Magnetospheric

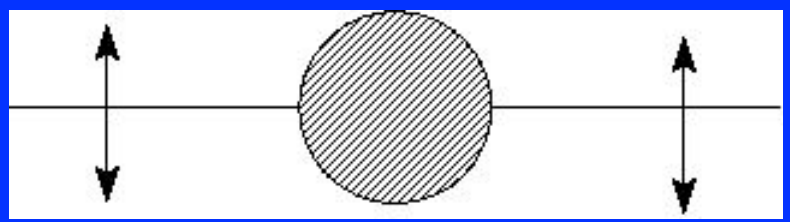


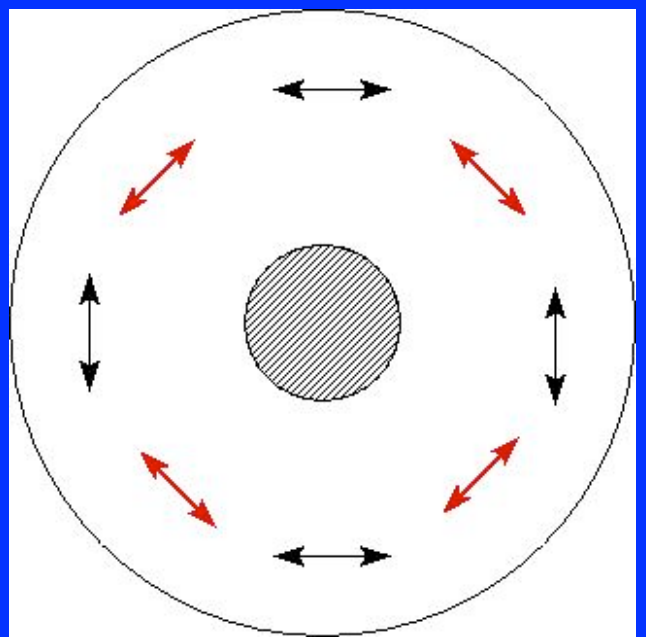
Polarimetry – from disks



$$P = \sqrt{(U^2 + Q^2)}$$

$$\theta = \frac{1}{2}\arctan\left(\frac{U}{Q}\right)$$

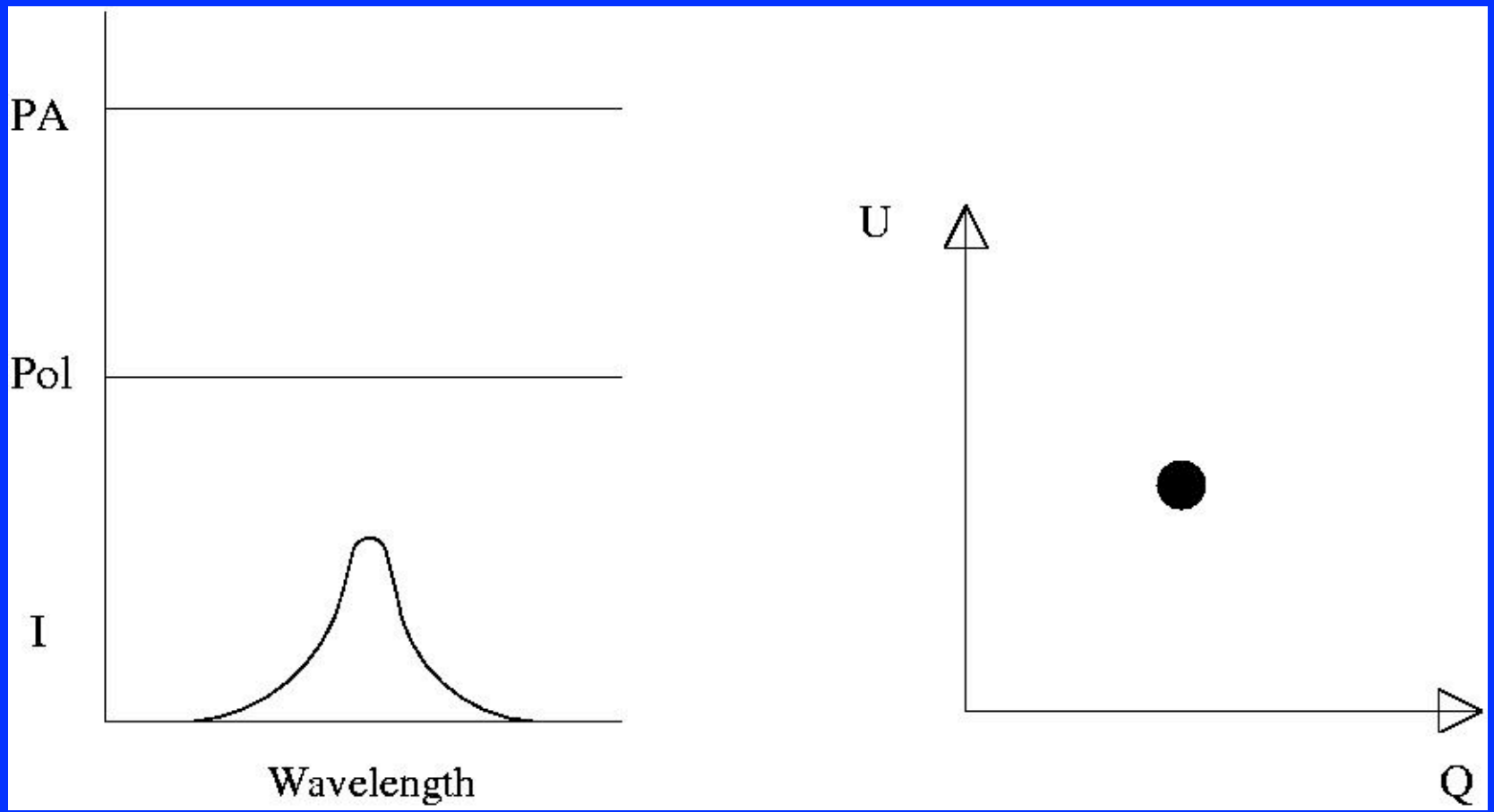




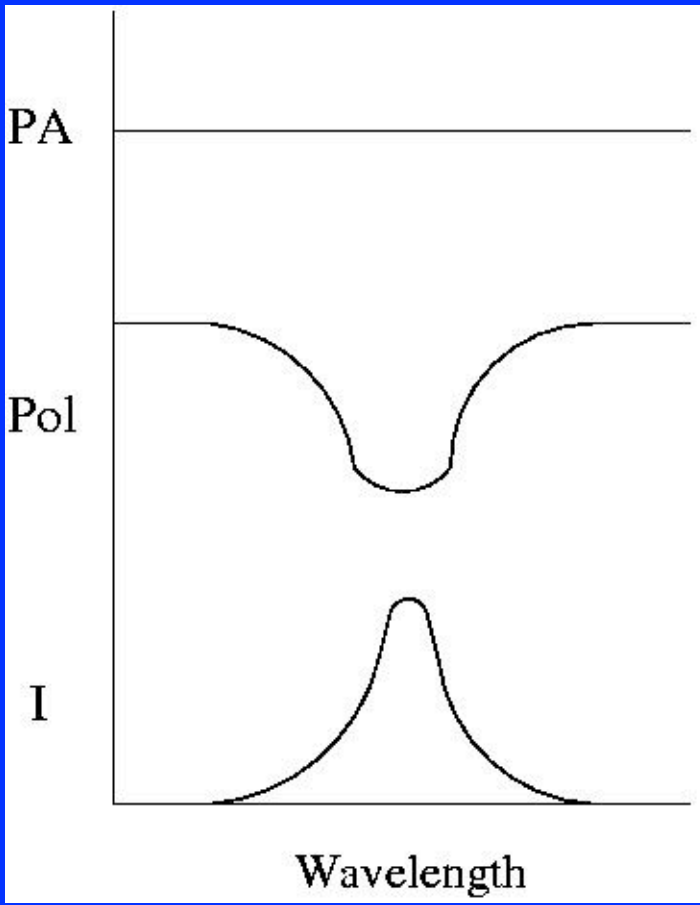
Polarisation across line?

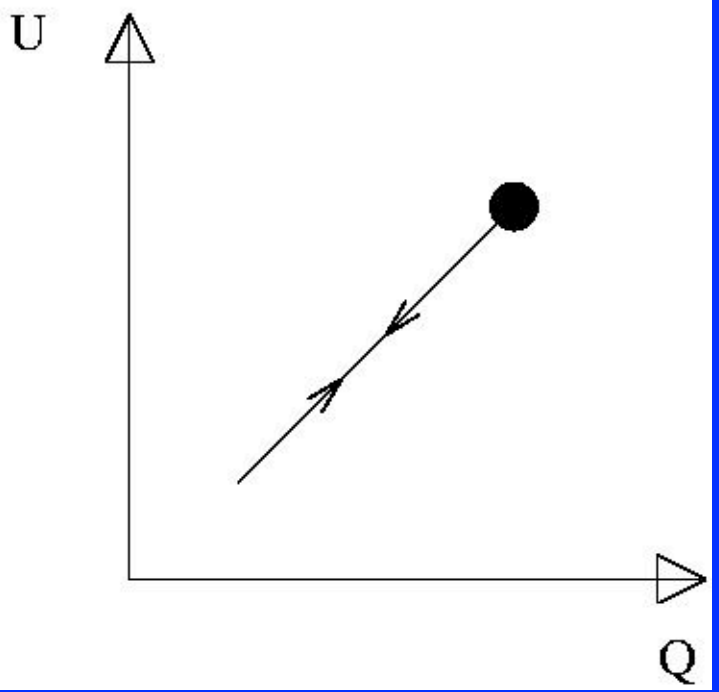
1. No change
2. Depolarisation
3. LINE Polarisation

No Polarisation

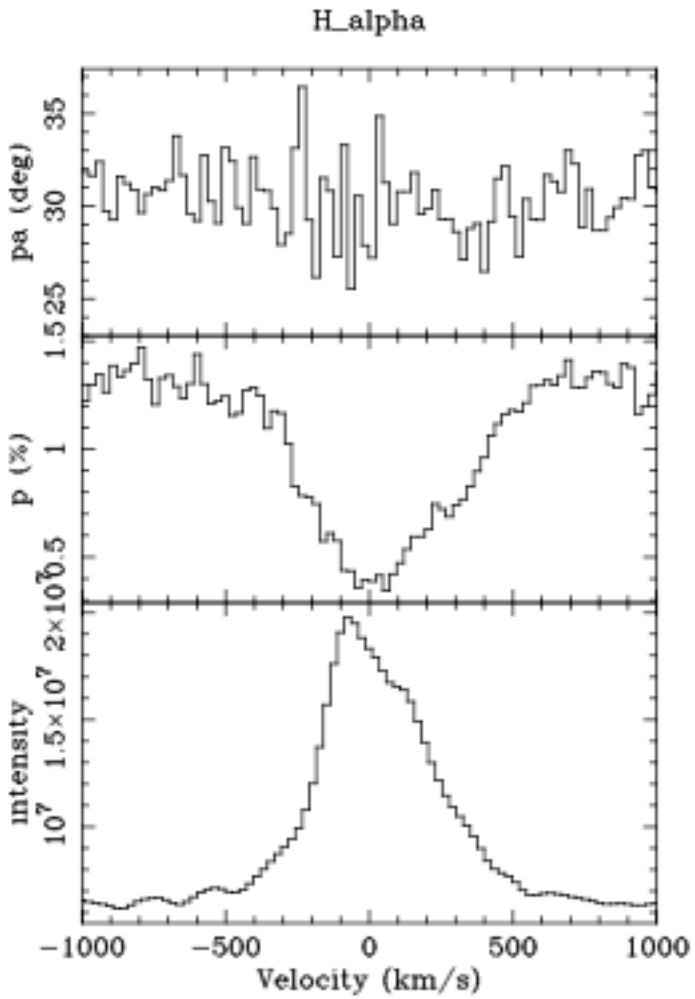


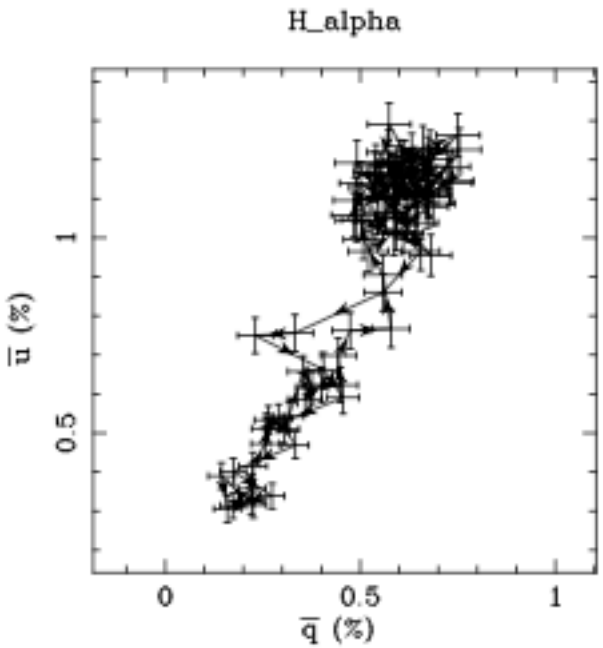
Depolarisation





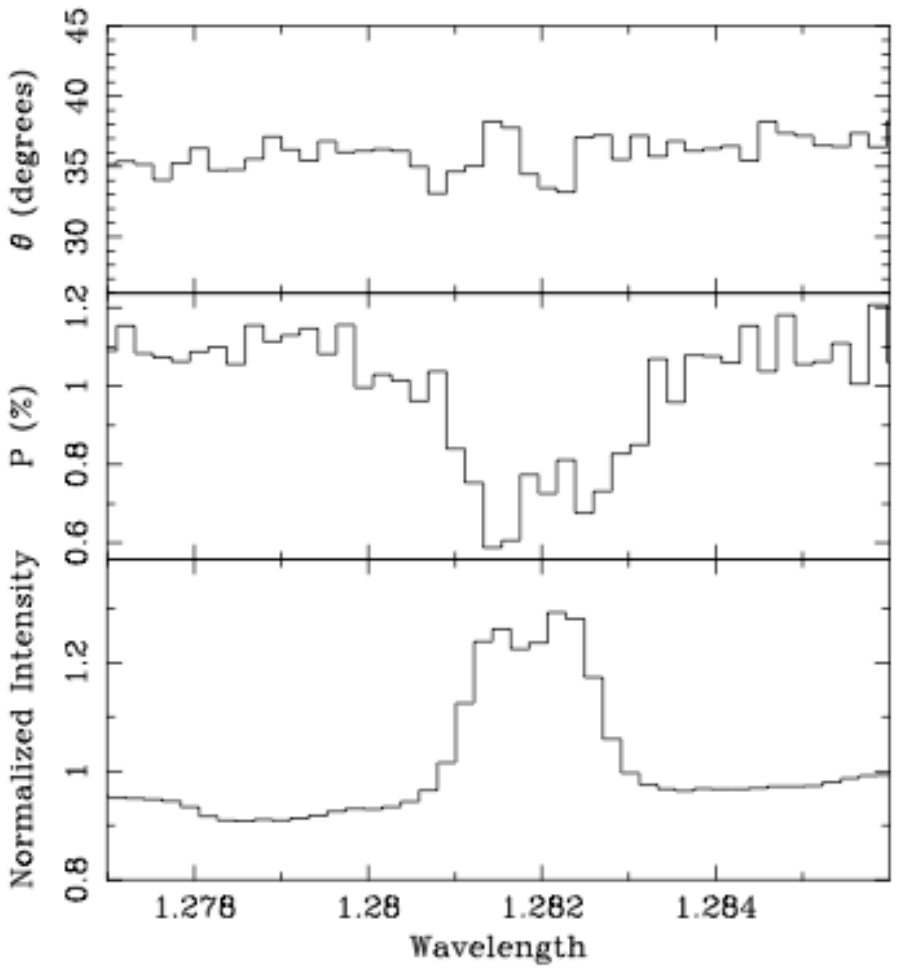
Be star Zeta Tau - it works!

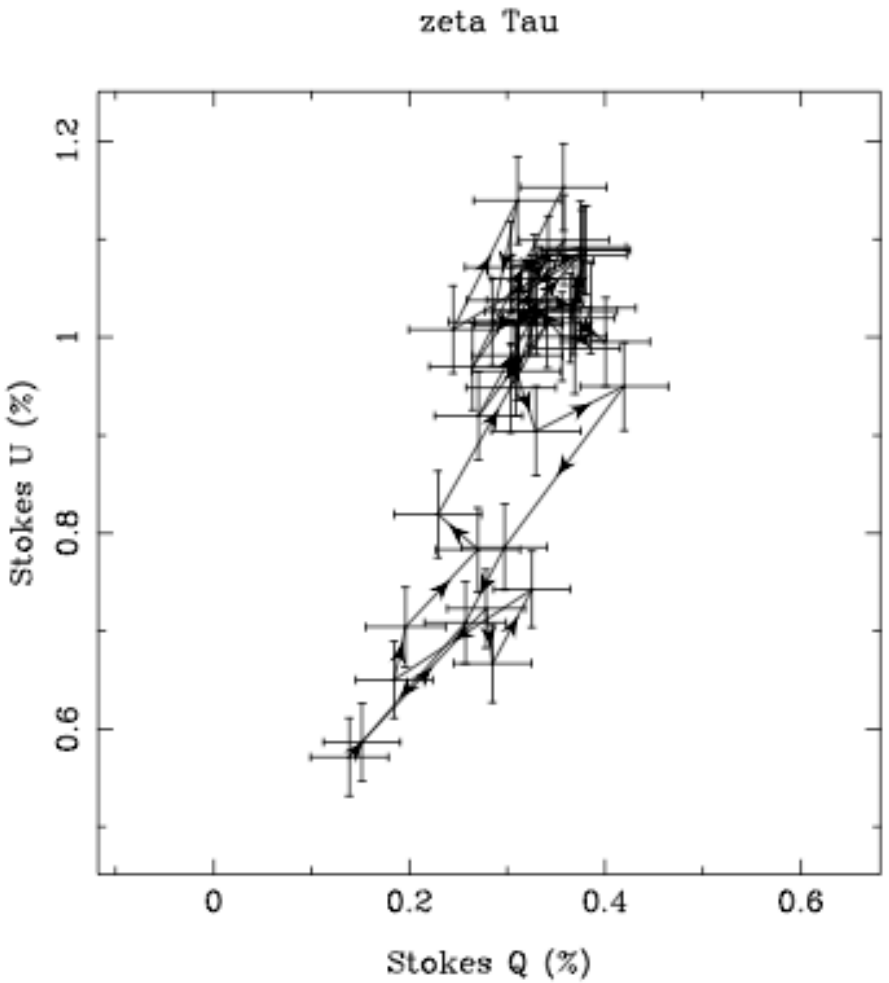




(Oudmaijer 2007)

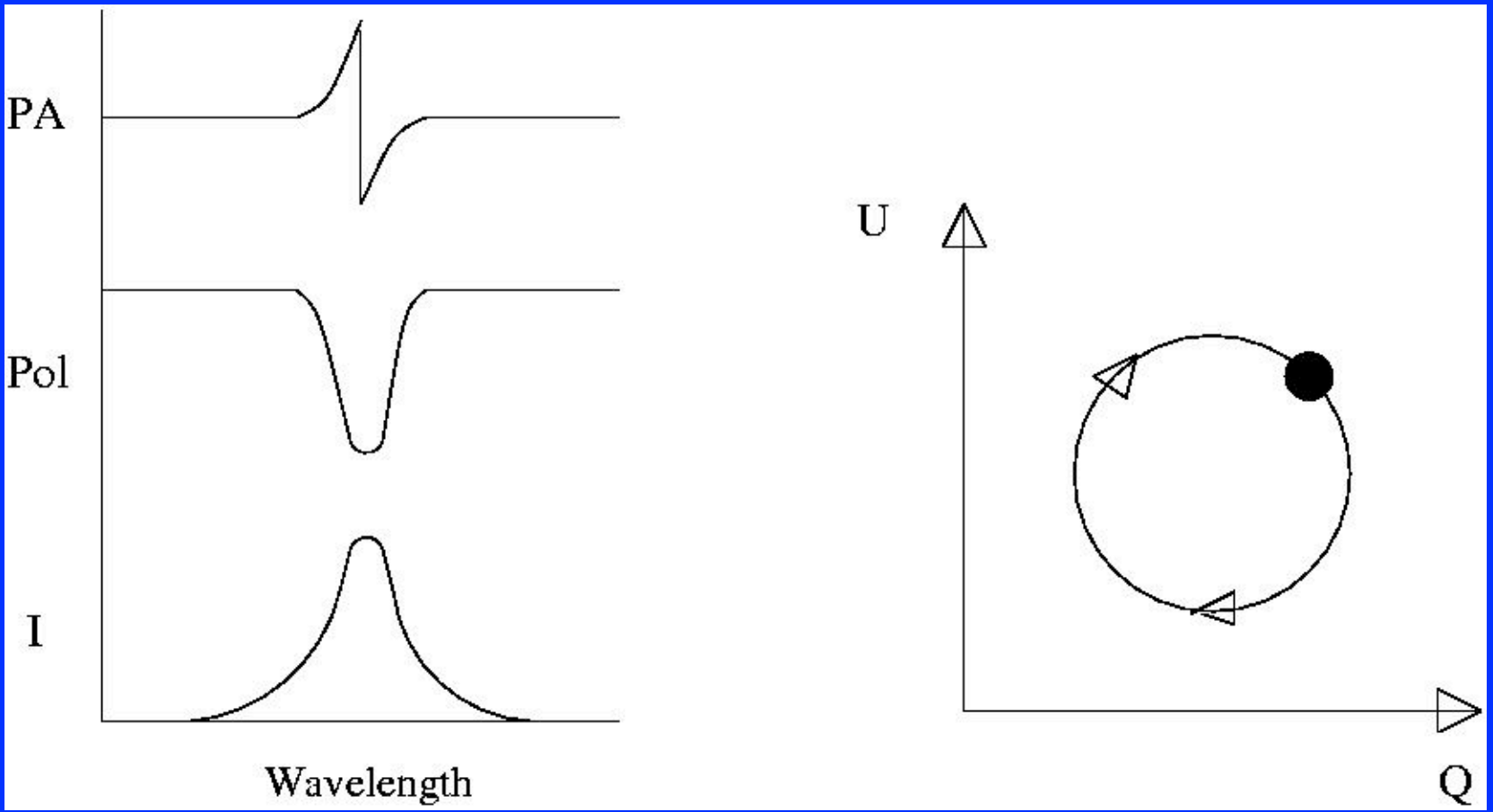
It works in the Infrared!



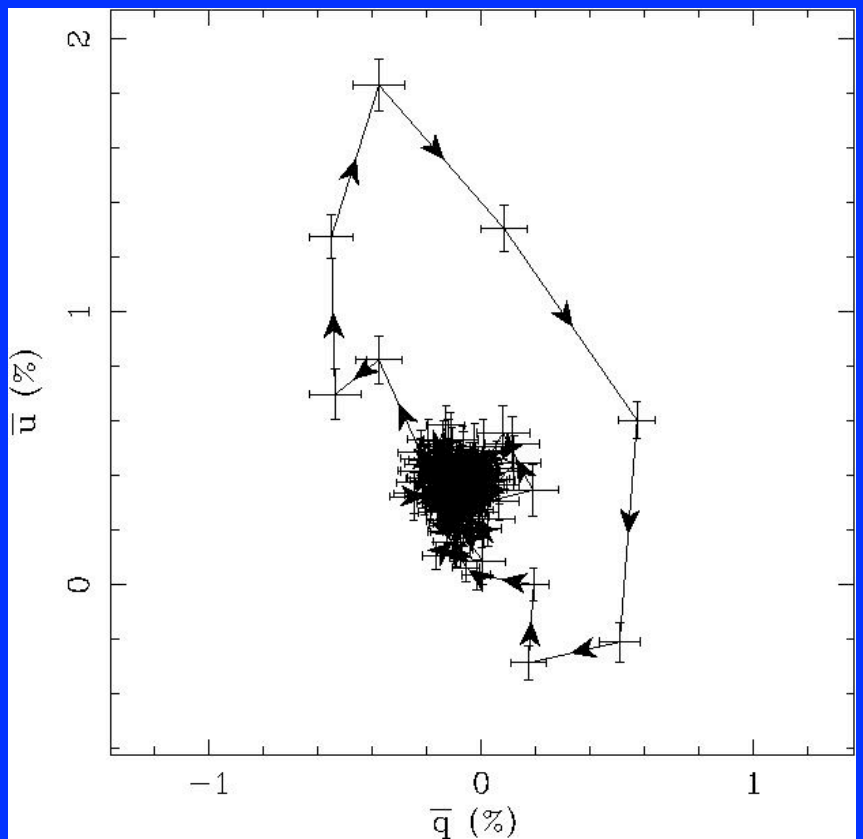


(Oudmaijer et al. 2005)

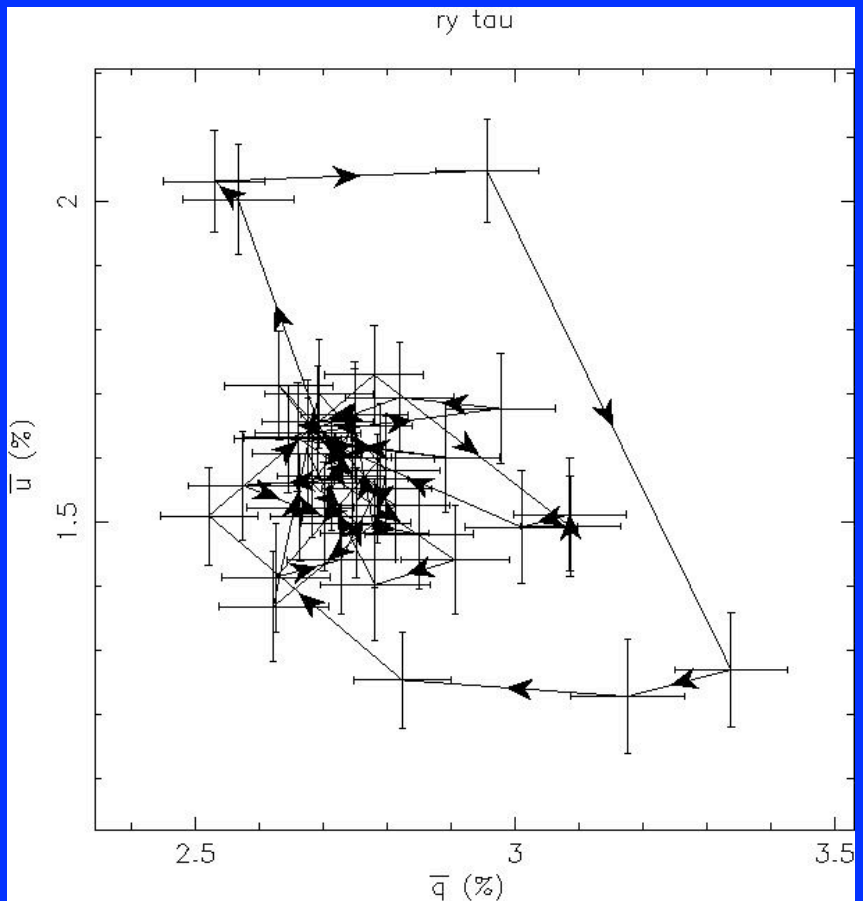
Line Polarisation – PA Flip



QU: Herbig Ae and T Tauri star



MWC 480



RY Tau

Polarisation across line?

1. No change
2. Depolarisation → Herbig Be: 7/12
3. LINE Polarisation

↓

Herbig Ae: 9/11

T Tauri: 9/10

(Vink et al. 2002, 2005b)

Polarisation across line?

1. No change
2. Depolarisation → Herbig Be: 7/12 → 24/34
3. LINE Polarisation2 → Herbig Ae: 9/11 → 18/22

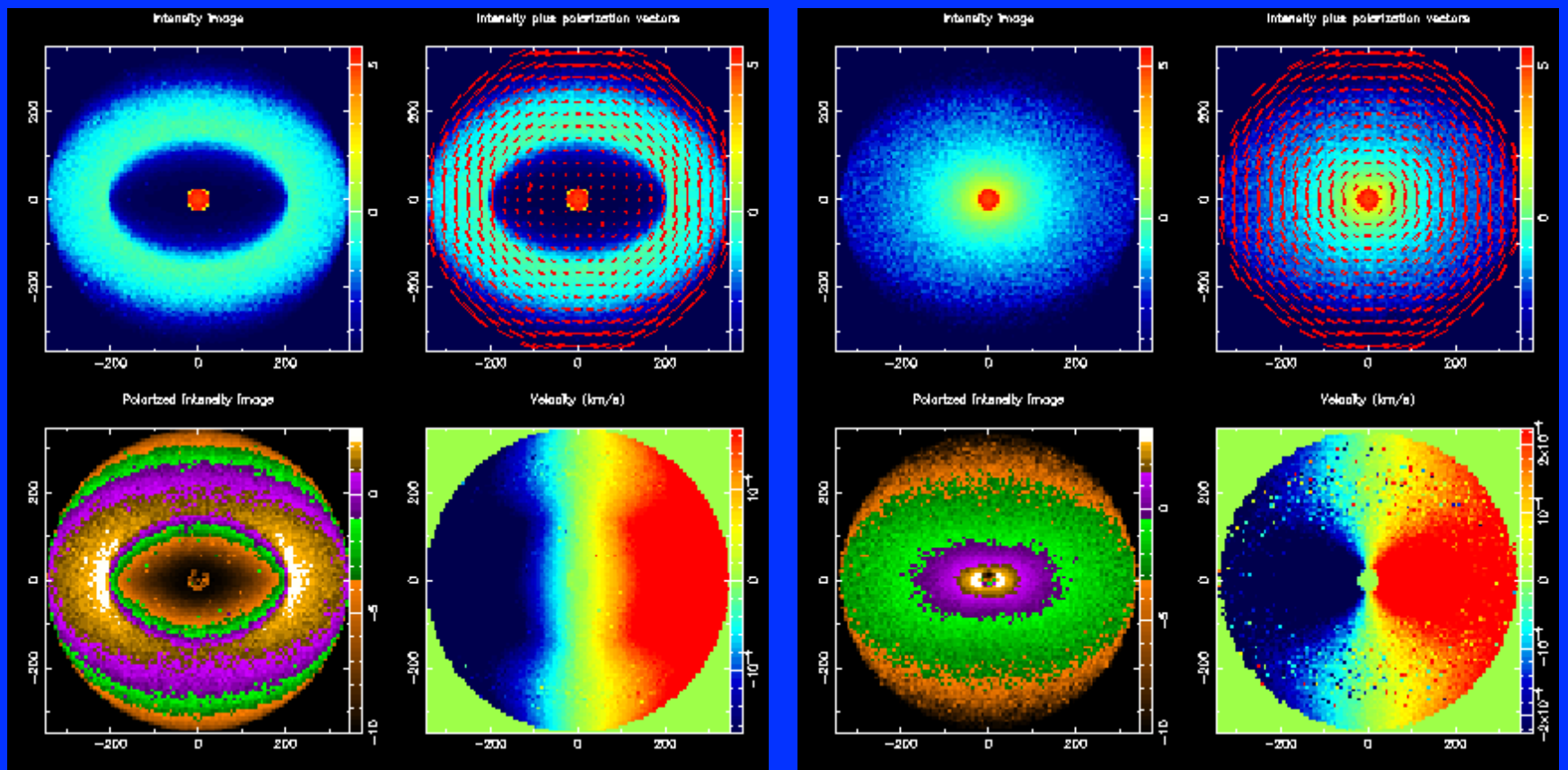
T Tauri: 9/10

(Ababakr et al. 2016, 2017)

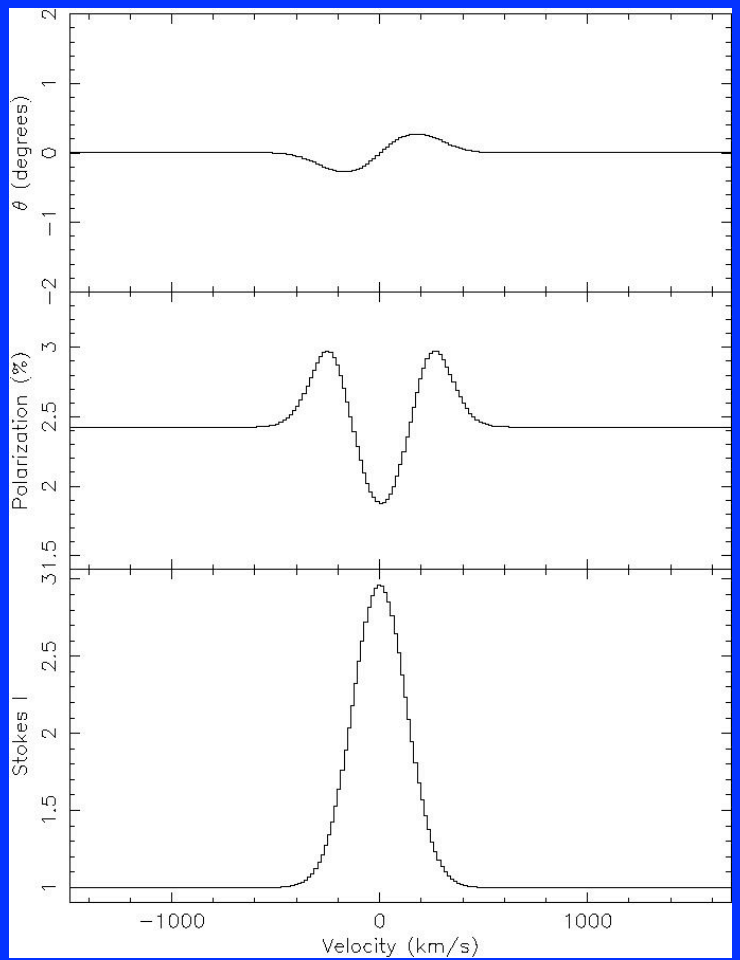
Models of COMPACT line emission

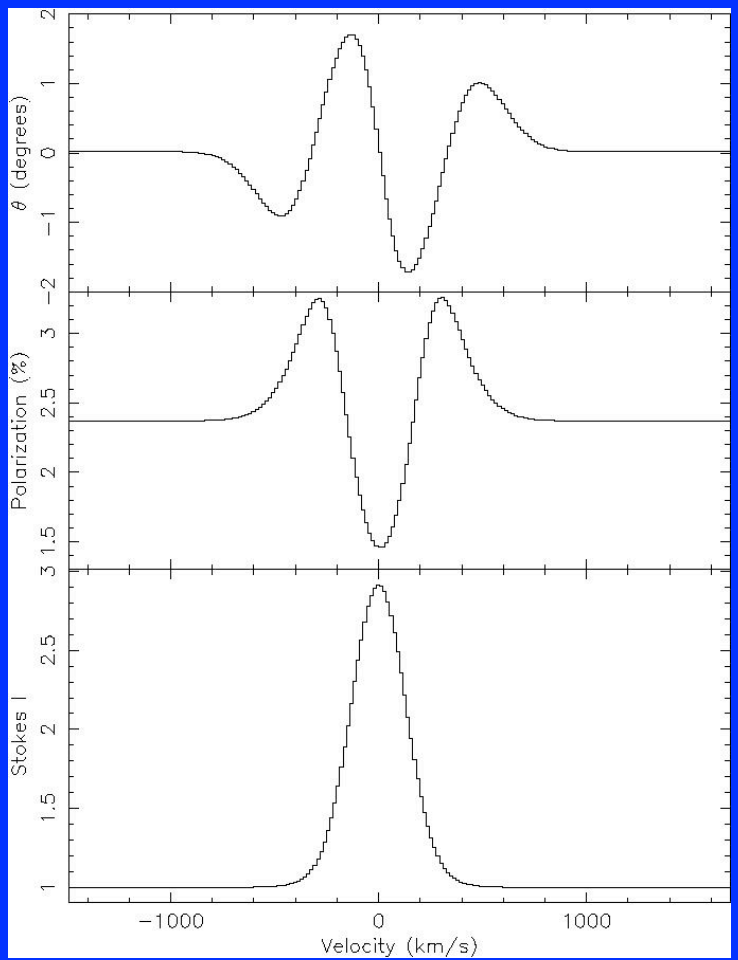
- 3D Monte Carlo TORUS (Harries 2000)
- Keplerian rotating disk
- Flat or constant opening angle
- Scattering only – no line transfer
- With and without an inner hole

With/without an inner hole



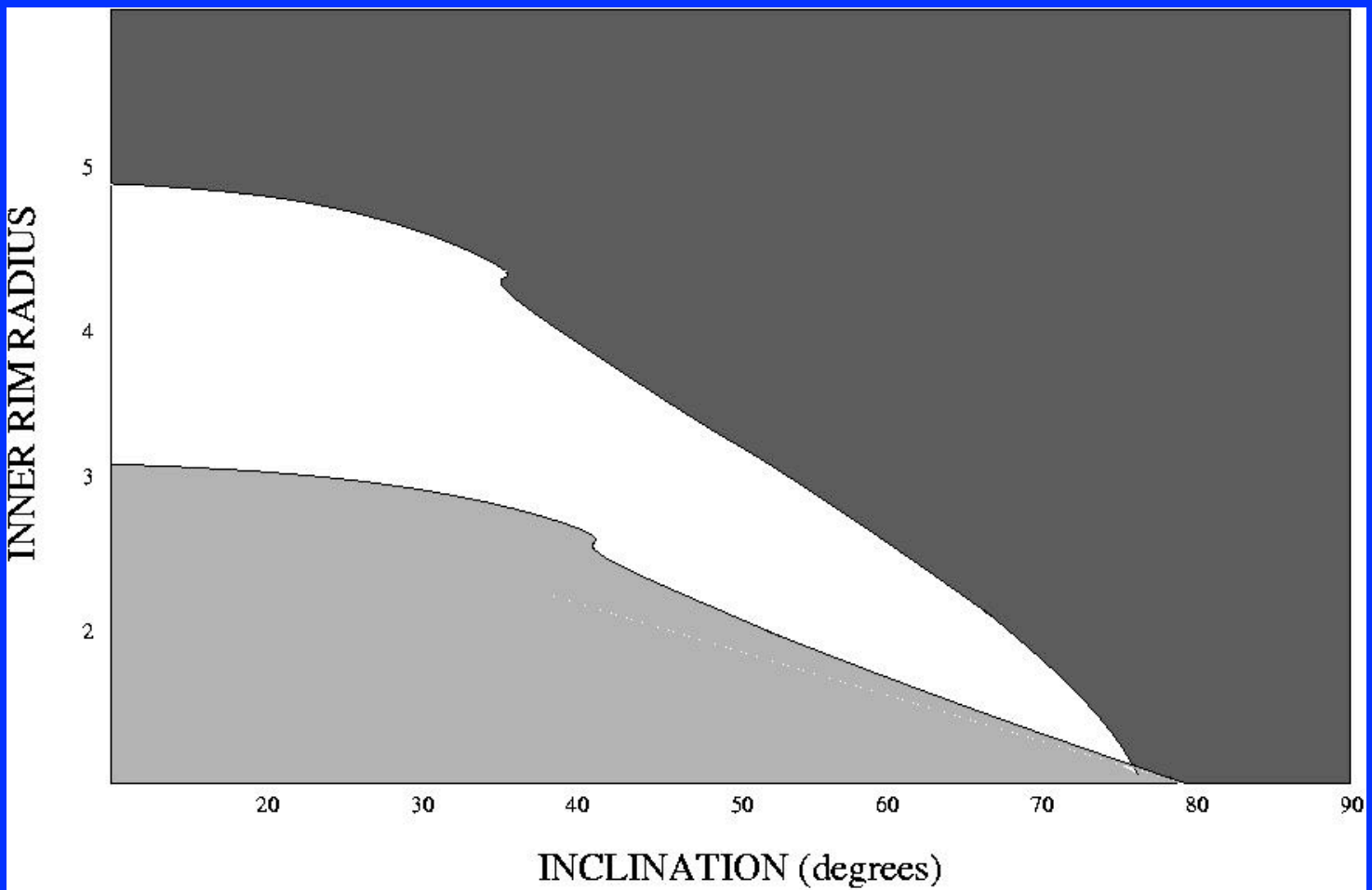
With/without a hole





Vink, Harries & Drew (2005)

Constraining the inner disk radius



Constraining the inner hole size:

Single PA flip; known inclinations

→ AB Aur Inner rim > 5 Rstar

→ CQ Tau Inner rim > 4 Rstar

→ SU Aur Inner rim > 3 Rstar

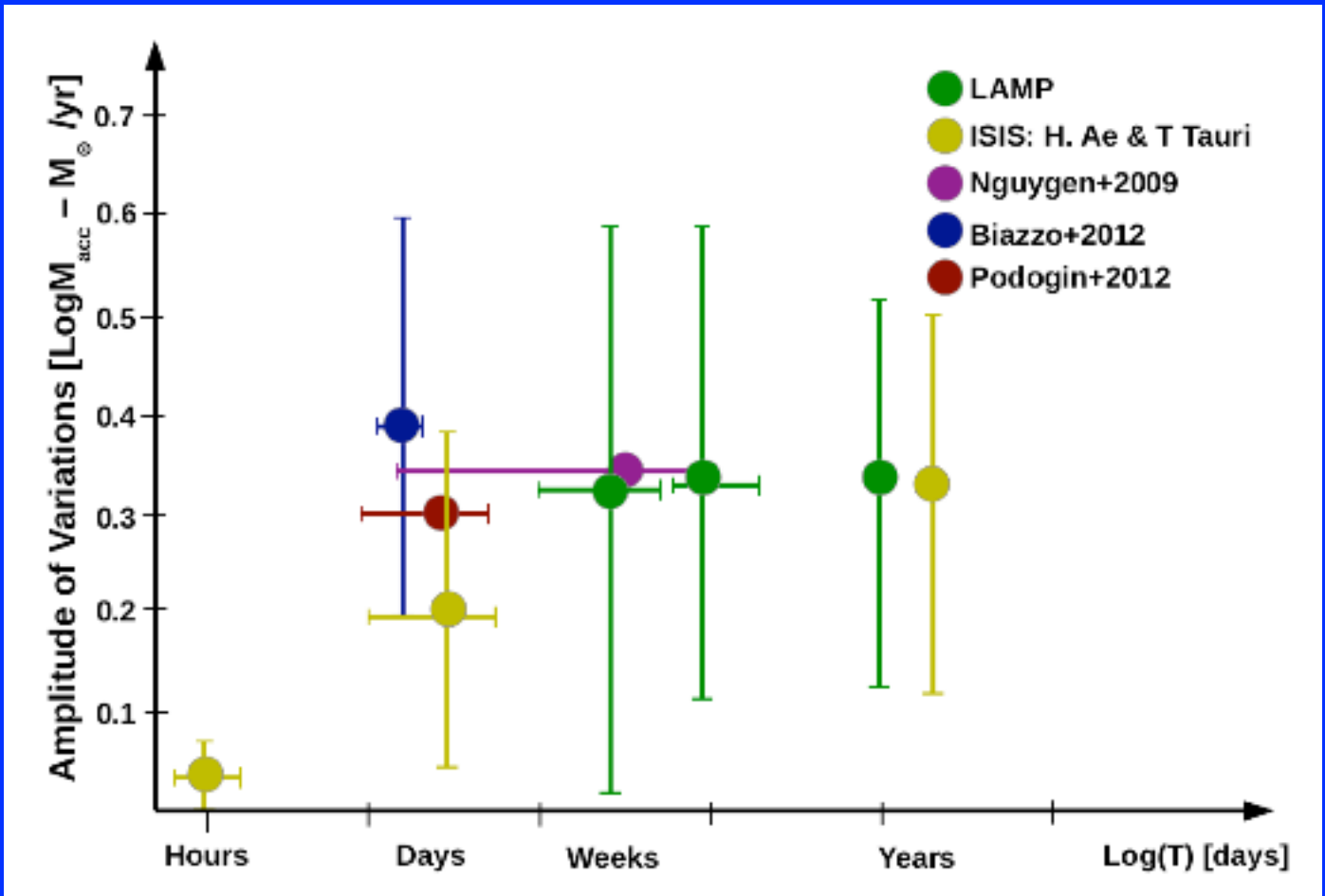
Gradual PA change

→ GW Ori Inner rim 3 or 4 Rstar

Summary

- Herbig Be: disks on small scales
- Herbig Ae/T Tau: rotating accretion disks
- Inner rim sizes 3 – 5 stellar radii

Spectroscopic Monitoring



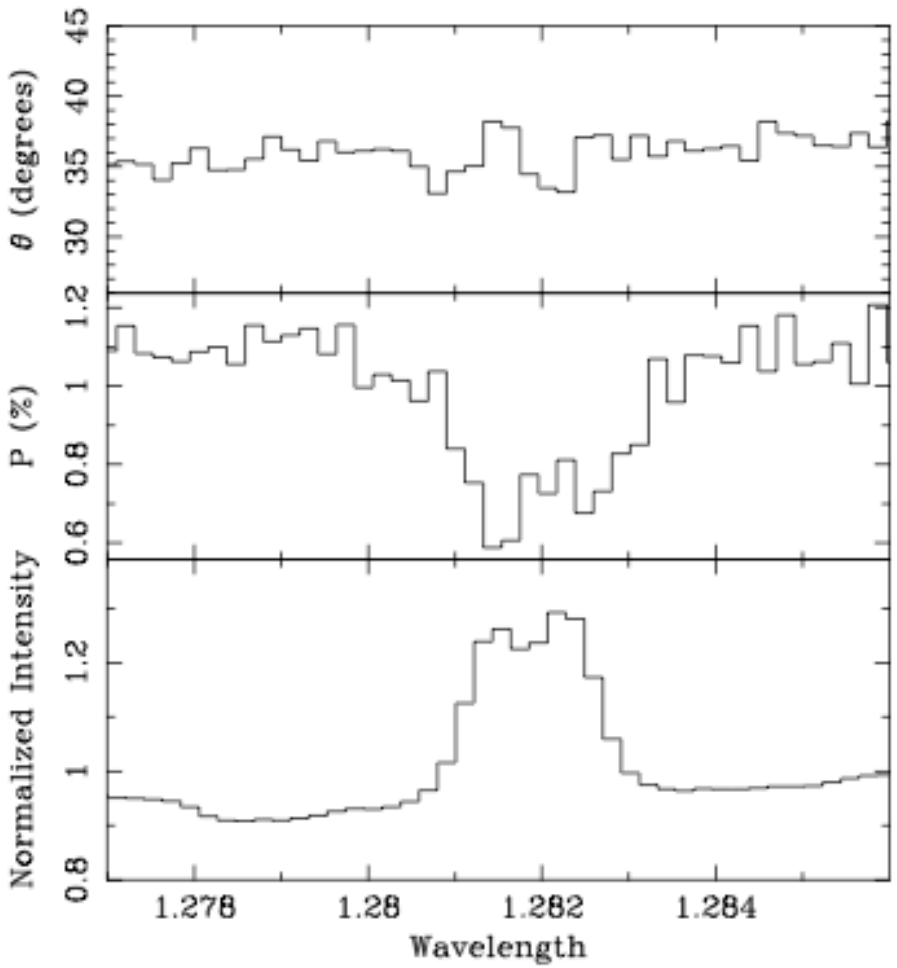
(Costigan, Vink et al. 2014)

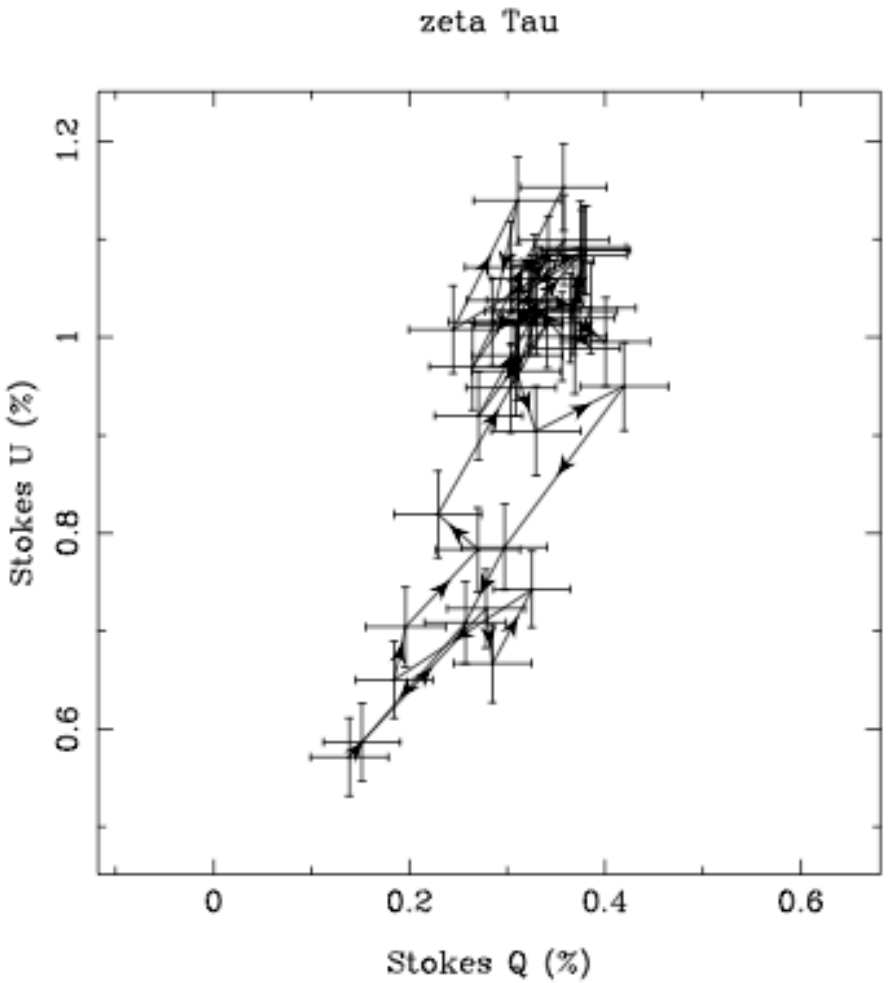
Summary

- Herbig Be: disks on small scales
- Herbig Ae/T Tau: rotating accretion disks
- Inner rim sizes 3 – 5 stellar radii

- Rotational timescale is the key
- We require linear QU monitoring!

It works in the Infrared!





(Oudmaijer et al. 2005)