Linear Spectro-polarimetry to map inner regions

Jorick S Vink (Armagh Observatory)

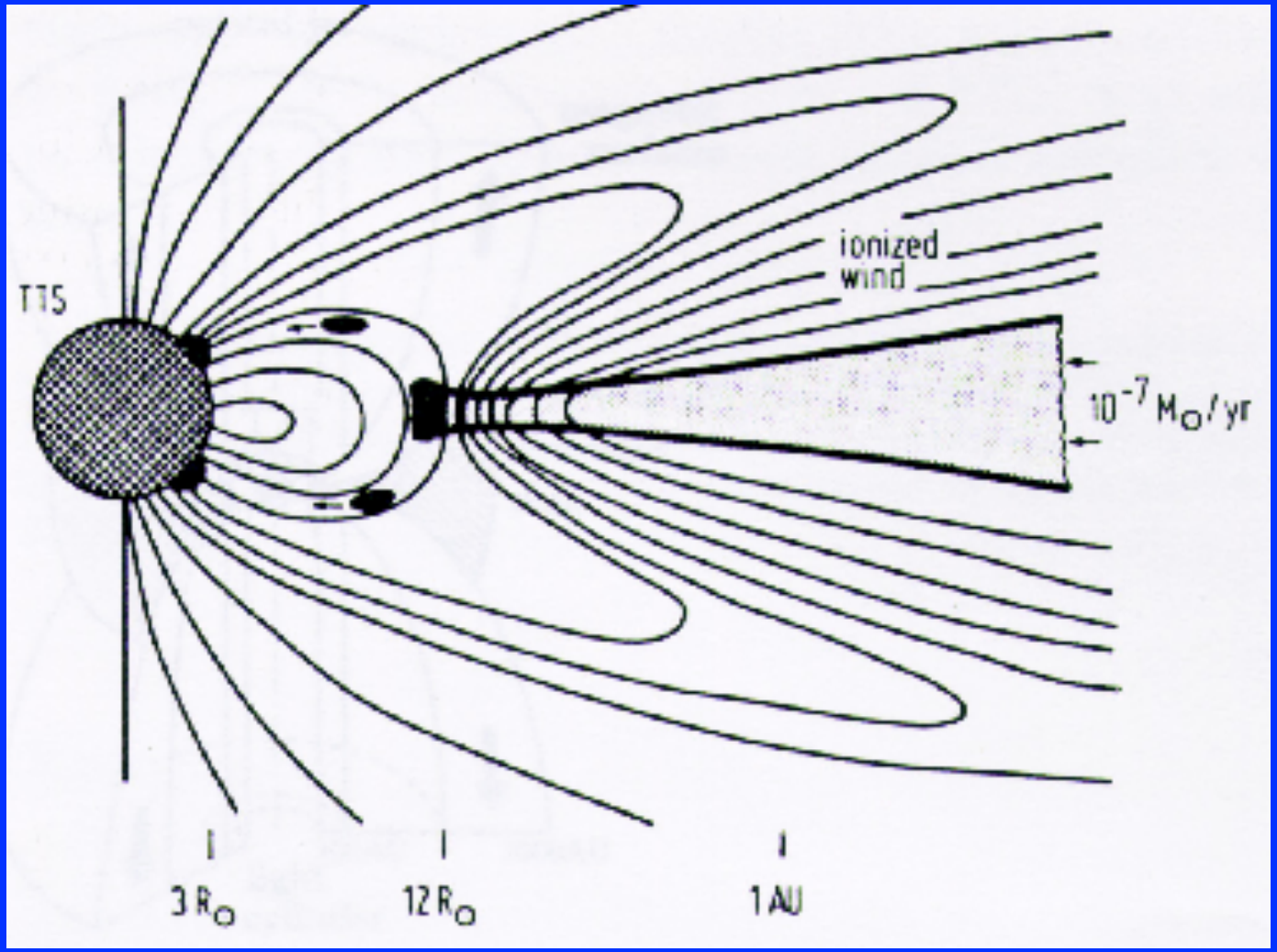
Oudmaijer, Drew, Harries, Mottram, Ababakr

Costigan, Scholz, Ray, Testi

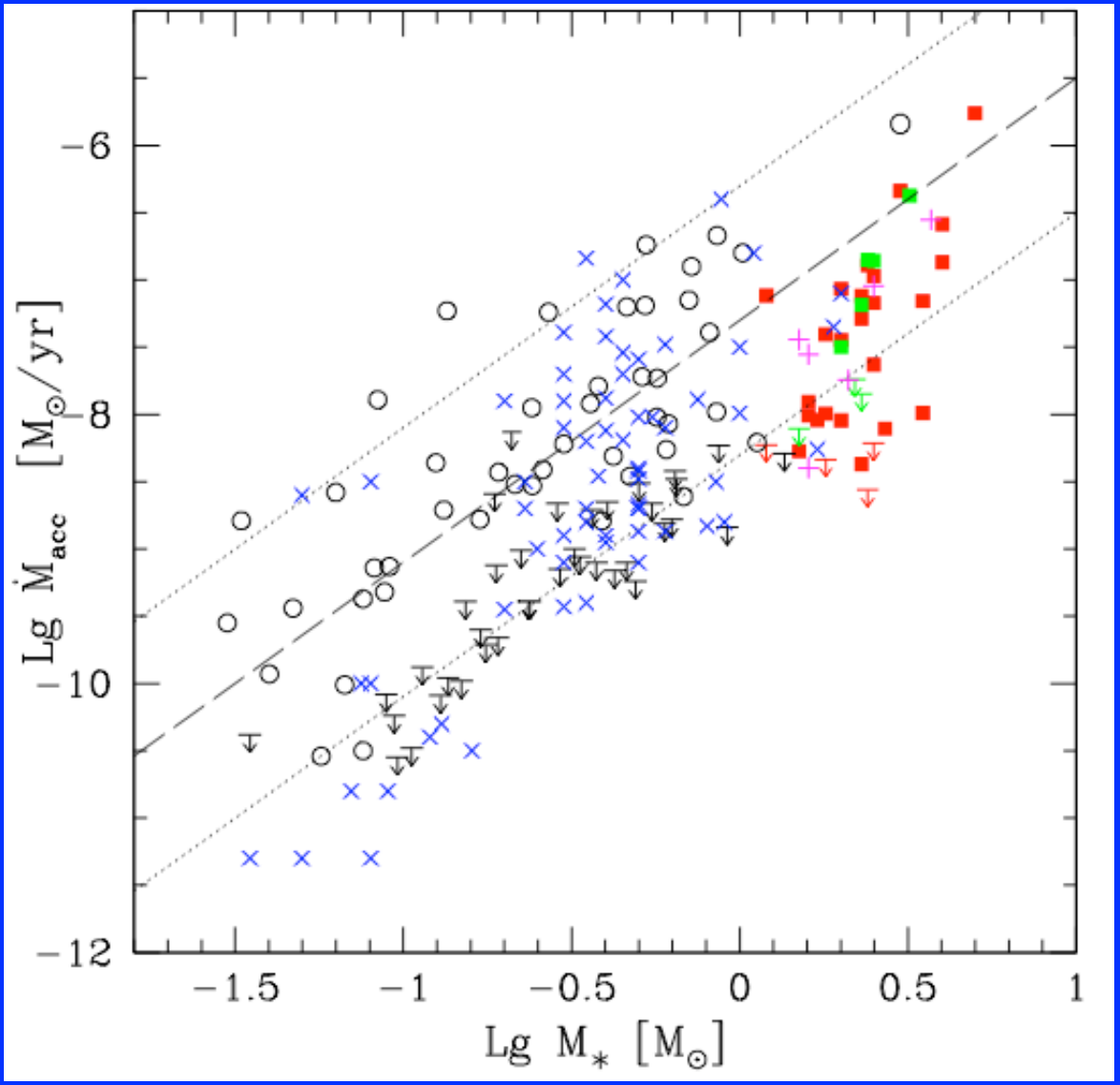
Outline

- Intro
- Data
- Monte Carlo disk scattering models
- Summary

T Tauri stars: Magnetospheric

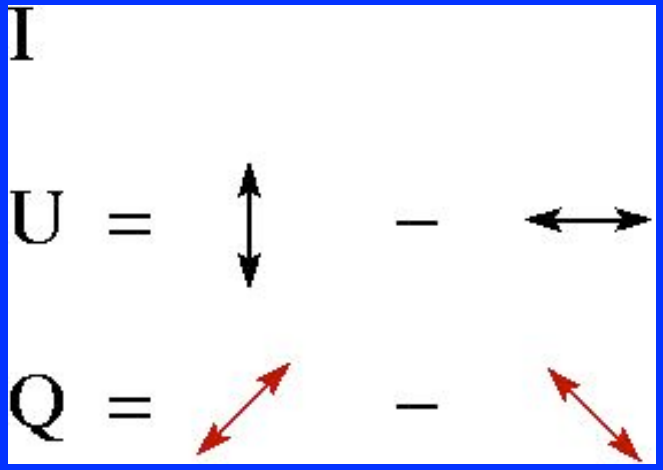


dM/dt - Mass Relation



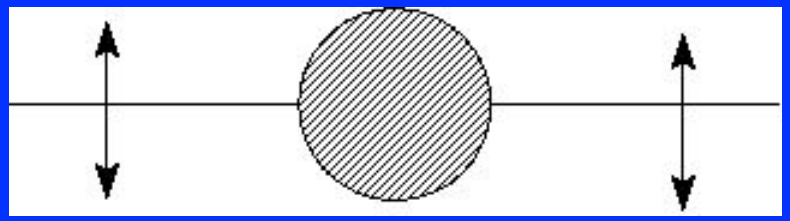
(eg. Garcia Lopez et al. 2006)

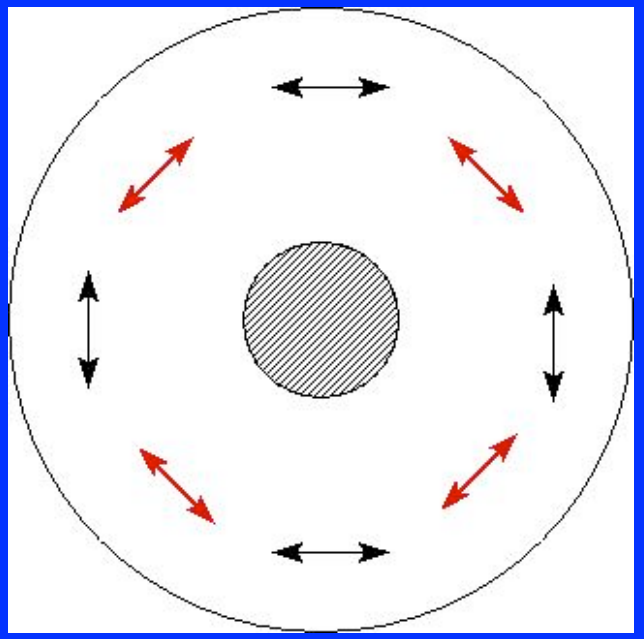
Polarimetry – from disks



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

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

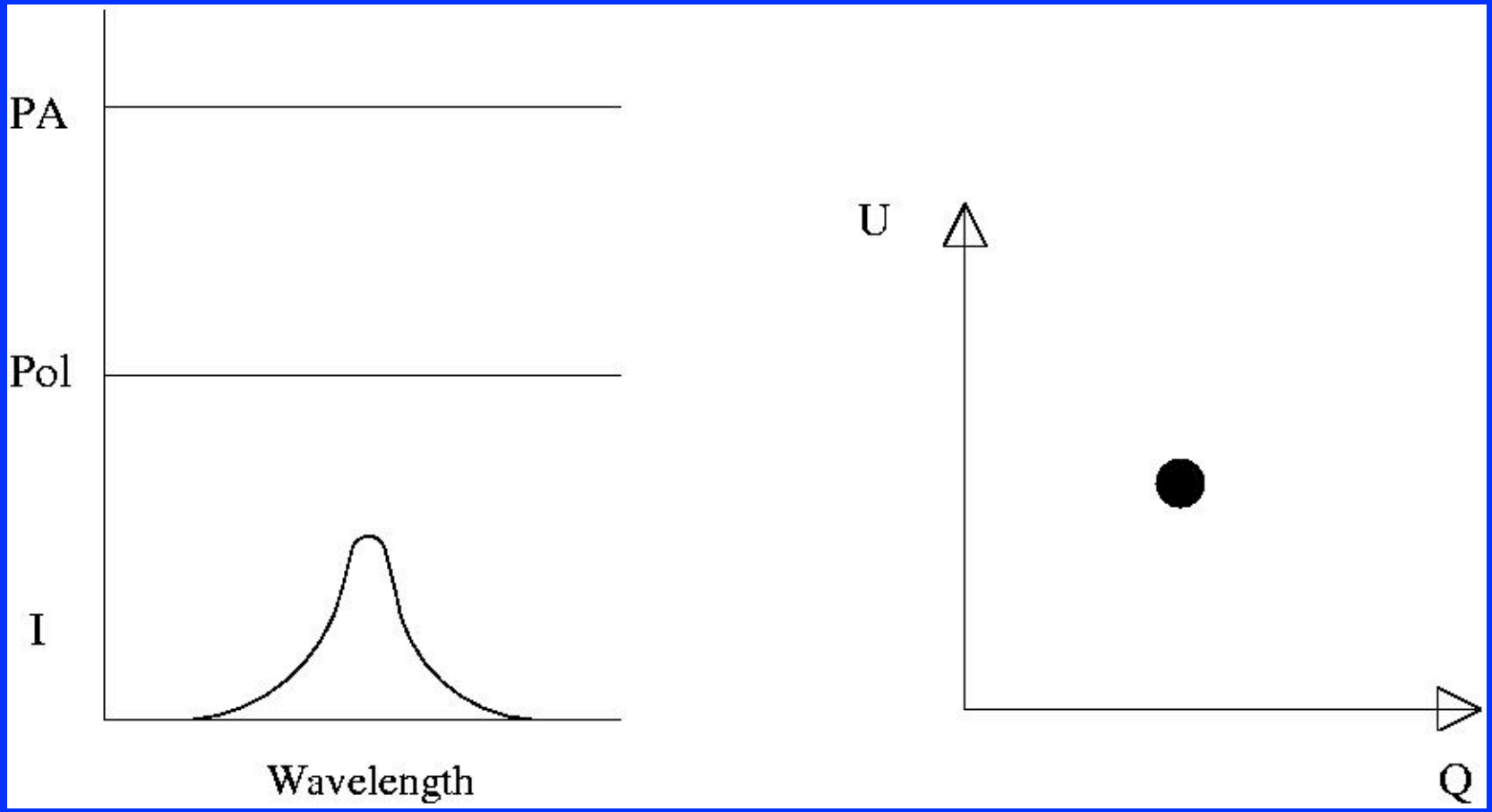




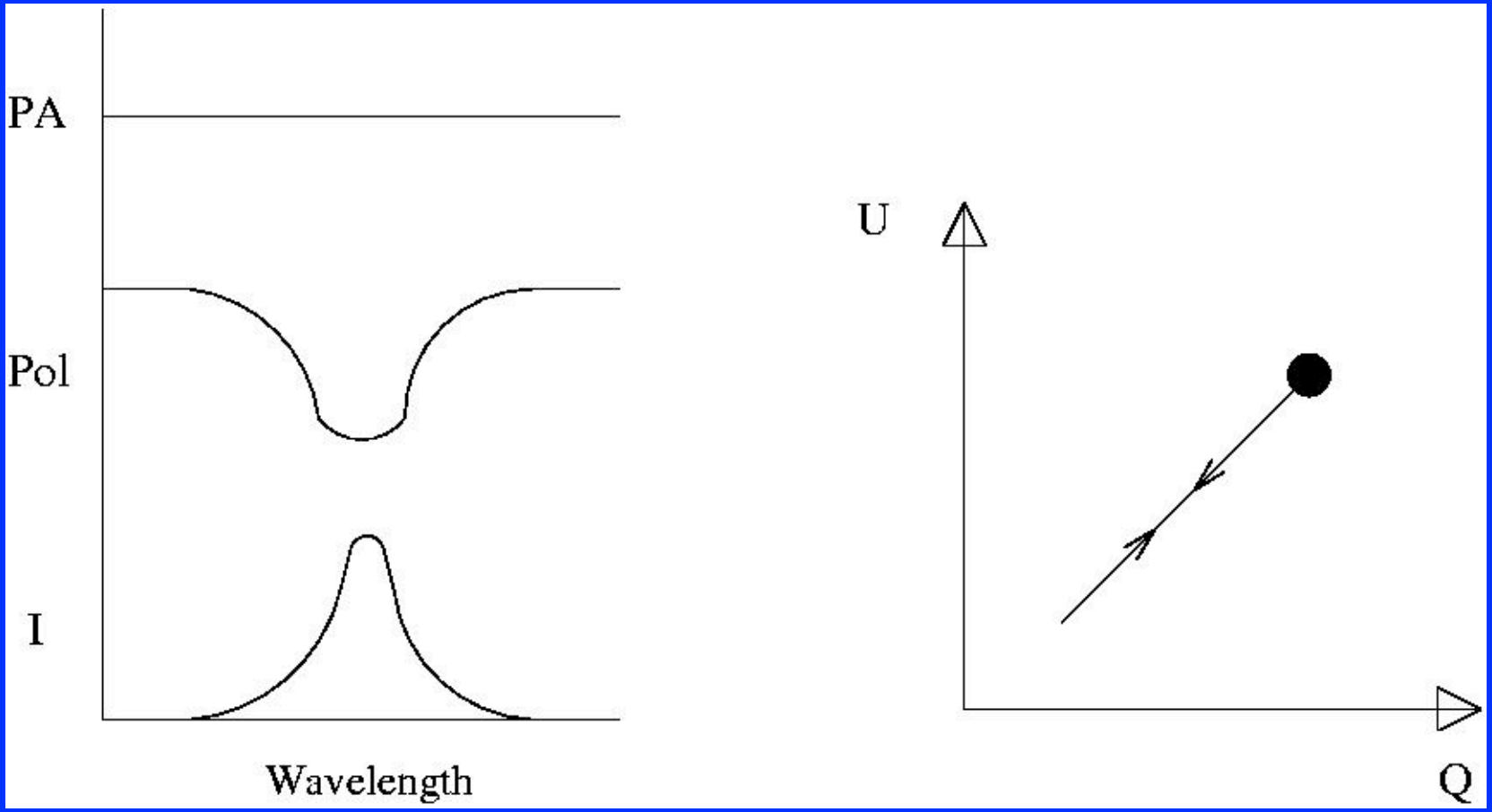
Polarisation across line?

1. No change
2. Depolarisation
3. LINE Polarisation

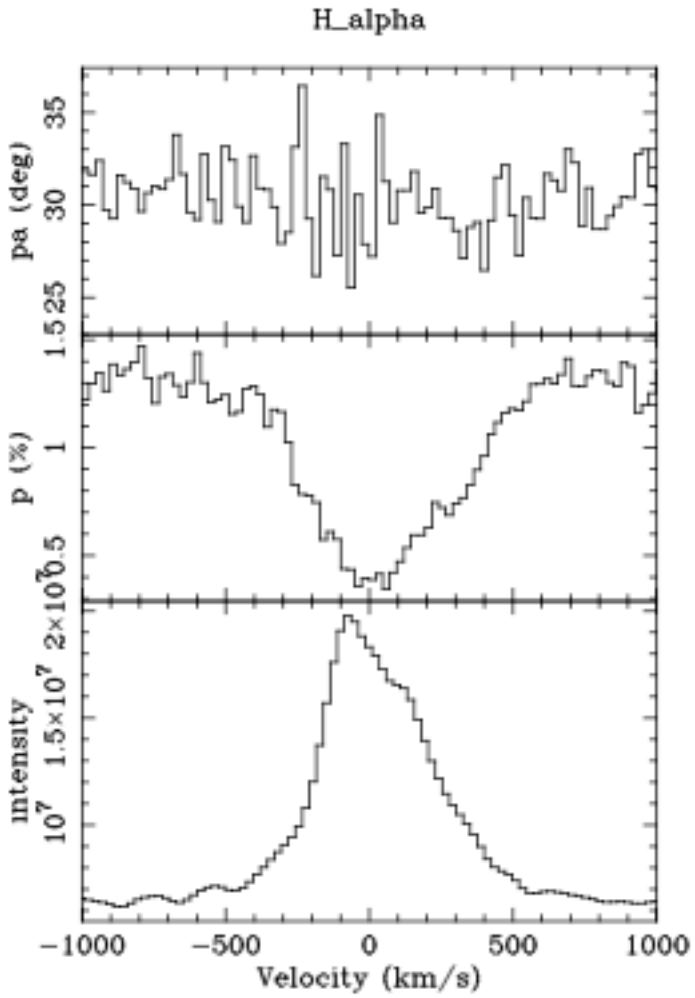
No Polarisation

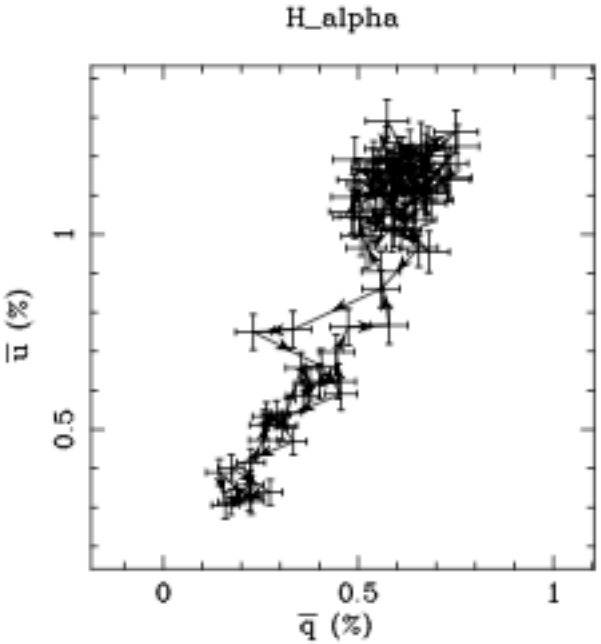


Depolarisation



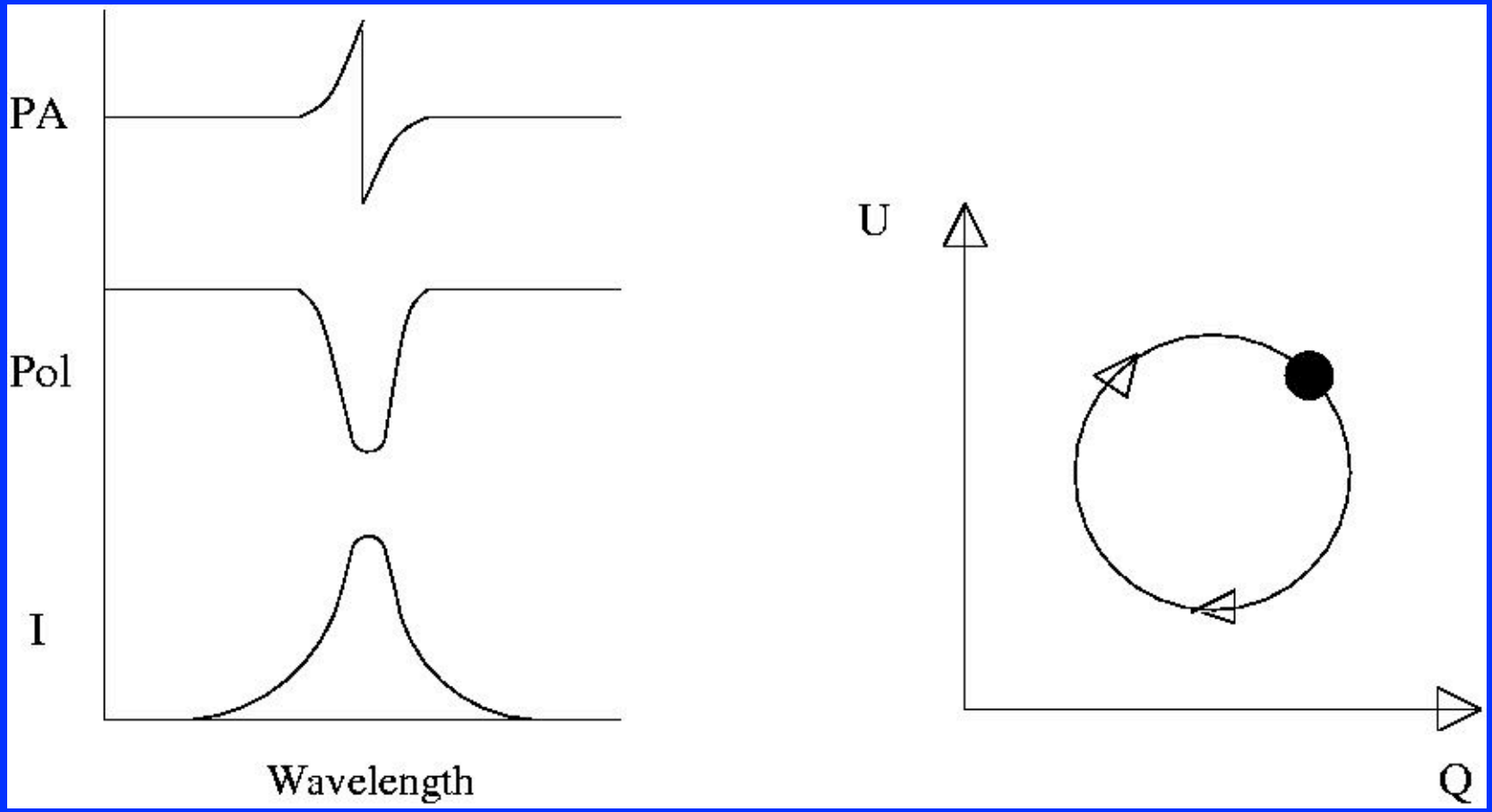
Be star Zeta Tau - it works!



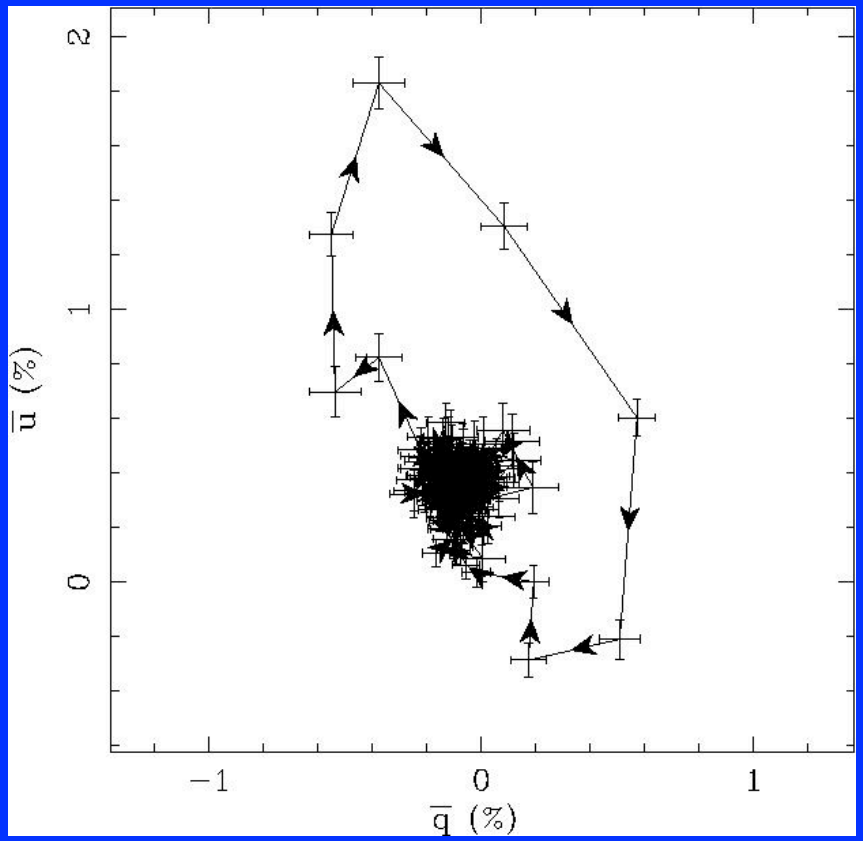


(Oudmaijer 2007)

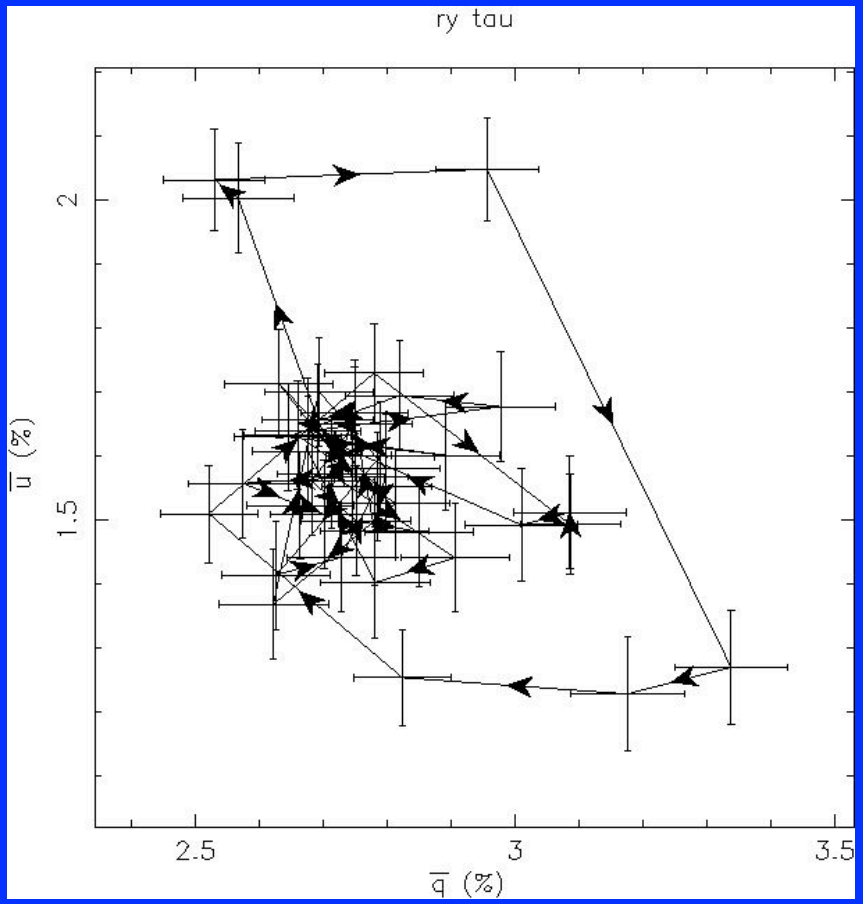
Line Polarisation – PA Flip



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 Polarisation

Herbig Ae: 9/11 → 18/22

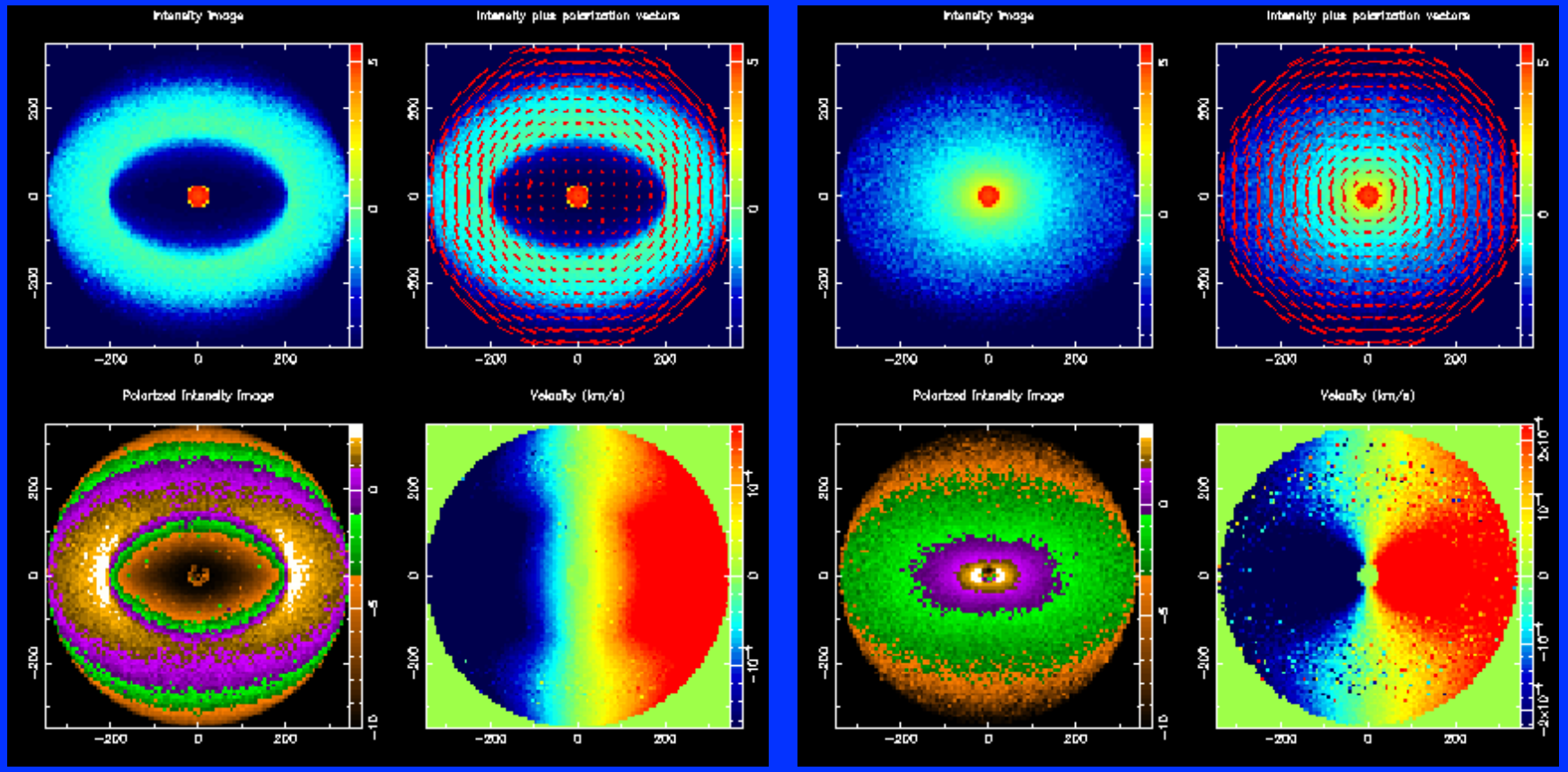
T Tauri: 9/10

Ababakr et al. (2017)

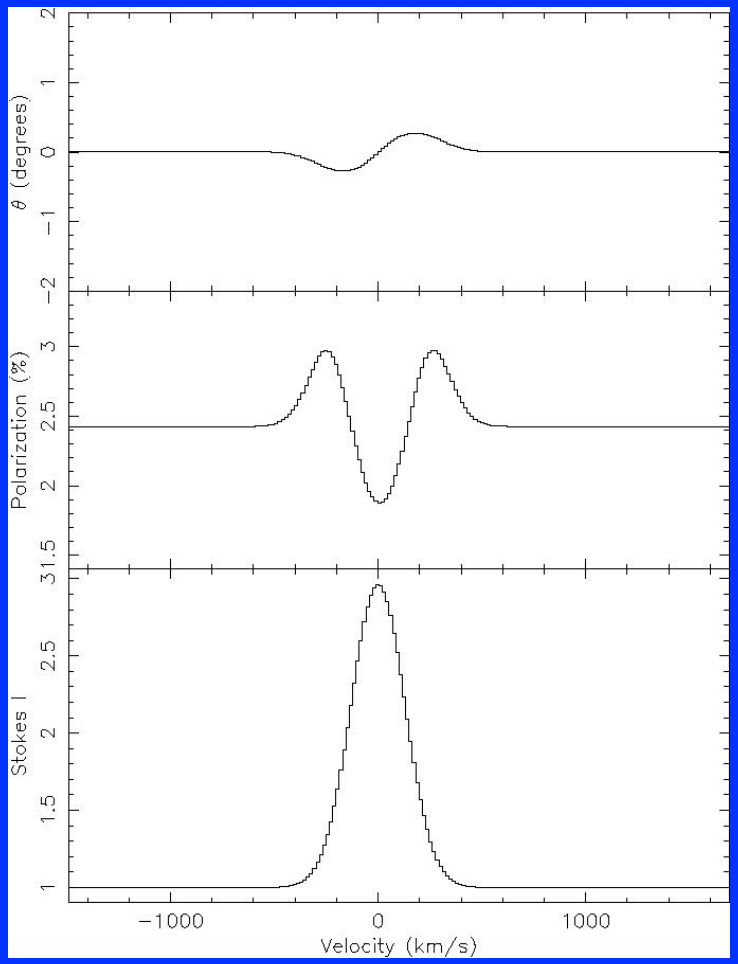
Models of COMPACT line emission

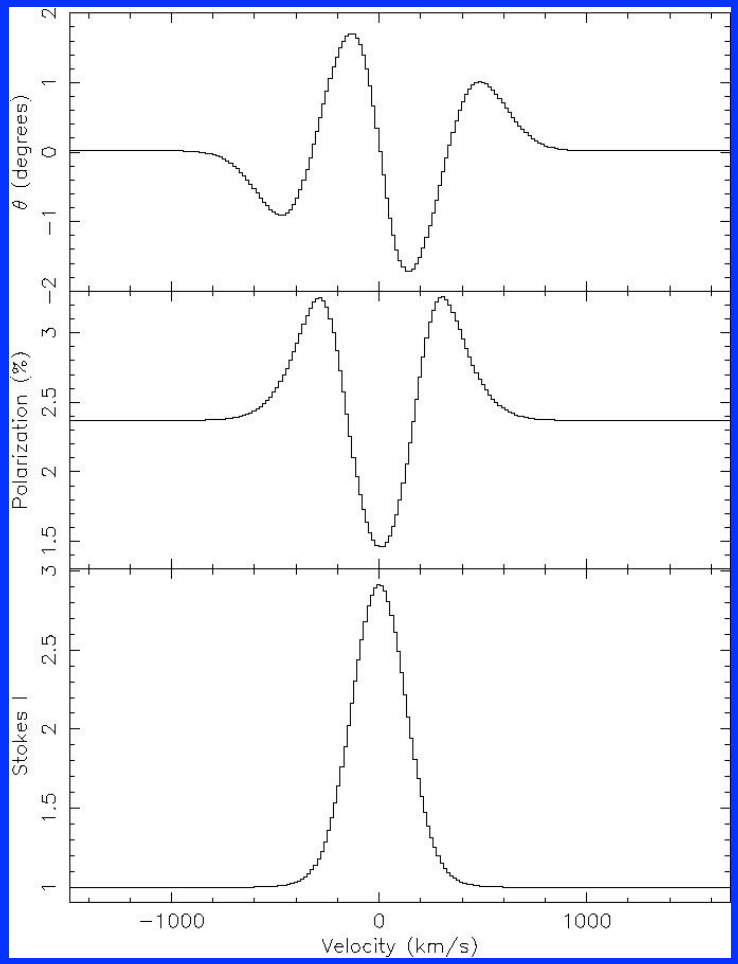
- 3D Monte Carlo TORUS (Harries 2000)
- Keplerian rotating disk
- Flat or constant opening angle
- Scattering only – no line transfer
- With and without an inner hole

With/without a hole



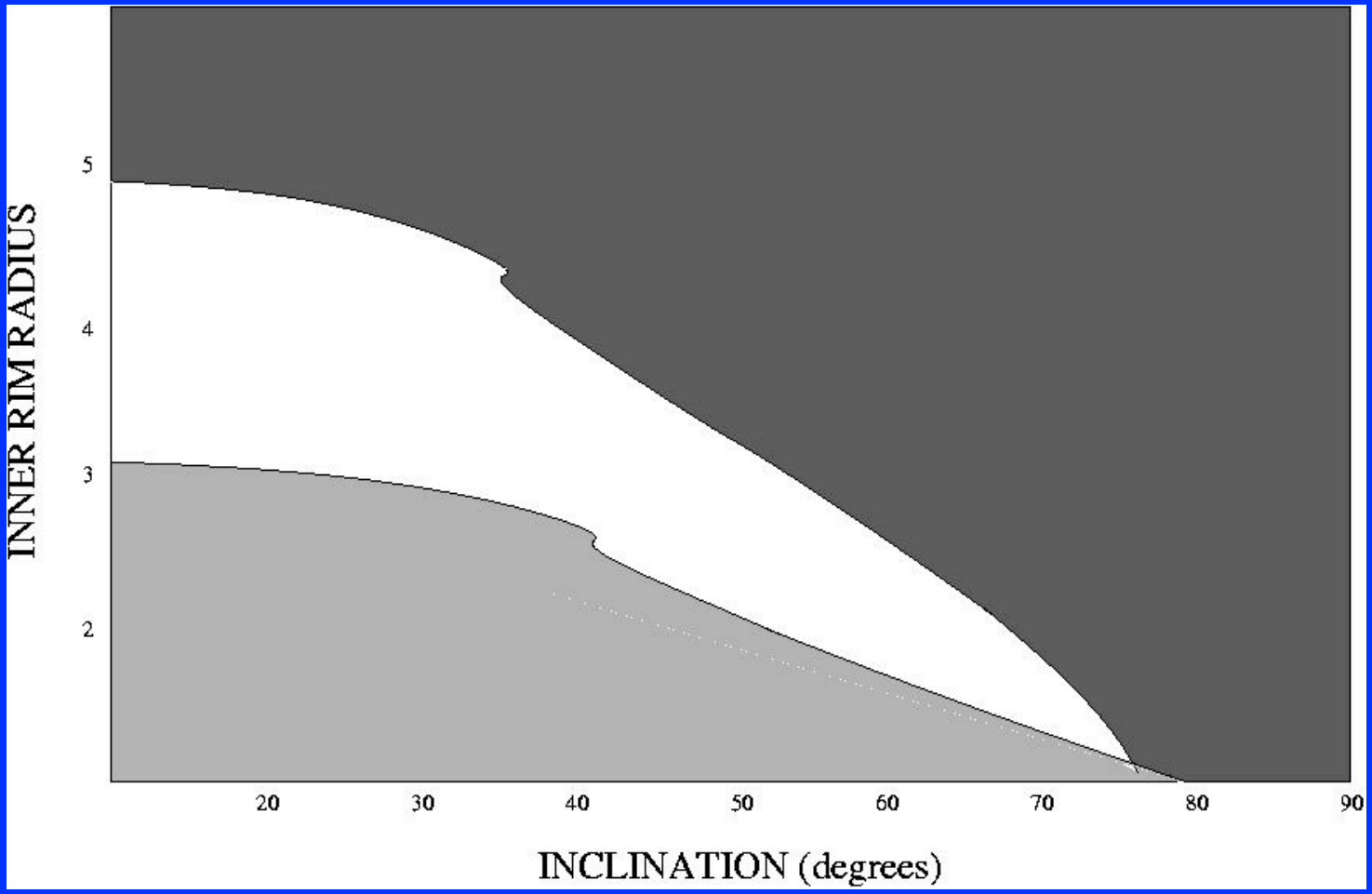
With/without a hole





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

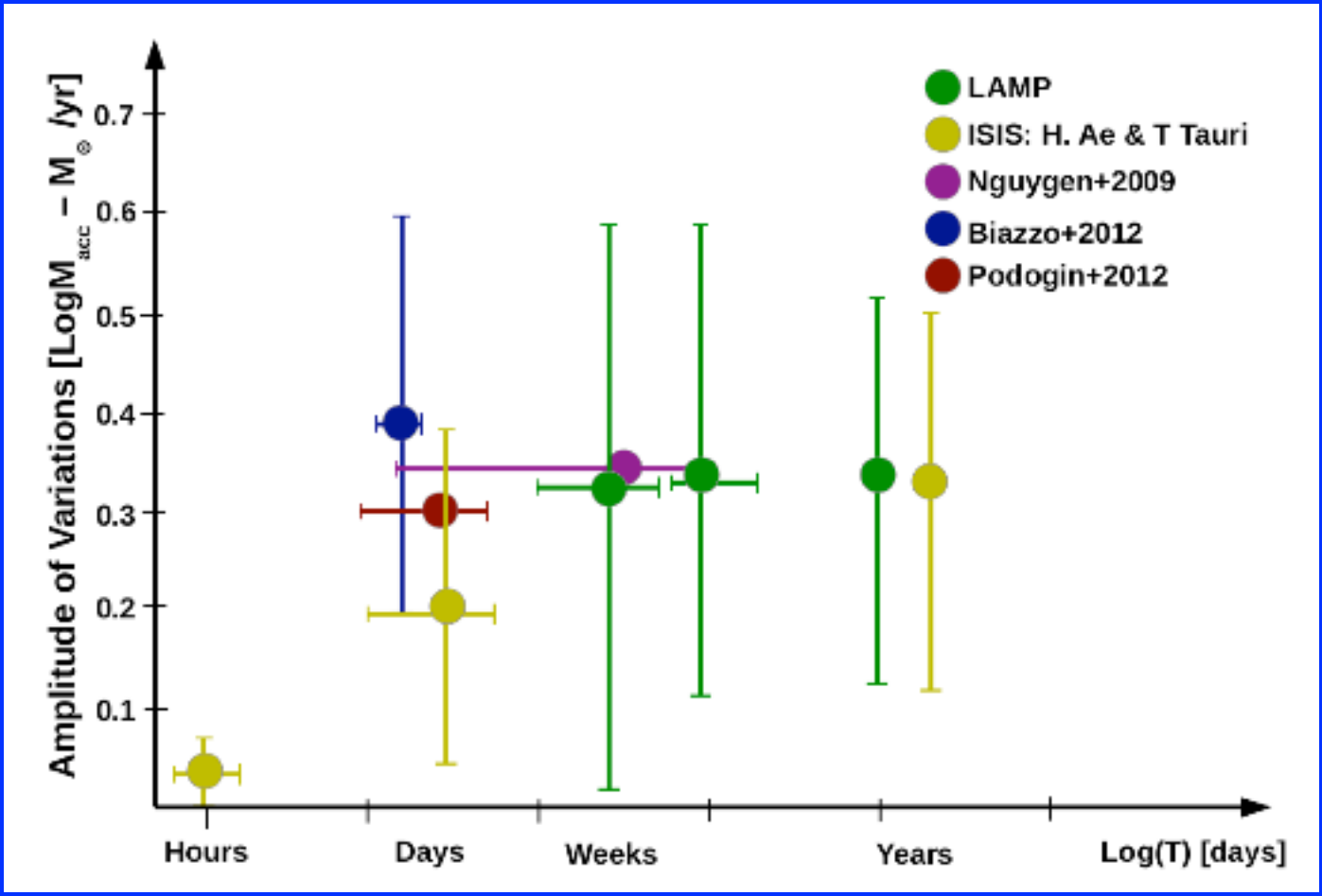
→ GW Ori Inner rim 3 or 4 Rstar

Object	Alt. name	Type	Disk PA (°)	Pol. PA (°)	ΔPA (°)	
HAe/Be						
HD 200775	MWC 361	B2	7[1]	93[2]	86	⊥
MWC 147	V700 Mon	B6	80[3]	168[2]	88	⊥
HD 45677	FS CMa	B2[4]	77[5]	164[6]	87	⊥
BD +40° 4124	V1685 Cyg	B3	110[7]	36[2]	74	⊥
MWC 1080	V628 Cas	B0	55[7]	75[2]	20	∥
CQ Tau	HD 36910	F3	120[8]	20[9]	80	⊥
MWC 480	HD 31648	A3	150[7]	55[9]	85	⊥
AB Aur	HD 31293	A0	79[10]	160[9]	81	⊥
HD 179218	MWC 614	A0IVe	23[11]	~45[12]	22	∥
T Tauri						
RY Tau	HD 283571	F8	62[13]	163[9]	79	⊥
SU Aur	HD 282624	G2	127[14]	130[9]	3	∥
FU Ori	HBC 186	G3	47[15]	45[9]	2	∥
GW Ori	HD 244138	G5	56[16]	(60)[9]	4	∥
DR Tau	HBC 74	K5	128[17]	120[9]	8	∥

Summary

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

Spectroscopic Monitoring



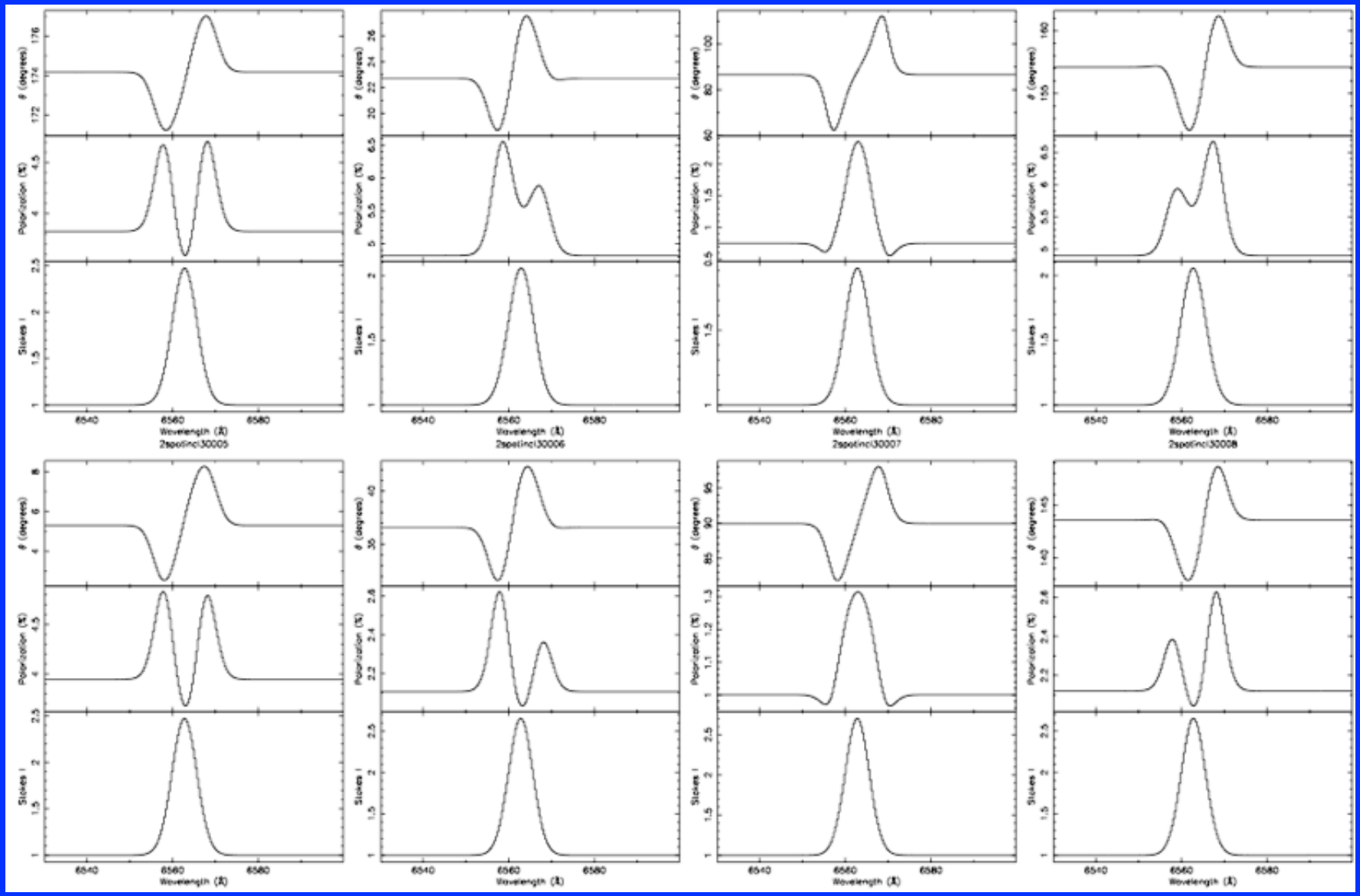
(Costigan, Vink et al. 2014)

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
- Next step: Linear QU monitoring!

Spectro-polarimetic Monitoring



ULLYSES

- HST Cycles 27 - 29: 1000 orbits
- Galaxies: Star Formation in the UV
- C Schneider, J Hillier, C Leitherer, E Stanway
- https://www.mdpi.com/journal/galaxies/special_issues/StarFormation