Differential interferometry

© Bill Pounds

Ph. Stee

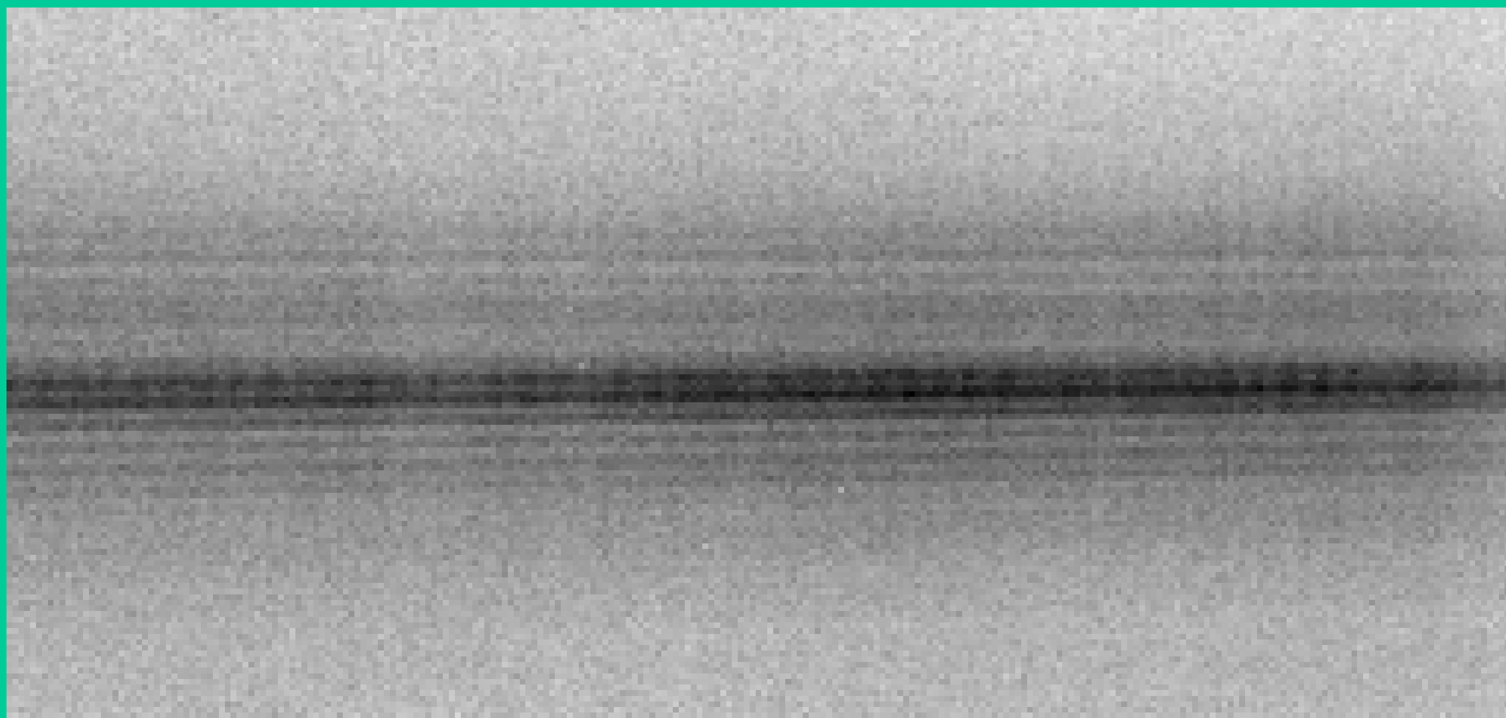
Observatoire de la Cote d'Azur

Dᵭpartement FRESNEL-Equipe GI2T

Interferometry: fringe analysis

A field of Zebra

*Fringes analysis (x-*λ mode)



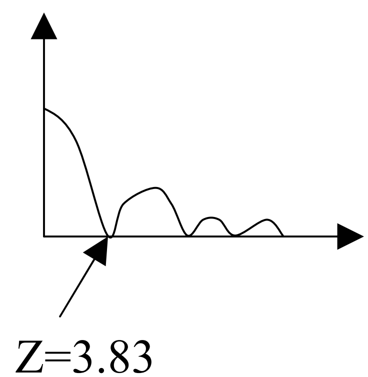
R Cas (V ≈ 6, K≈ -1.5) B= 14 m - Dispersed Fringes in K band (GI2T).

Modulus of the visibility

- Unresolved object (point source) V=1

- Extended object V < 1

For a circular object $V = |2J_1(z)/z|$



$B_r = 250\ \lambda/\phi_{ud}$

(λ in μm Br in m, ϕ in mas)

How to define a stellar diameter ?

Not trivial !

Some definitions:

Optical radius: $$\tau(r) = \int_{r_0}^{r} K(r')\rho(r')dr' \approx 1$$

with $K(r) = \kappa(r) + \sigma(r)$

Intensity radius:

R_I=r with $I(r)/I(0) \approx 0$

Measure the temperature of a star

$$L = 4\pi R^2 \sigma T_{eff}^4$$

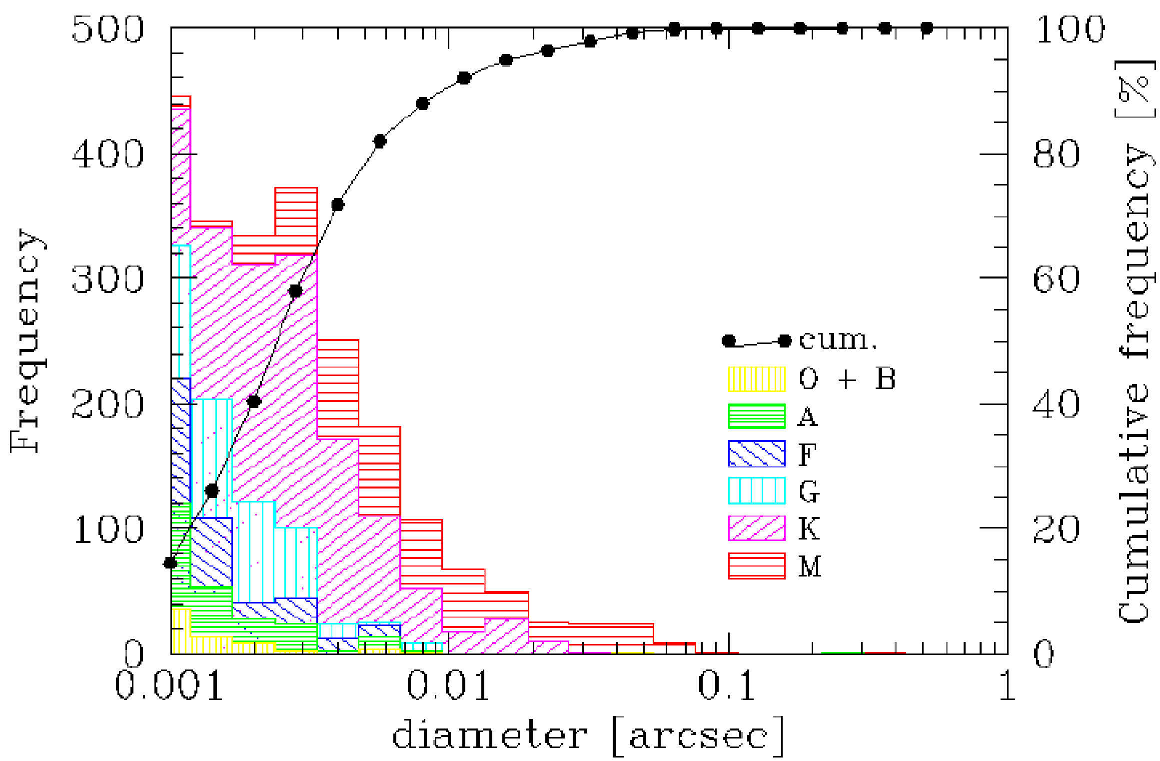
$$L = 4\pi d^2 f$$

$$\alpha = \frac{R}{d}$$

$$T_{eff}^4 = \frac{1}{\sigma}\frac{f}{\alpha^2}$$

Q: What is Teff ? ; -)

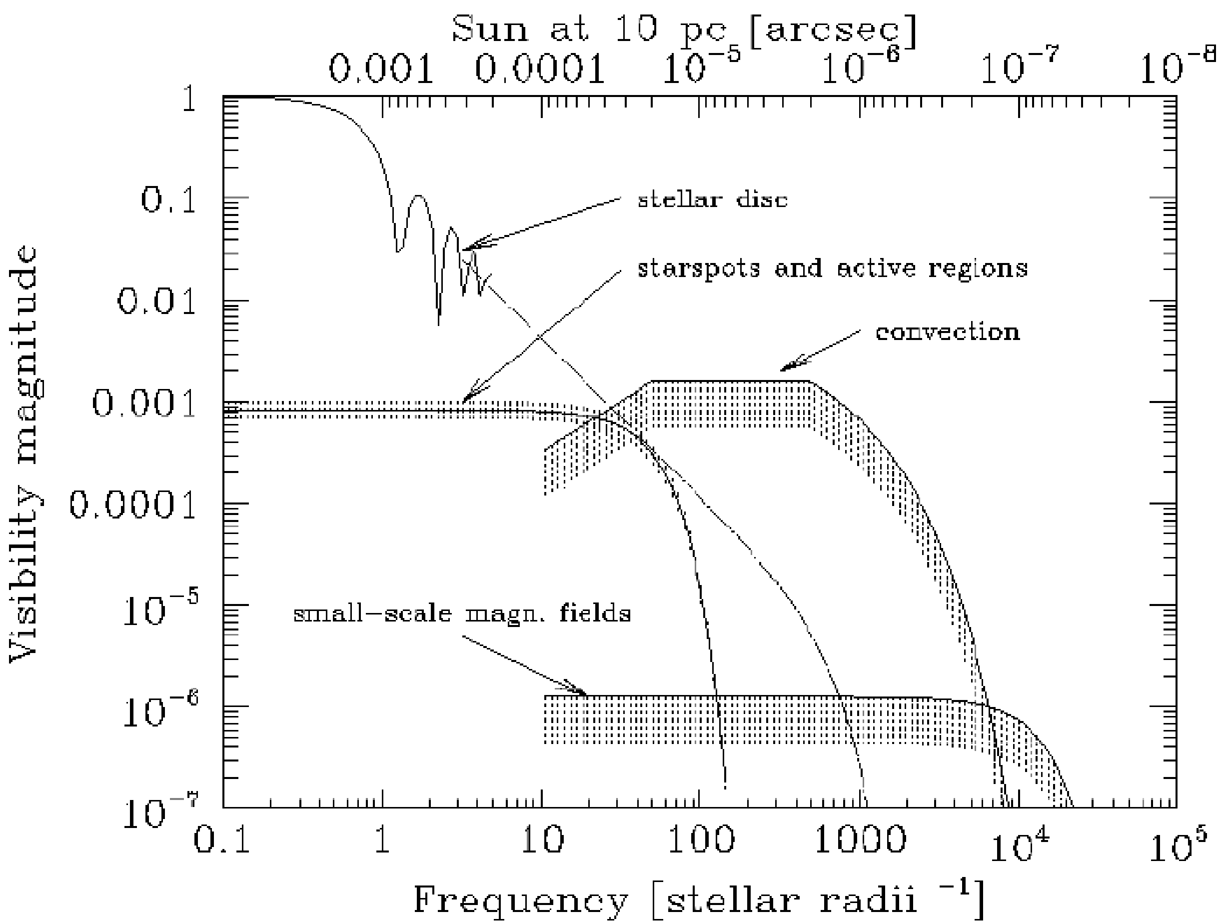
Diameter distribution of stars ?



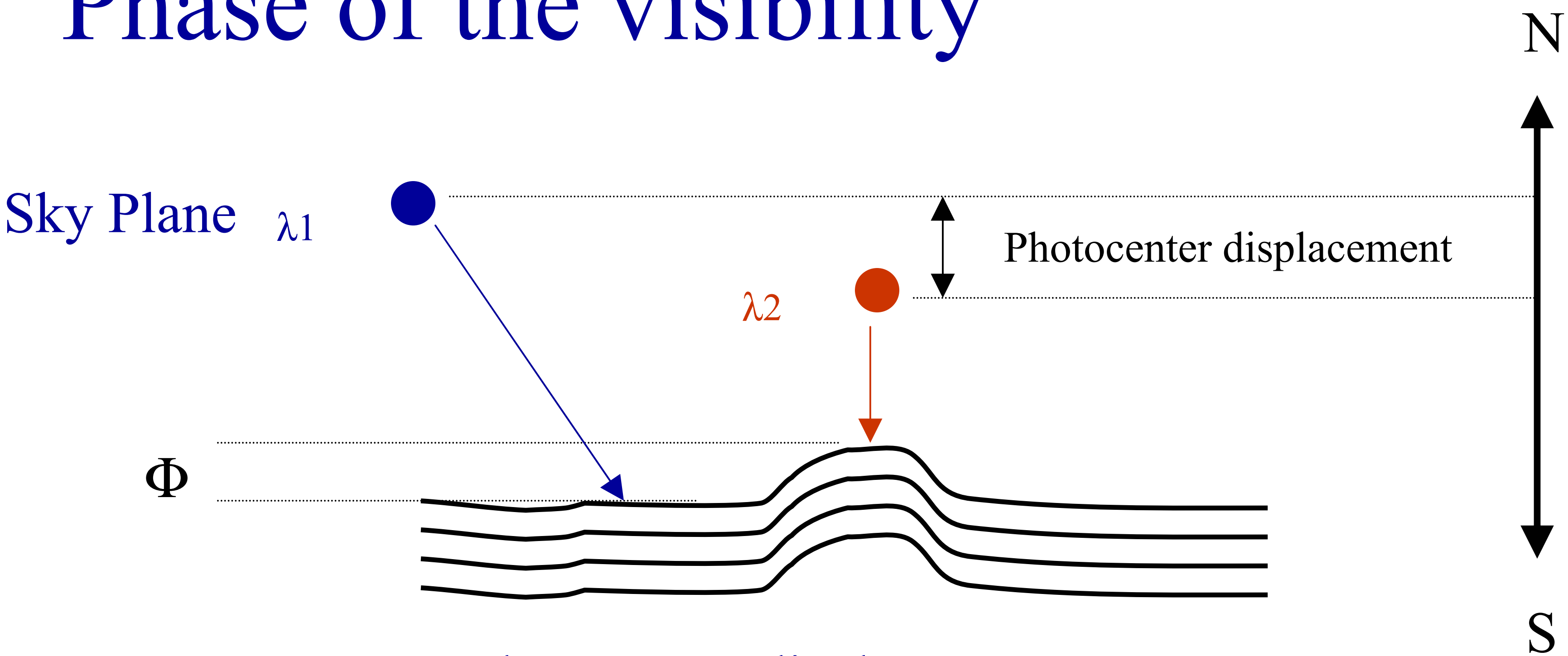
1309 sources
50 % < 2.5 mas
20 % > 5 mas
7% > 10 mas -> UT

Von der Lühe, O., 1995, UAI Symp. 176, Eds. Strassmeier K. & Linsky J , Kluwer, p 147

What can be seen on a solar type star (1 R_m) at 10 pc ?



Phase of the visibility



Photocenter displacement

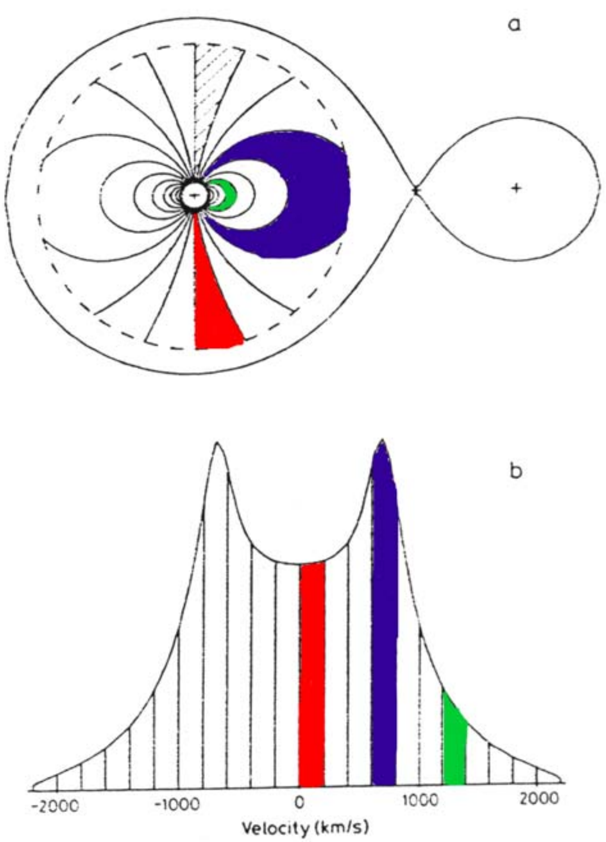
⇓

Shift of the fringes (ϕ)

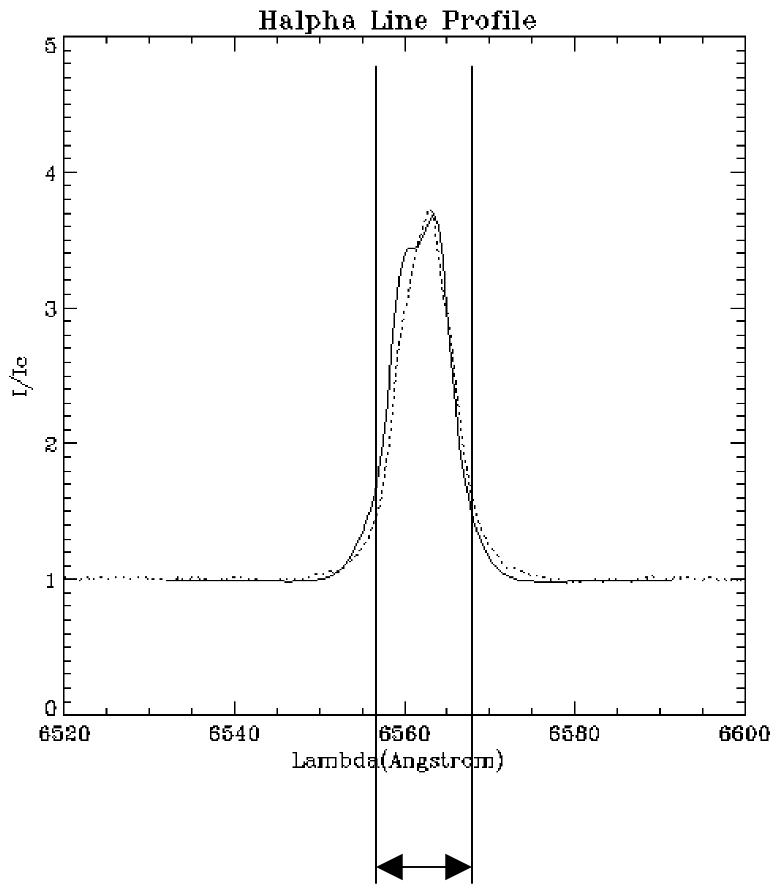
⇓

Change in the visibility phase

Spectral filter = spatial filter

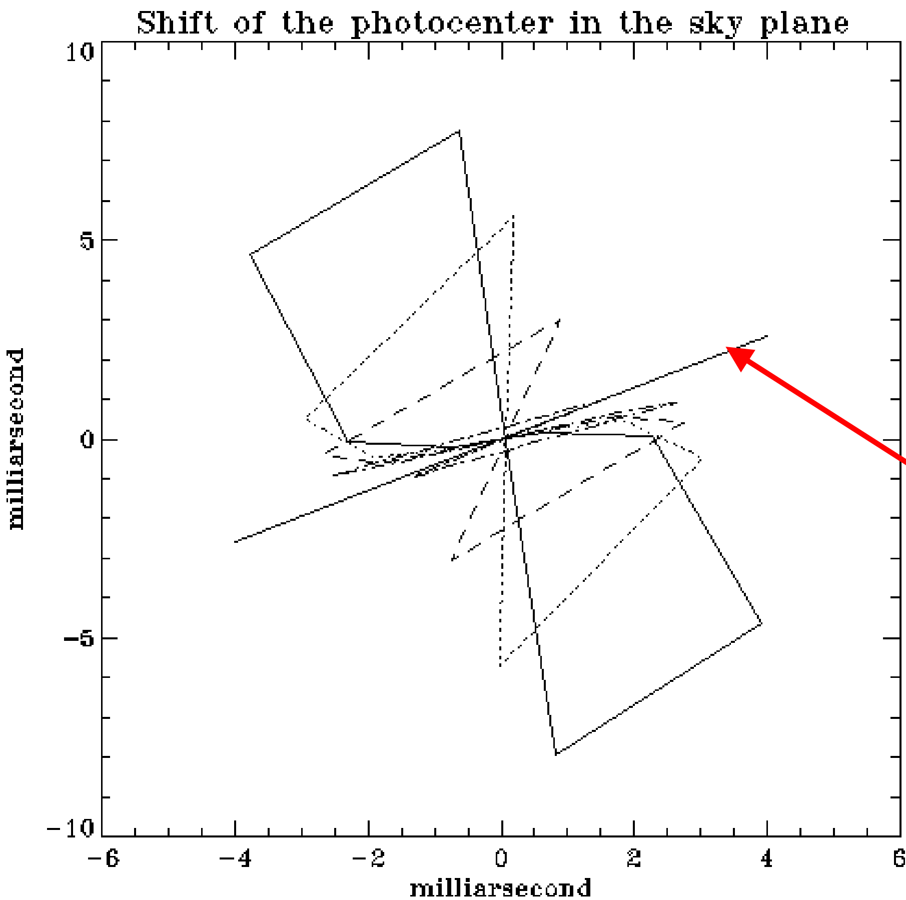


Line formation in a rotating envelope



MkIII filter: 10Å

Photocenter displacement on the sky plane: $\phi=f(\lambda)$



Constant rotation

Keplerian rotation

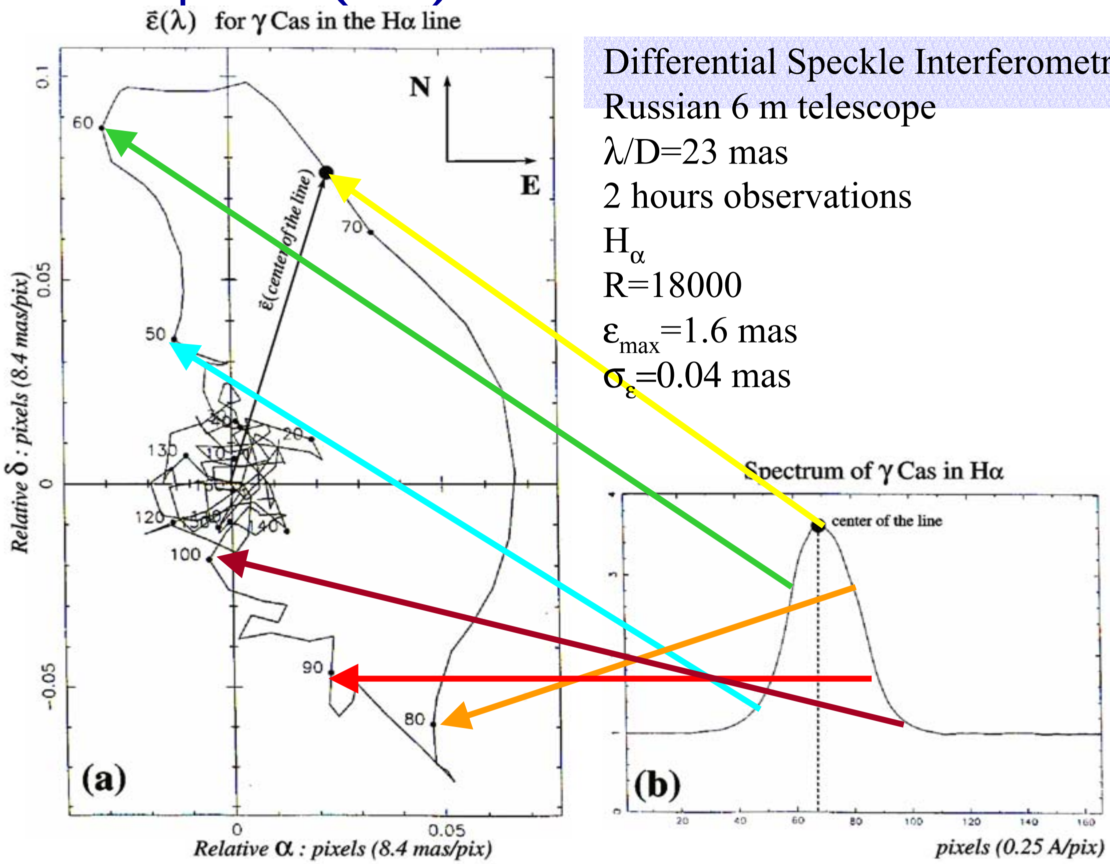
Angular momentum conservation

Rotation axis

γ Cas: Keplerian rotation

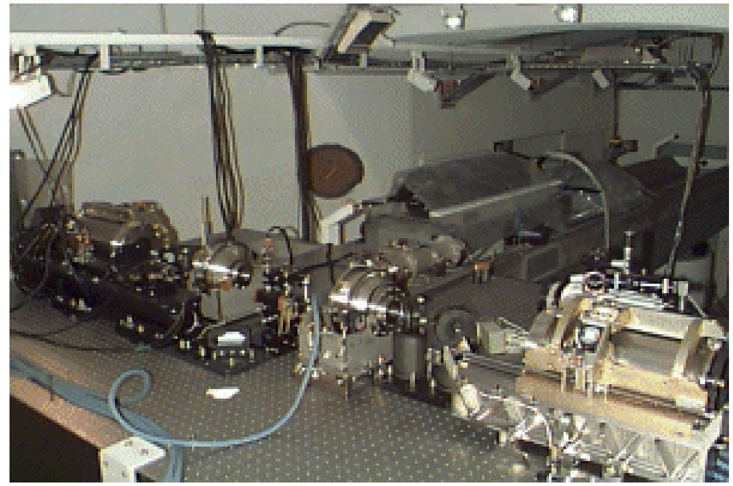
Stee 1996, A&A, 311, 945

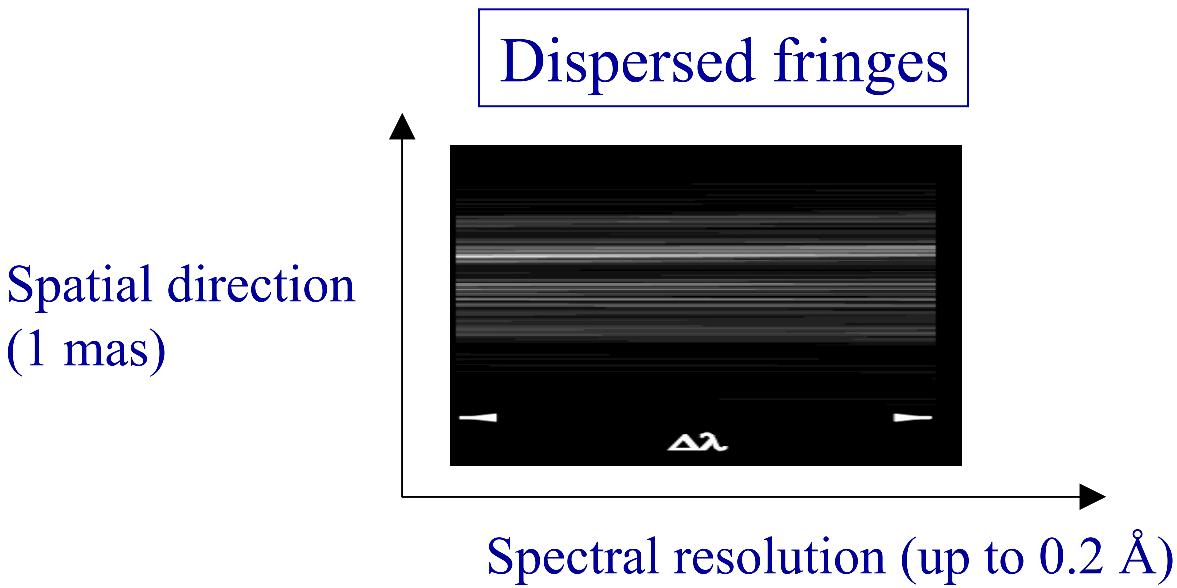
Differential speckle interferometry of γ Cas: $\phi=f(\lambda)$



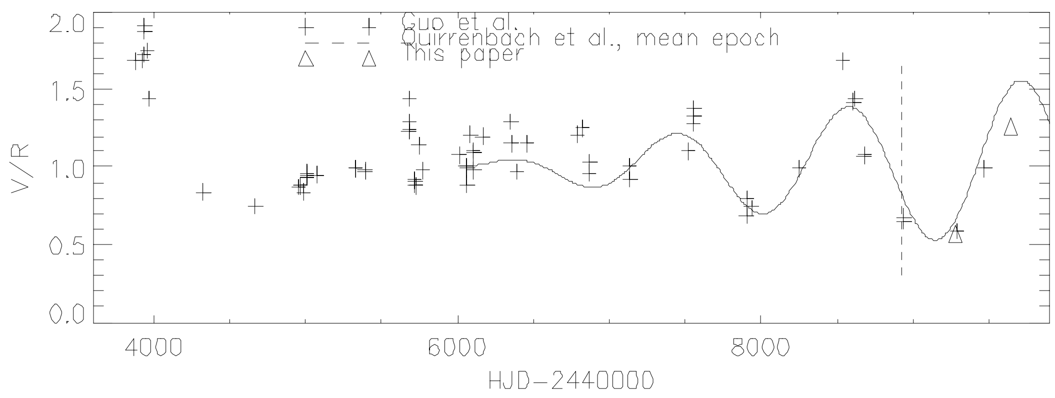
Differential Speckle Interferometry
Russian 6 m telescope
λ/D=23 mas
2 hours observations
H_α
R=18000
ε_{max}=1.6 mas
σ_ε=0.04 mas

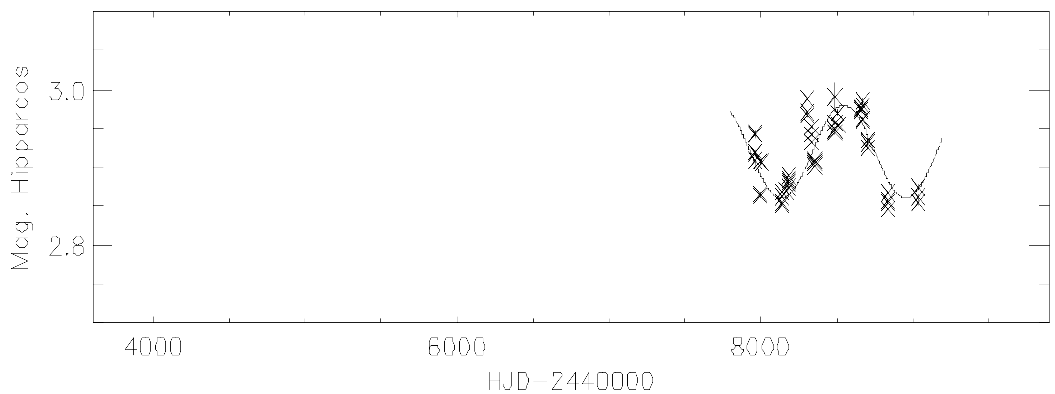
GI2T interferometer





« One-armed » oscillations in the Be Shell star ζ Tau

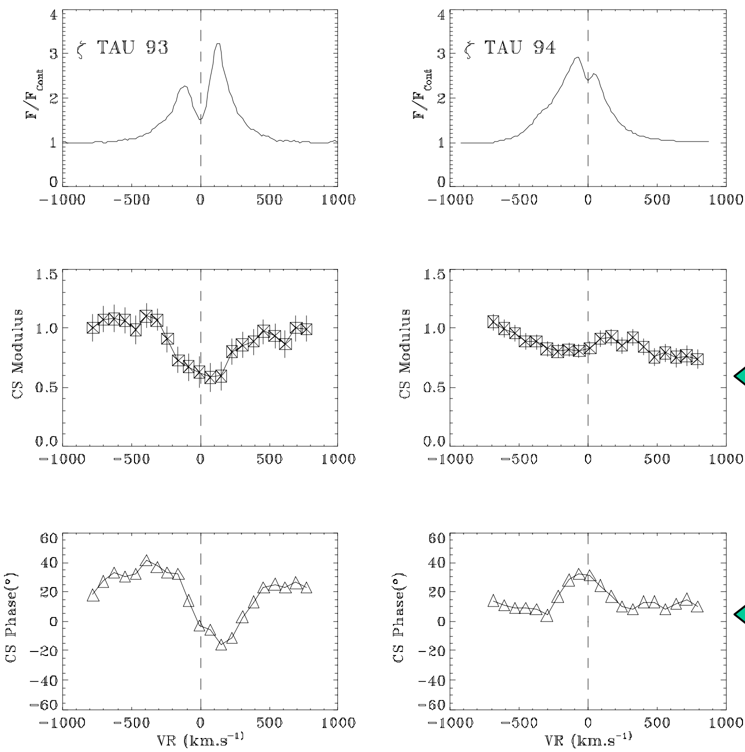




- Long Term Hα Variability of ζ Tau fromGuo et al. (+) and GI2T (Å) Spectroscopy
- Oscillation Curve = Sine Wave Amplifying after 1988, P=3.1 y
- Vertical Dashed Line : Mark III Observations of ζ Tau
- Photometric Data from Hipparcos Mission

Note that the star became brighter just at the V/R minimum corresponding to GI2T observations in November 1993

Interpretation of GI2T observations



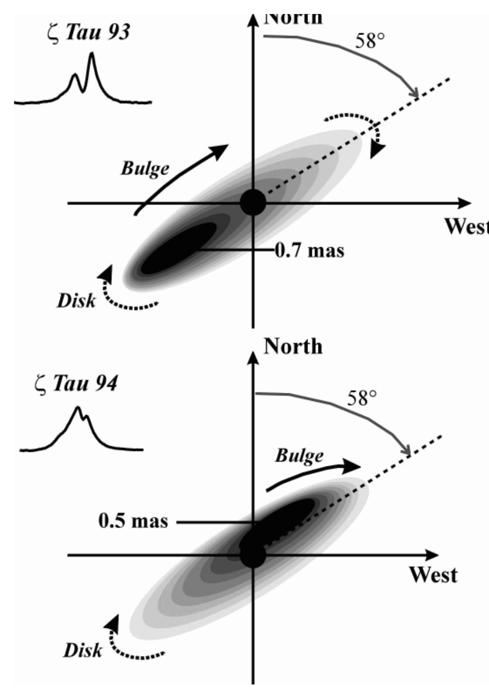
Hα GI2T Profiles Versus Doppler-shift for 93 and 94 Observations of ζ Tau

Fringe Amplitude and Phase Diagrams

:

CS Modulus

CS Phase



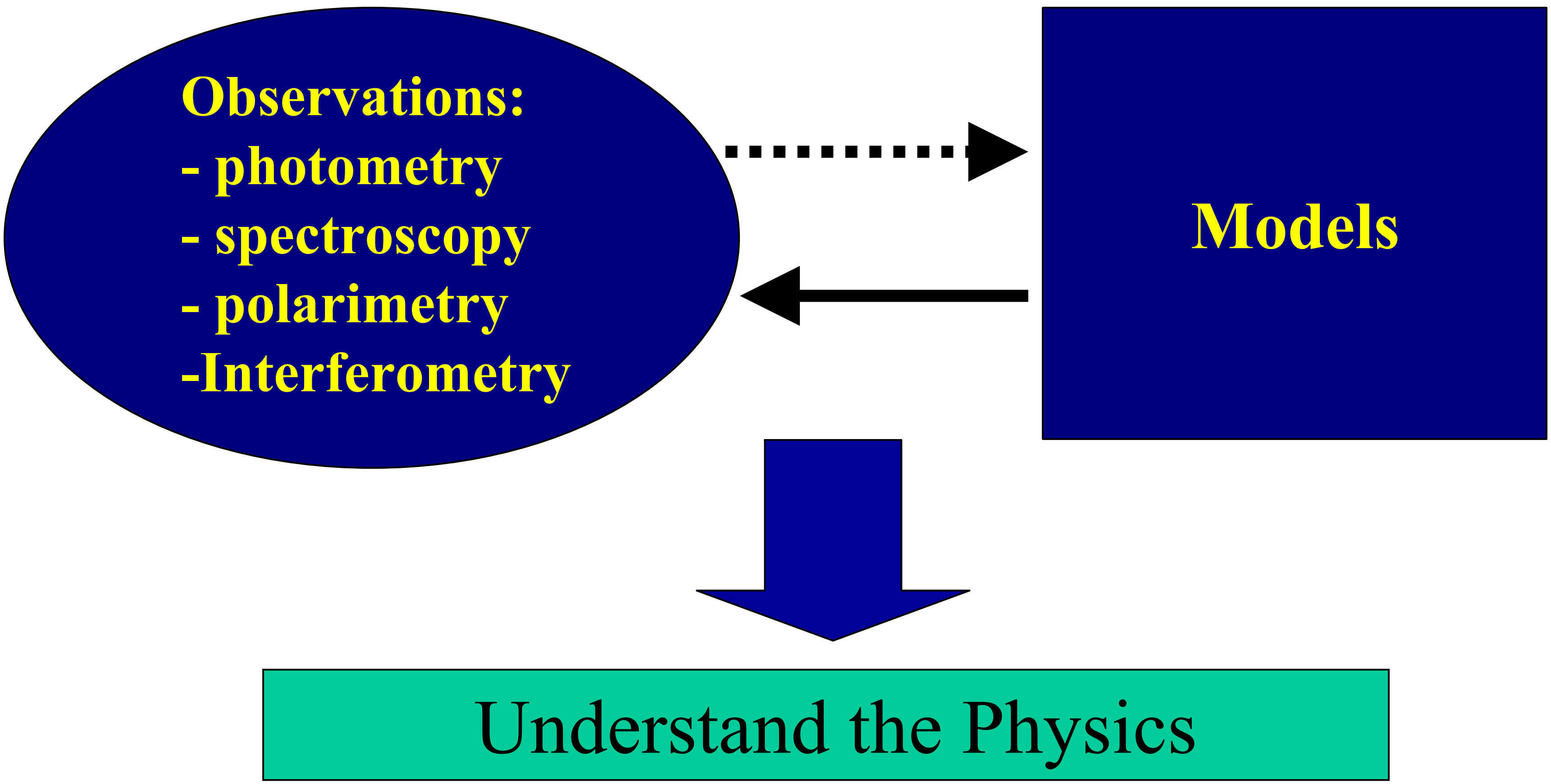
Schematic Representation of ζ Tau Hα long Term Variability According to GI2T.

Nov. 93 : Hα Emission with V/R=0.57 and Originates in a Region of the Envelope whose N-S Projected Position is at 0.7 mas South of the Star

Oct. 94 : V/R=1.26, N-S Projected Position at 0.5 mas North of the Star

Rotation of the Bulge in the Equatorial Disk of ζ Tau

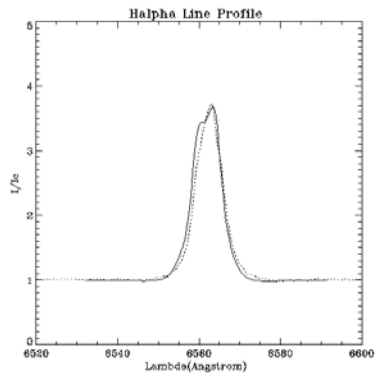
Interferometry needs models...

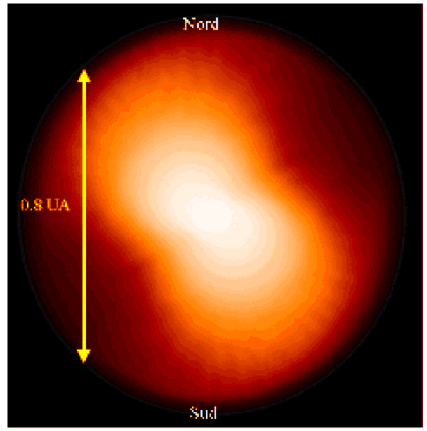


Models need interferometry!

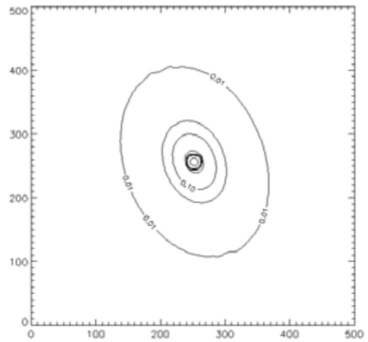
Models: to be quantitative...

Parameters	
Spectral type	B0.5IVe
Effective temperature	25000 K
Mass	16 $M_\odot$
Radius	10 $R_\odot$
Stellar angular diameter	0.45 mas
Luminosity	$3.5 10^4$ $L_\odot$
Vsin i	230 km s^{-1}
Inclination angle i	45°
Results	
Polar terminal velocity	2016 km s^{-1}
Polar mass flux	$1.7 \cdot 10^{-9}$ $M_\odot$ yr^{-1} sr^{-1}
Equatorial terminal velocity	200 km s^{-1}
Equatorial mass flux	$5.1 \cdot 10^{-8}$ $M_\odot$ yr^{-1} sr^{-1}
Mass loss rate	$3.2 \cdot 10^{-7} M_\odot$ yr^{-1}
Hα major axis	17 stellar radii
Hα oblateness	0.72
Hα extension	4 mas
Mass of the disk	$6.4 \cdot 10^{-8}$ $M_\odot$



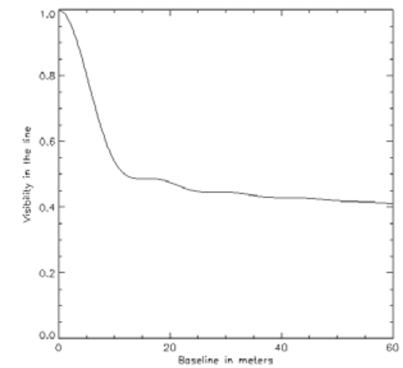


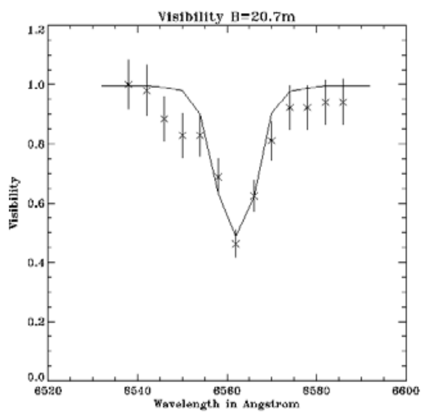
Map in spectral line



Map in continuum

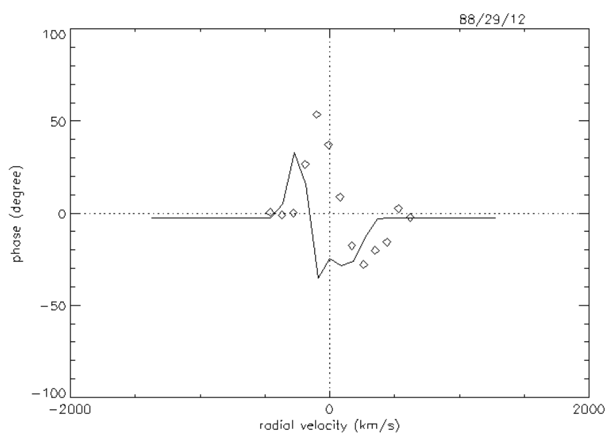
Line profile

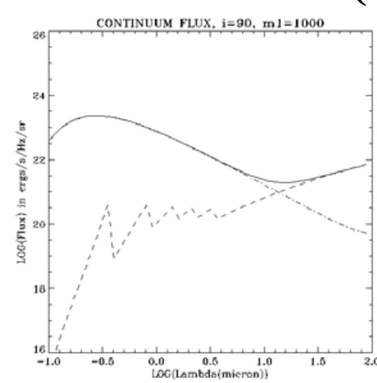




V=f (B)

V=f (λ)

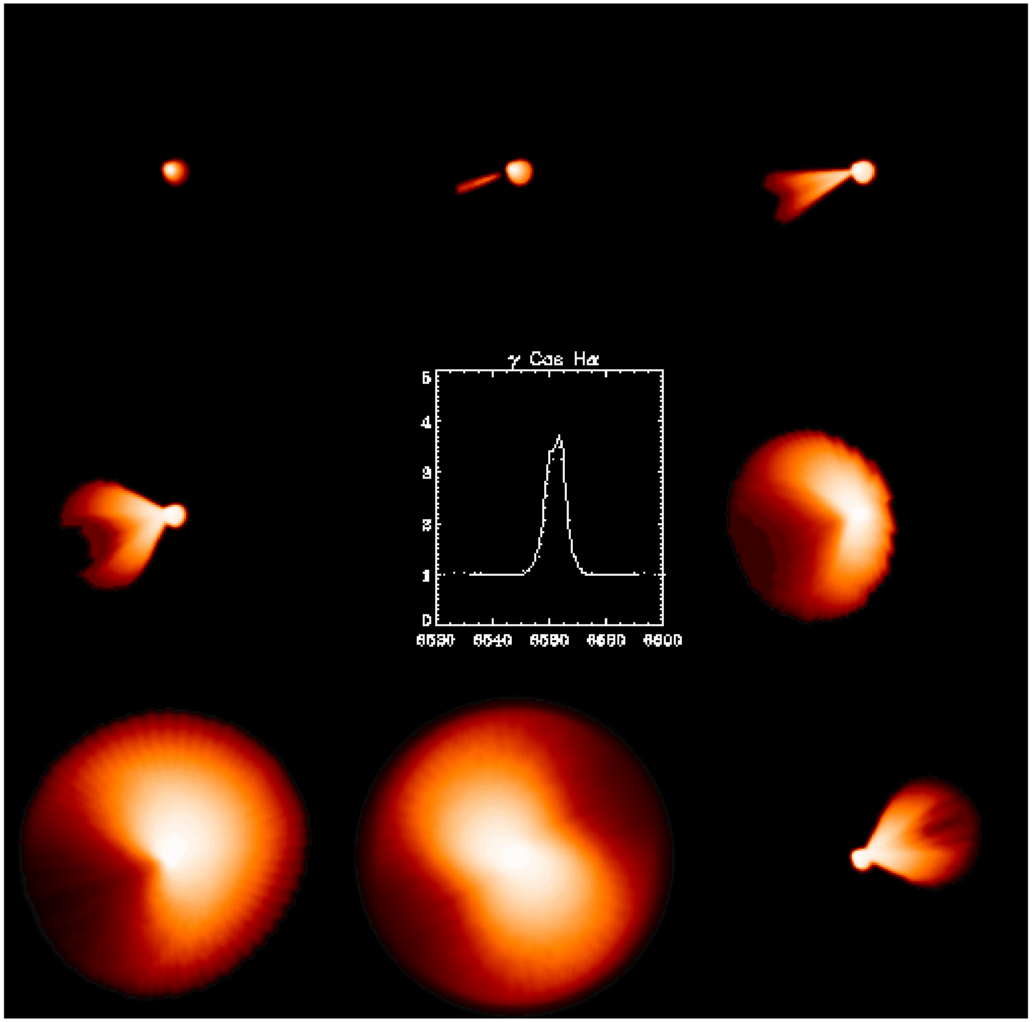




Phase = f(λ)

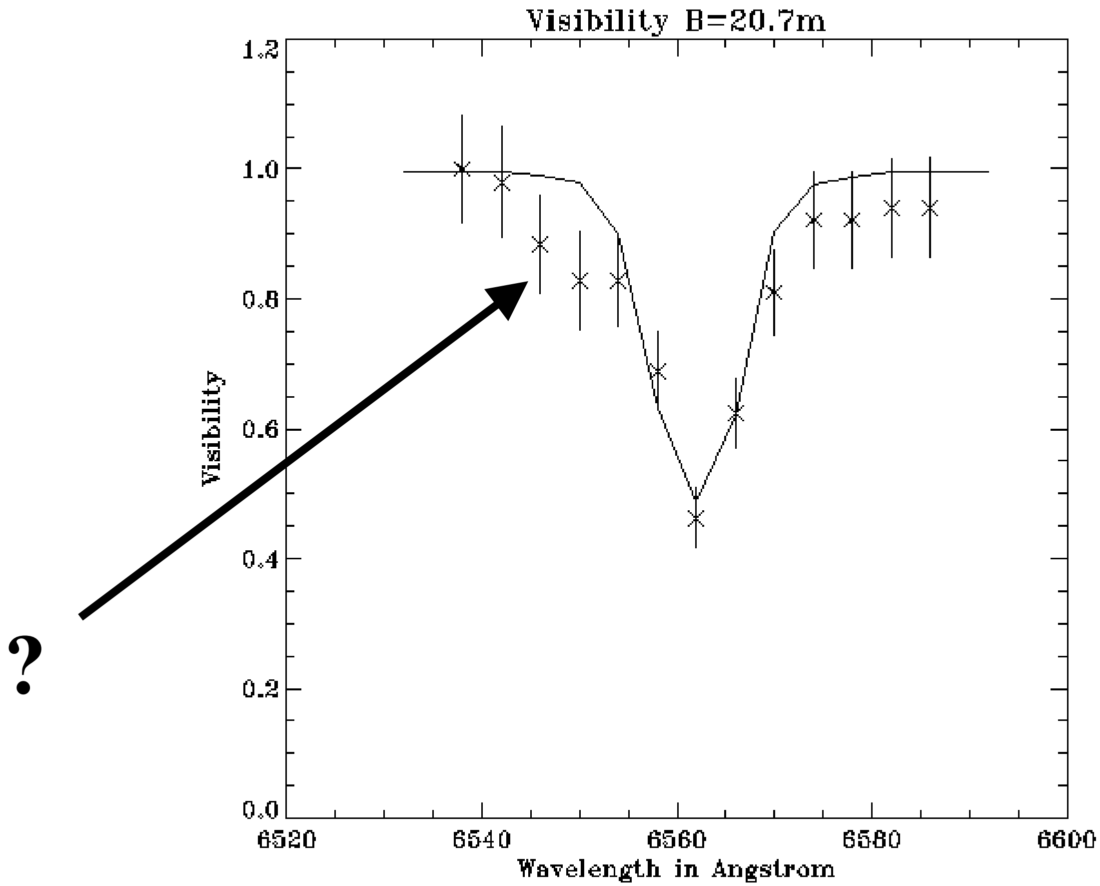
Energy distribution

γ Cas across Hα line profile



Stee et al. 1995, A&A, 300, 219

Can HARO put constraints on these maps ?



X : GI2T data

: model

Stee et al. 1995, A&A, 300, 219

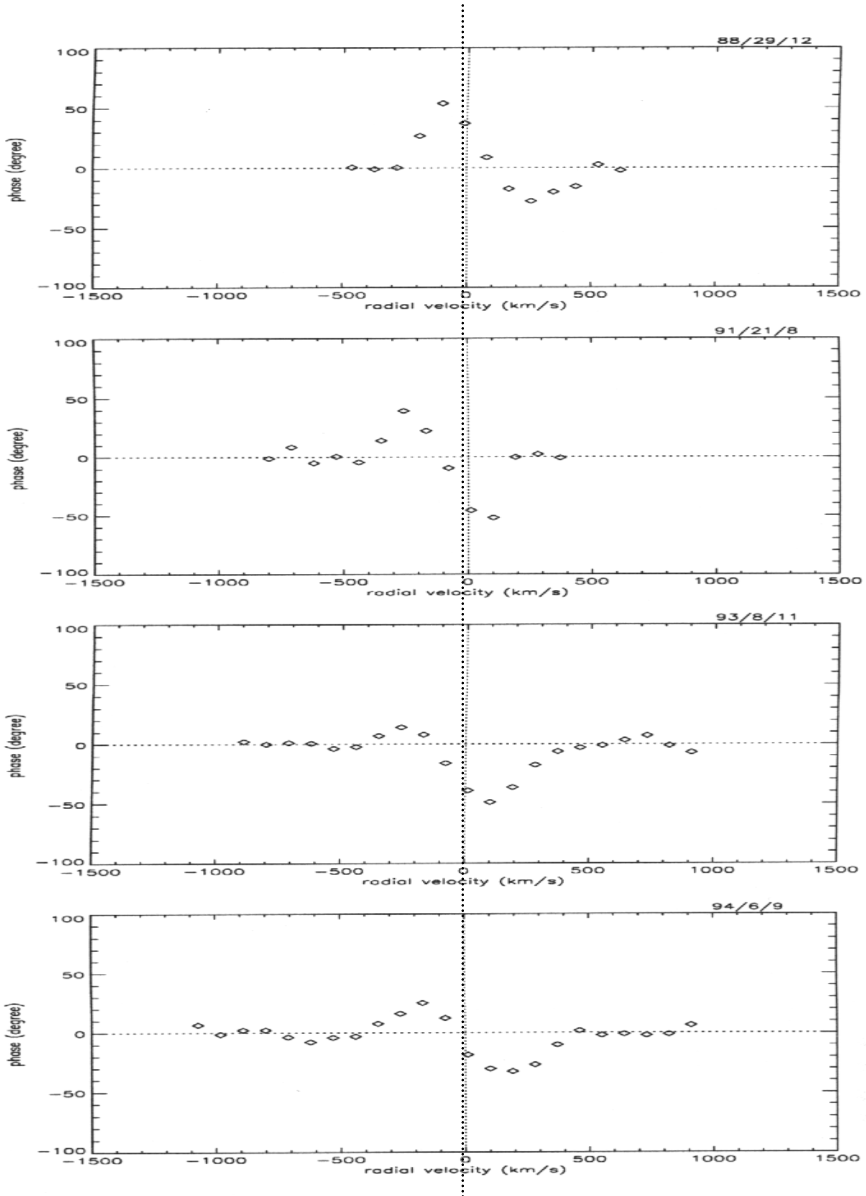
γ Cas « one-armed » oscillations: $\phi = f(t)$

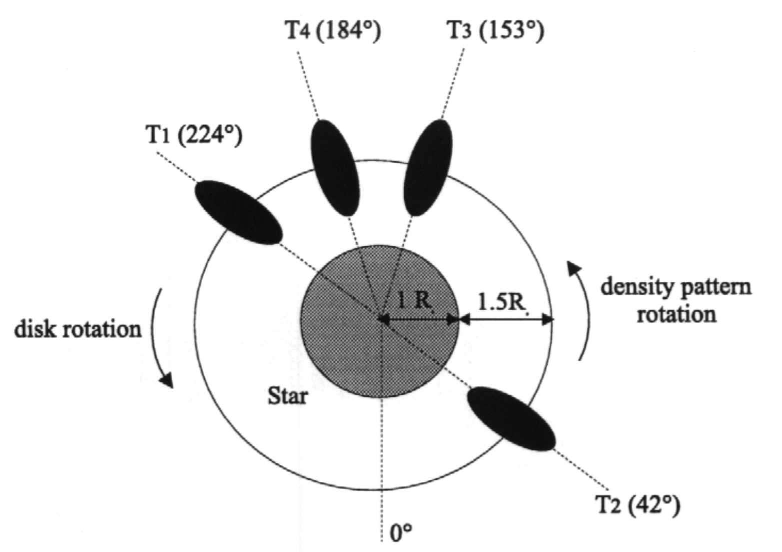
88
V>R

91
V<R

93
V<R

94
V<R

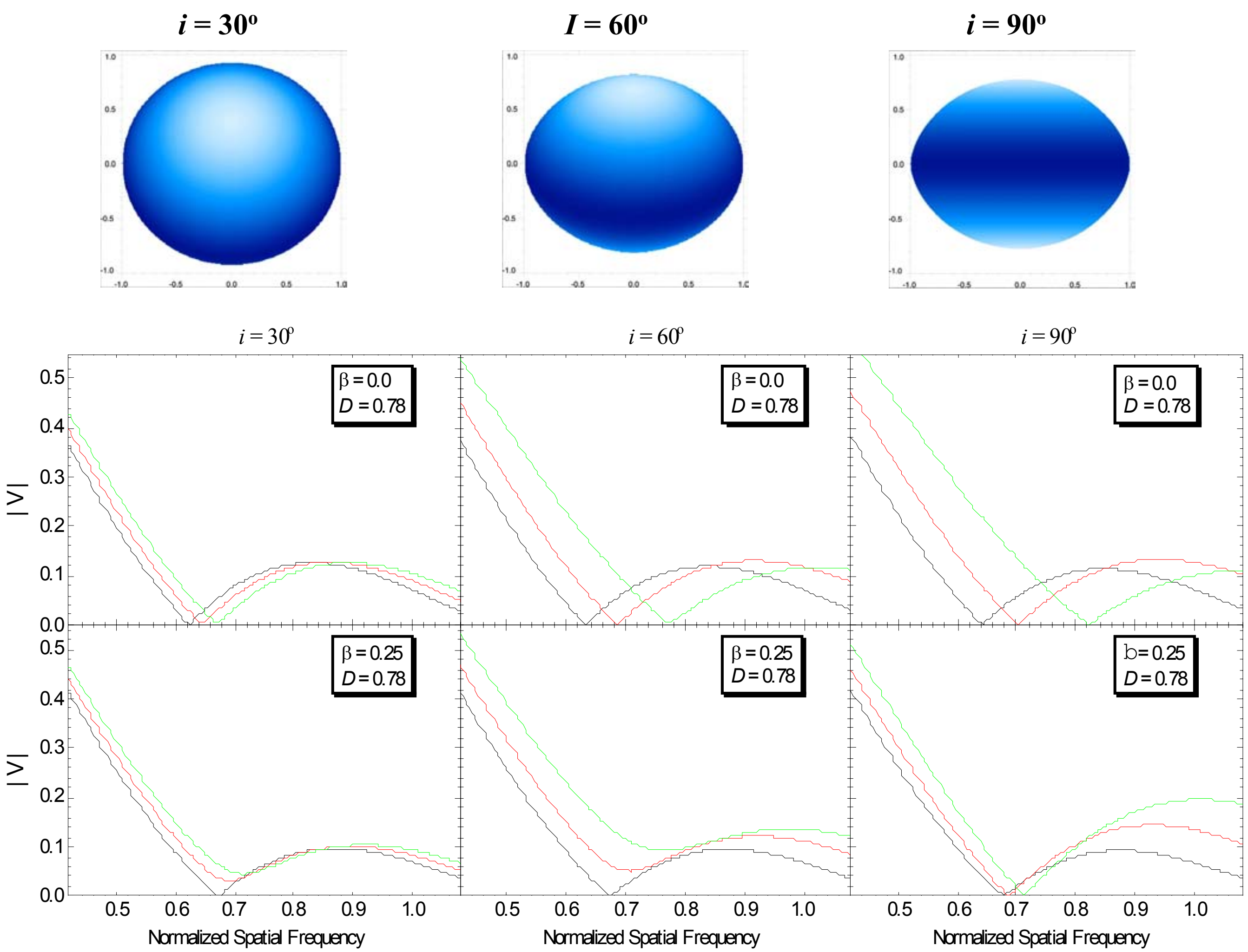




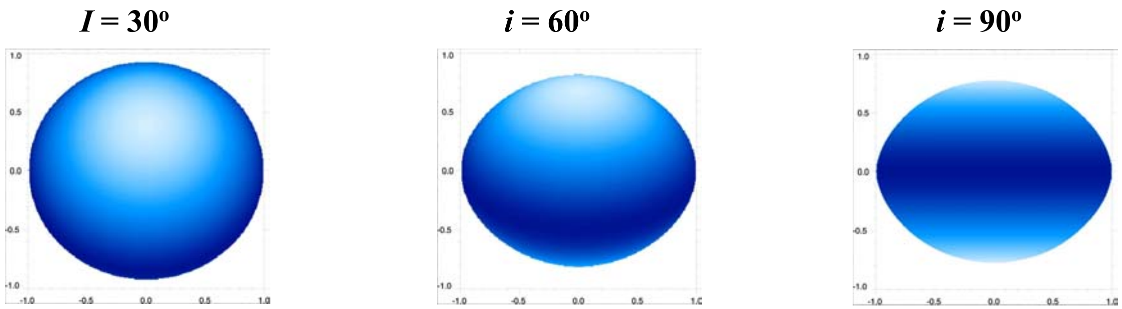
High density pattern in γ Cas equatorial disk

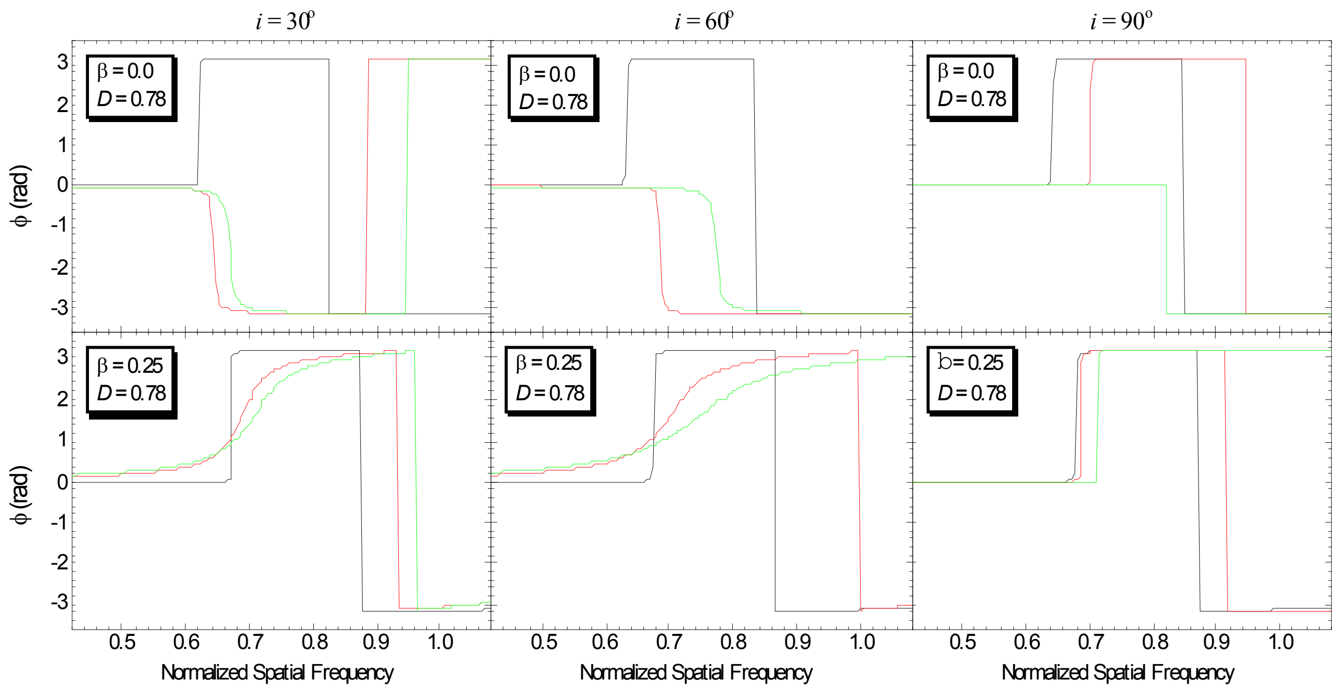
Berio et al. 1999, A&A, 345, 203

Stellar rotation |v|=f(B)



Stellar rotation $\phi = f(B)$





Differential interferometry

- Very accurate
- High precision
- Access to very small detail ï µas
- Put very strong constraints

-Difficult to interpret
-Be careful with resolved objects
-Need models