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Kiepenheuer-Institut
für Sonnenphysik

Hydrogen lines in Mira stars through interferometry and polarimetry

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Titre:

Étude spectropolarimétrique des étoiles variables de type Mira

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O.C.A. 30 Sept. 2011

Rapport sur le mémoire de thèse intitule:
Etude spectropolarimétrique des étoiles variables de type Mira

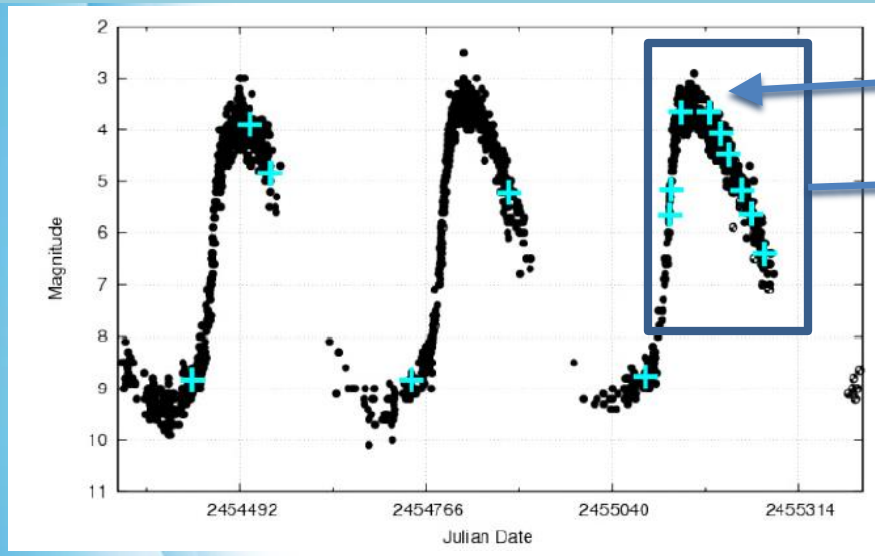
J'ai apprécié la lecture du chapitre 5, qui aborde les différentes hypothèses sur le processus à l'origine de la polarisation. J'ai aussi apprécié la perspective ouverte par ces observations. Bien sûr, en tant qu'interférométriste, je n'ai pas pu résister au plaisir de lire les perspectives et la demande VLTI dans ce domaine. Je pense que la demande pourrait être fortement améliorée si elle se basait de manière directe sur le travail de Nicolas, c'est-à-dire sur la détection d'un signal dans une raie et non dans une bande large. L'instrument AMBER du VLTI offre une résolution spectrale intéressante (R=12000) qui est accessible pour ces étoiles extrêmement brillantes, et des observations très similaires à celles présentées dans cette thèse pourraient être conduites. Cet exemple montre que cette thèse ouvre plusieurs voies d'investigations prometteuses.

- Atmospheric shocks in Mira stars
- Spectropolarimetry
- Interferometry
- Shocks and stellar activity

Atmospheric shocks in Mira stars

Emission lines of hydrogen are one of the most conspicuous features in Mira stars' spectra

Several studies have established that they are produced by hypersonic radiative shock waves



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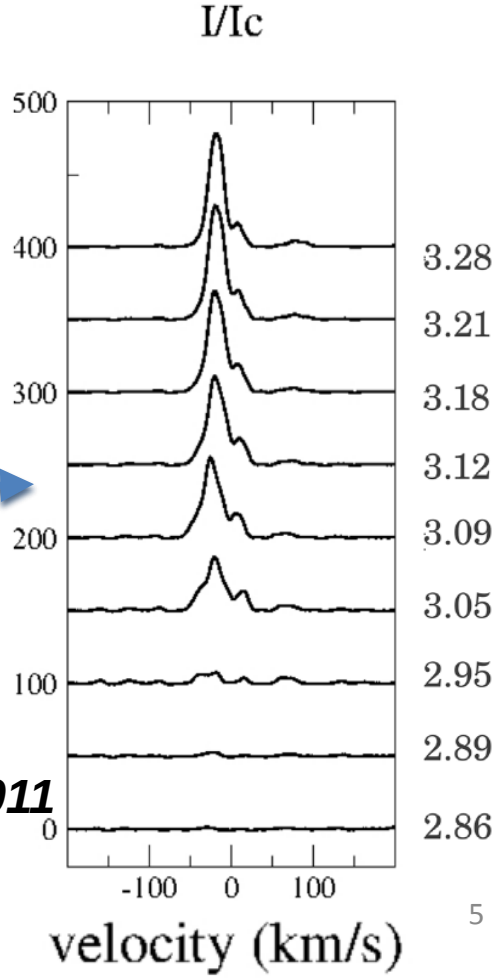

Fabas et al 2011

AAVSO light curve for **omicron Ceti**

Atmospheric shocks in Mira stars

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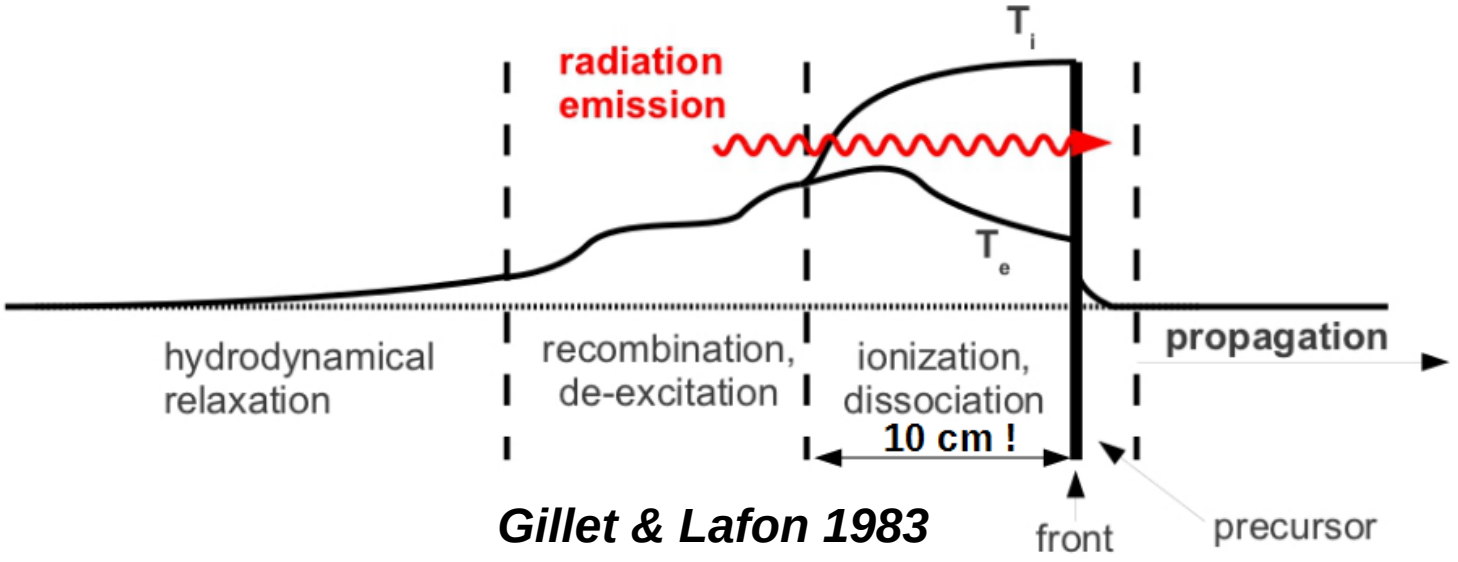


Gillet & Lafon 1983

Spectropolarimetry

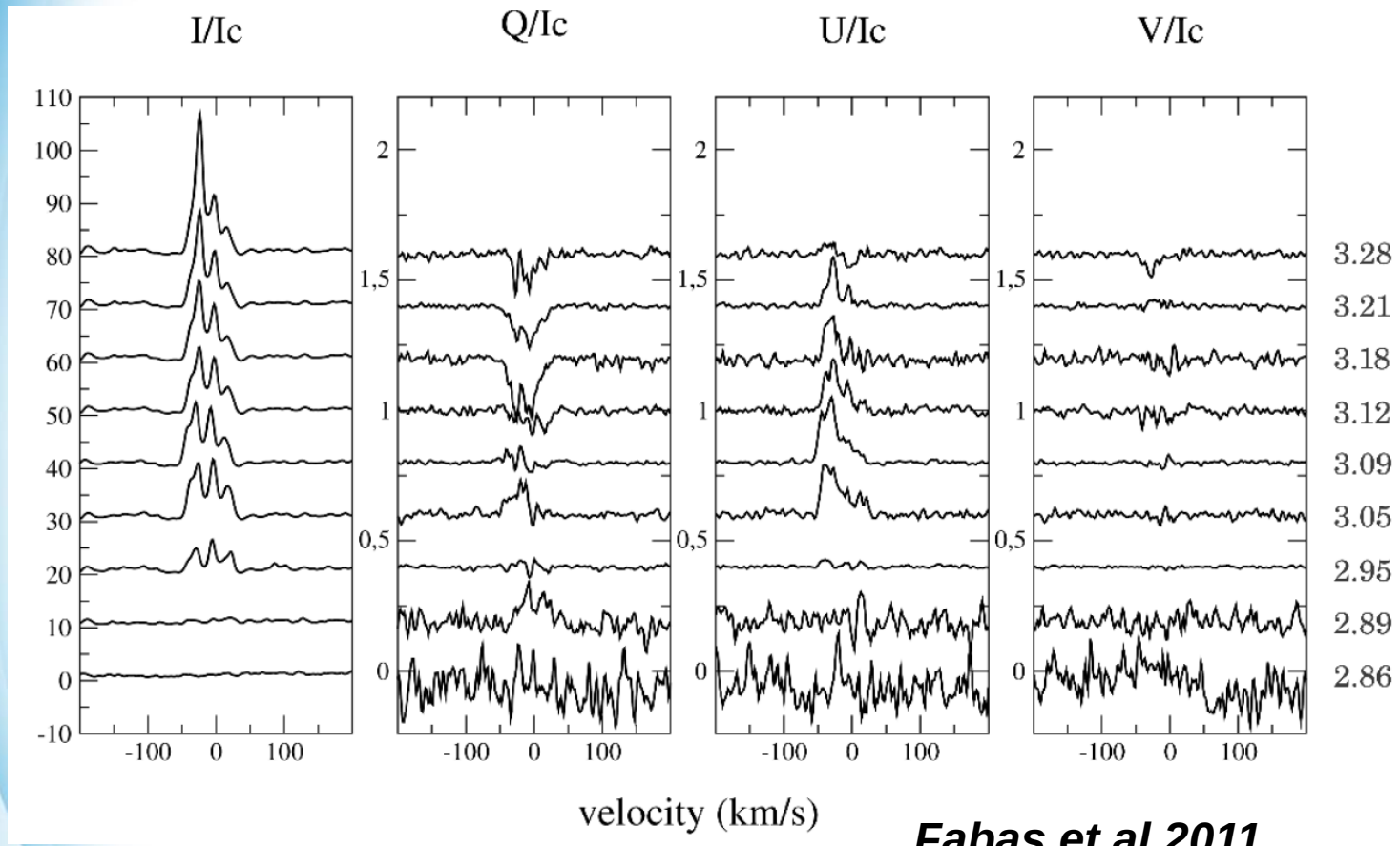
- In Fabas et al. 2011, we presented a spectropolarimetric survey on these lines with NARVAL@TBL on omicron Ceti.
- TBL is a telescope at Pic du Midi, France and NARVAL is a spectropolarimeter

Telescope type	Cassegrain
Spectral resolution	R=68000
Spectrograph type	Echelle (40 orders)
Spectral range	380 to 1100 nm

Full Stokes: both linear (Stokes Q and U) and circular (Stokes V) polarization measured

Spectropolarimetry

Omicron Ceti (H alpha represented here)

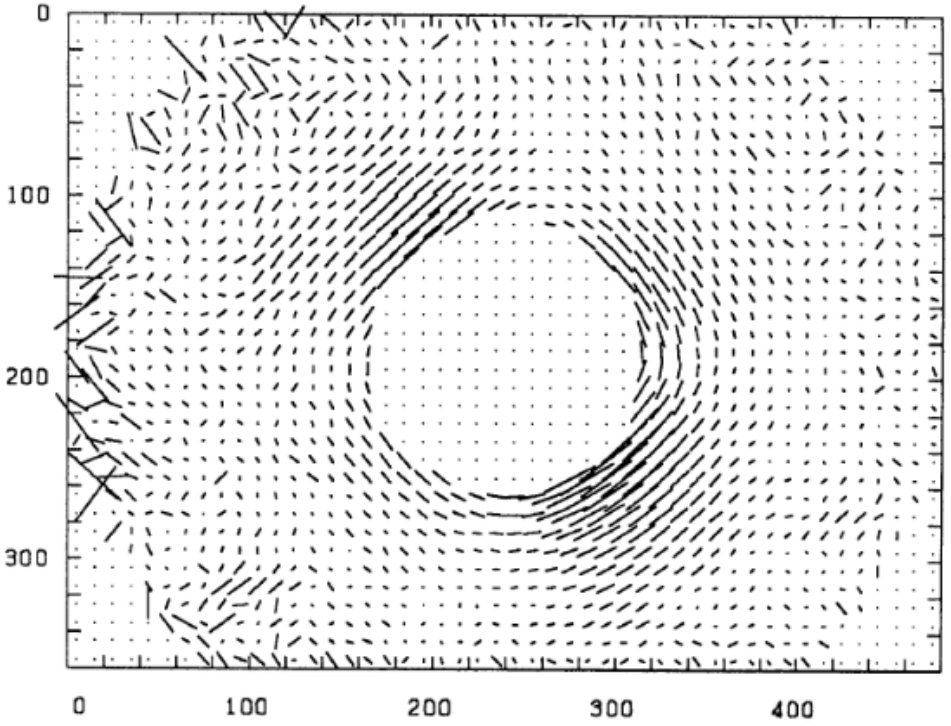


Fabas et al 2011

Spectropolarimetry

Linear polarization induced by atmospheric scattering

For non-resolved stars: cancellation of global linear polarization if no departure from spherical symmetry (such as a flattened atmosphere, clumps…)



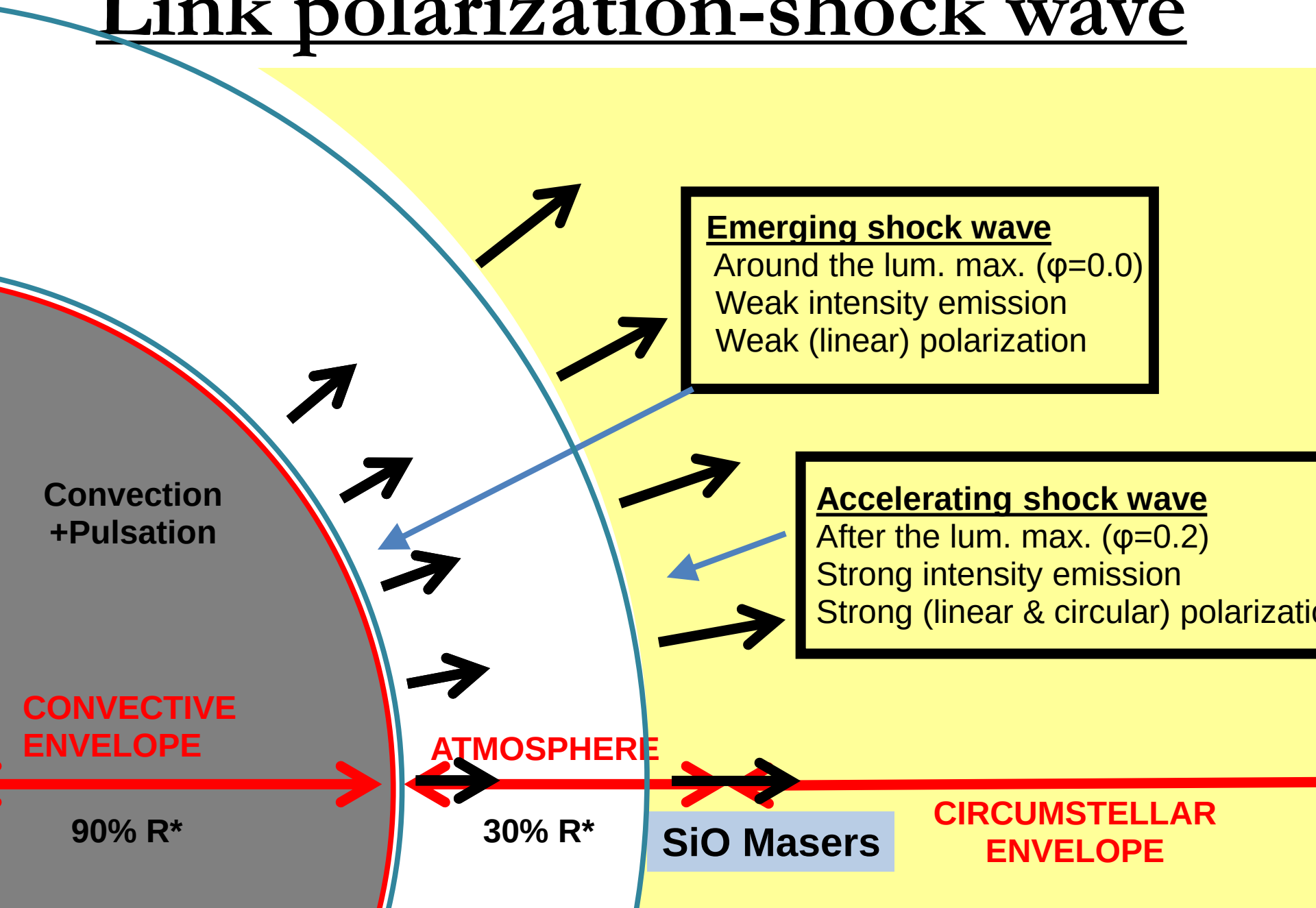
Linear polarization in solar corona (Tanabe et al. 1992)

Spectropolarimetry

- Since we observe a non-null linear polarization in Balmer line → departure from spherical symmetry
- Linear polarization structure changes with time → evolution of the shock's geometry with time

Polarizing mechanism potentially intrinsic to the shock wave
(results published in Fabas et al. 2011)

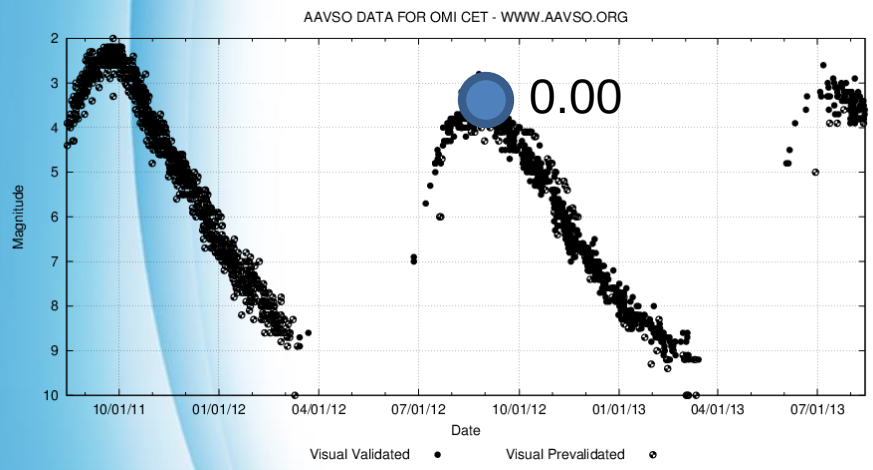
Link polarization-shock wave



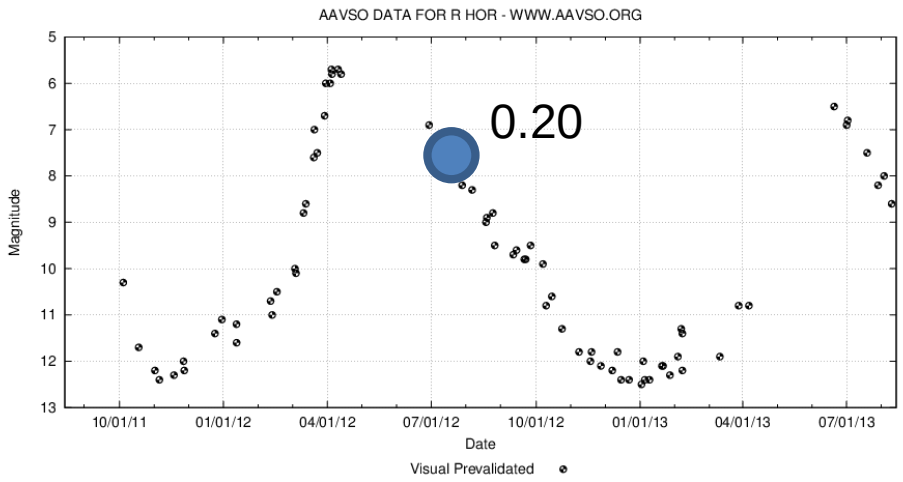
Interferometry

2012: observations of omicron Ceti and R Hor with AMBER

Station	Omicron Ceti	R Hor
A1-G1-I1	4	0
A1-I1-K0	4	1
D0-H0-I1	0	7
A1-C1-D0	6	4



Omicron Ceti

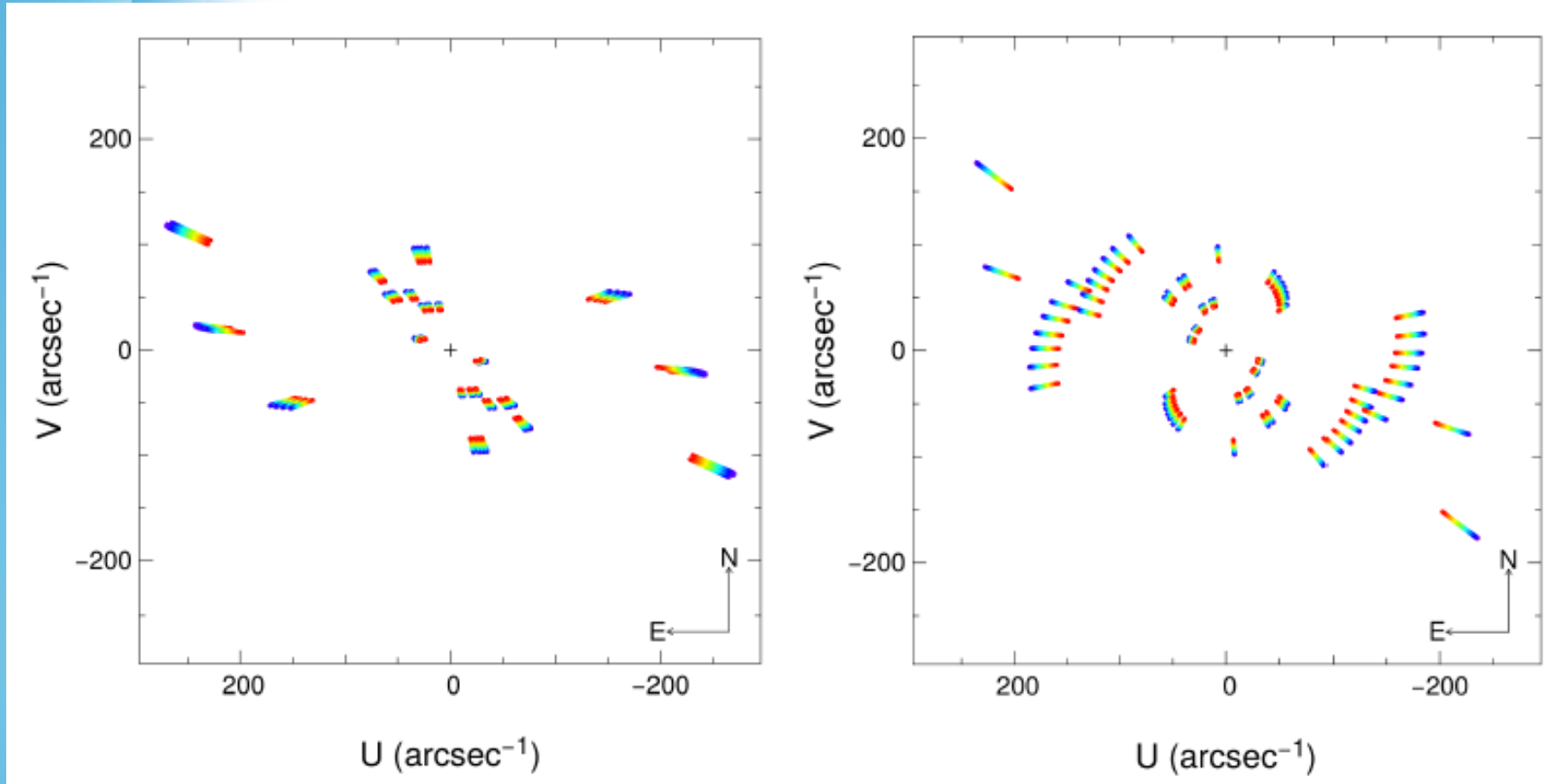


R Hor

Interferometry

2012: observations of omicron Ceti and R Hor with AMBER

u-v plane coverage



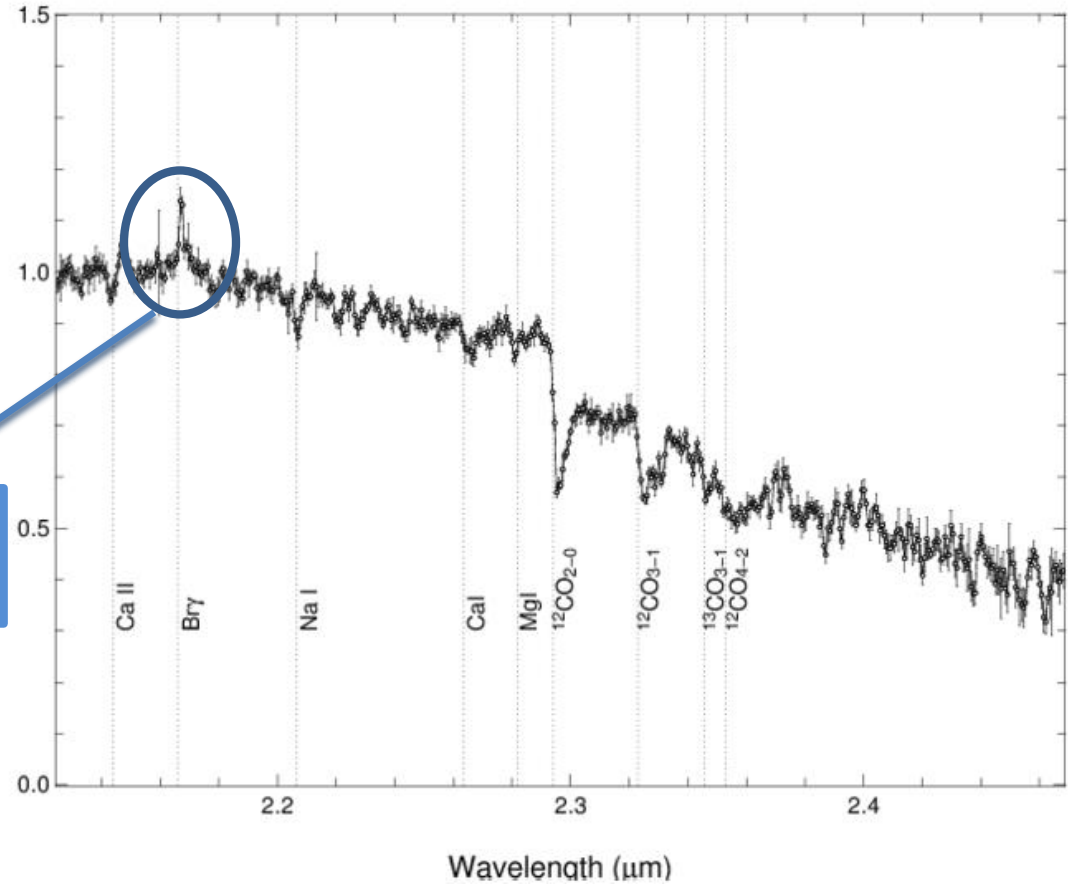
Omicron Ceti

R Hor

Fabas et al 2015 (in prep.)

Interferometry

observations of omicron Ceti : median spectrum

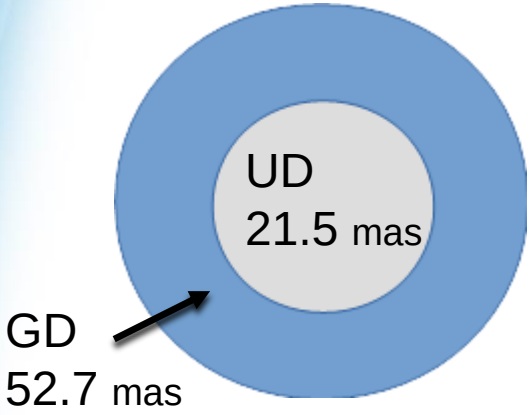


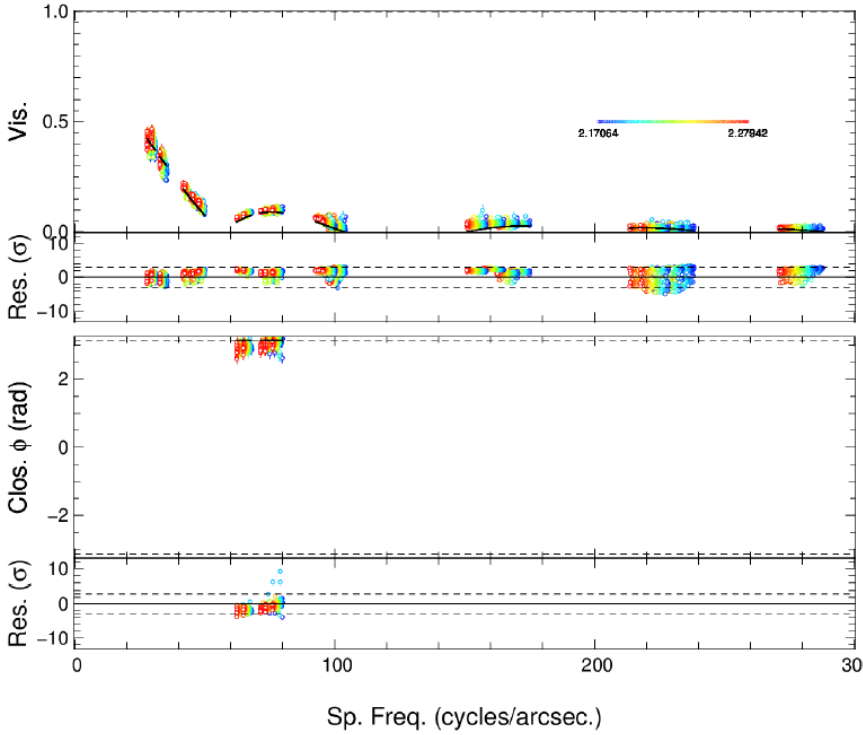
Brγ in emission !

Fabas et al 2015 (in prep.)

Interferometry

Vis2(sp.freq.) and ϕ(sp.freq.)





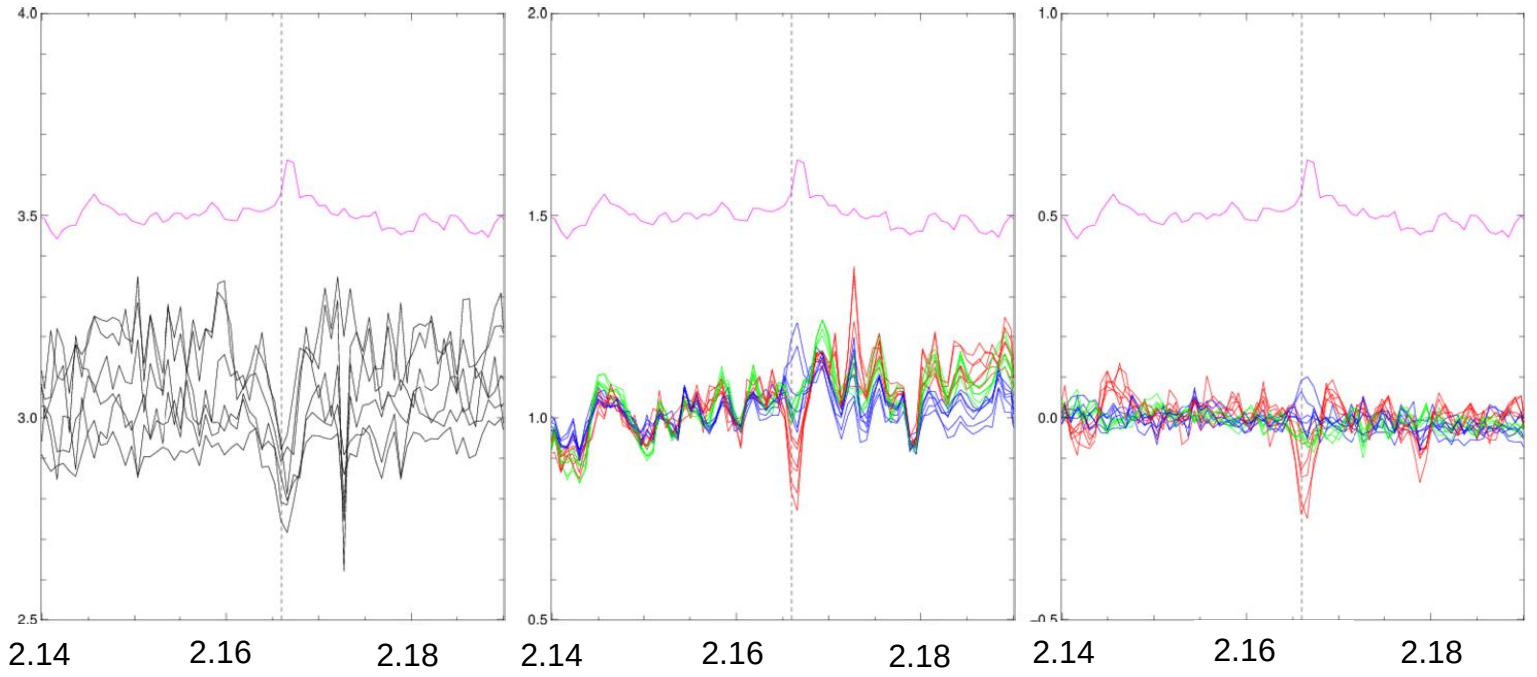
Coloured line: observations
Black line: model

Omicron Ceti

Fabas et al 2015 (in prep.)

Interferometry

Median spectrum
+
ϕ(λ), vis2(λ) and diff. phases (λ)



Departure from sphericity around Brγ

Fabas et al 2015 (in prep.)

Shocks and stellar activity

Discussion

We have a shock-induced source for the alteration of sphericity

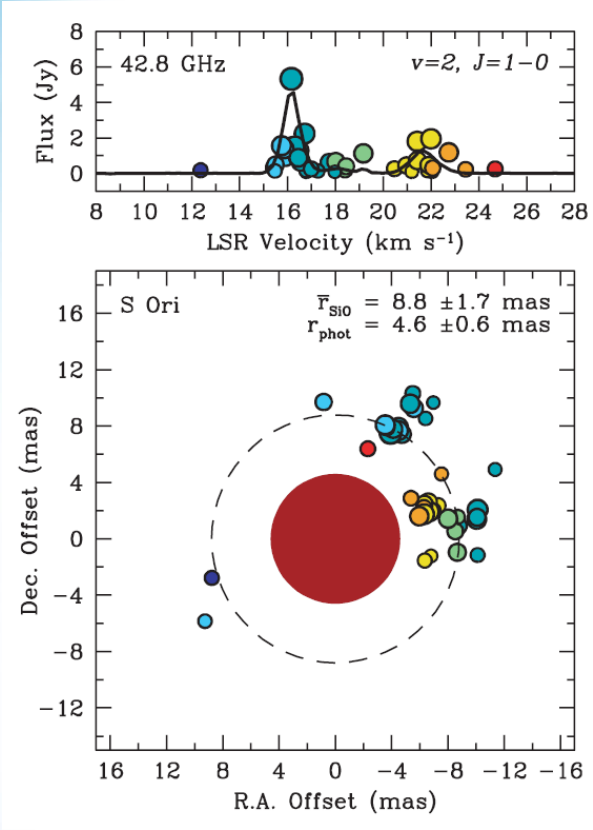
Other studies point at the interaction of the shock with a global surface magnetic field, more specifically through **amplification** (Lebre et al. 2014 and Hartquist & Dyson 1997, introducing a Parker instability) and **reconnection** (Soker 2002)

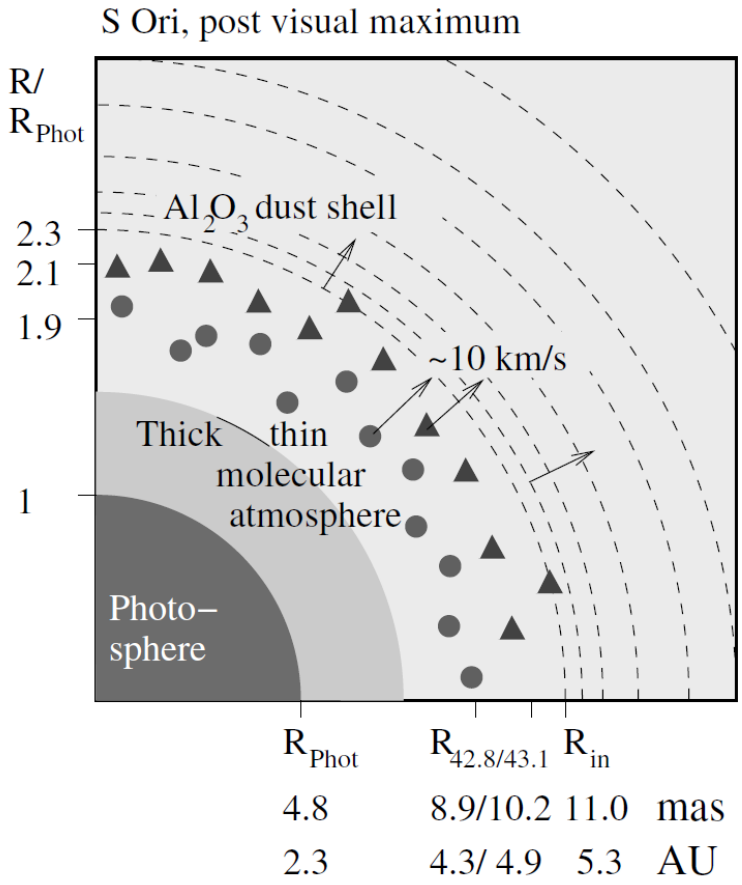
SiO masers produced in clumps in the circumstellar atmosphere are likely to be enhanced by the passage of the shock

→ **Shock-induced chromospheric activity**

Shocks and stellar activity

Joint observations Infrared/radio → mol. shells and SiO masers





Boboltz & Wittkowski 2005

Wittkowski et al. 2007

Conclusions

- **Asphericity** necessary to explain global linear polarization
- Hydrogen lines are used to trace the propagation of the shock → **polarization is shock-induced**
- Through interferometry, we observe an (extra?) asymmetry in an hydrogen line with respect to the pseudo continuum
- This could lead the way to further **joint observations between polarimetry and interferometry** to characterize the evolution of the shock in time and how it could allow to study **magnetic fields in Mira stars**

Thanks !