VEGAS Workshop

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Polarimetric Perspective for Mira Stars with VEGAS

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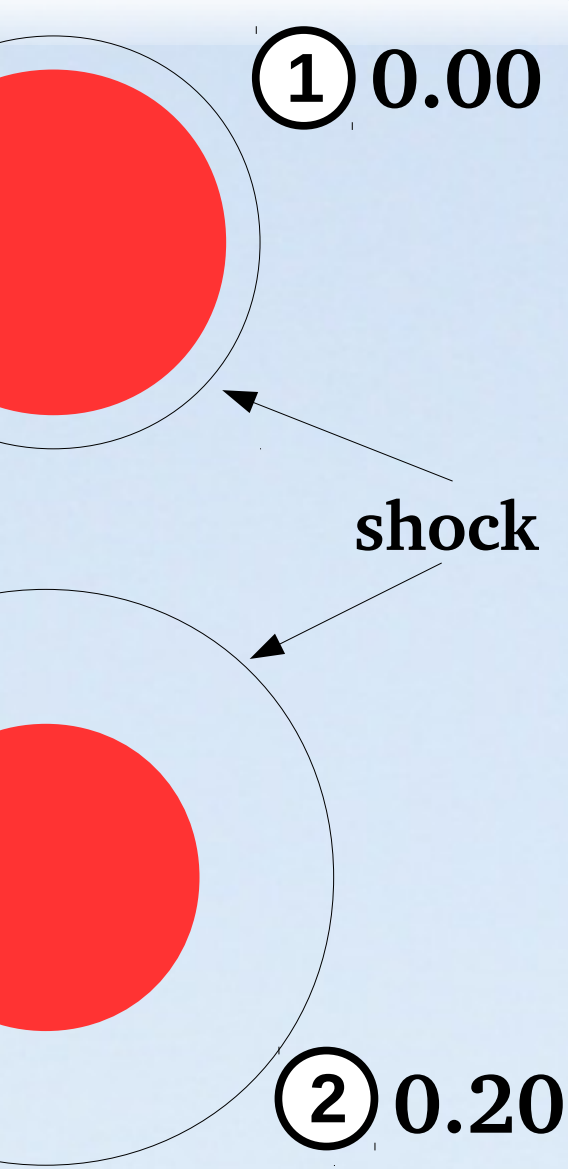
Outline

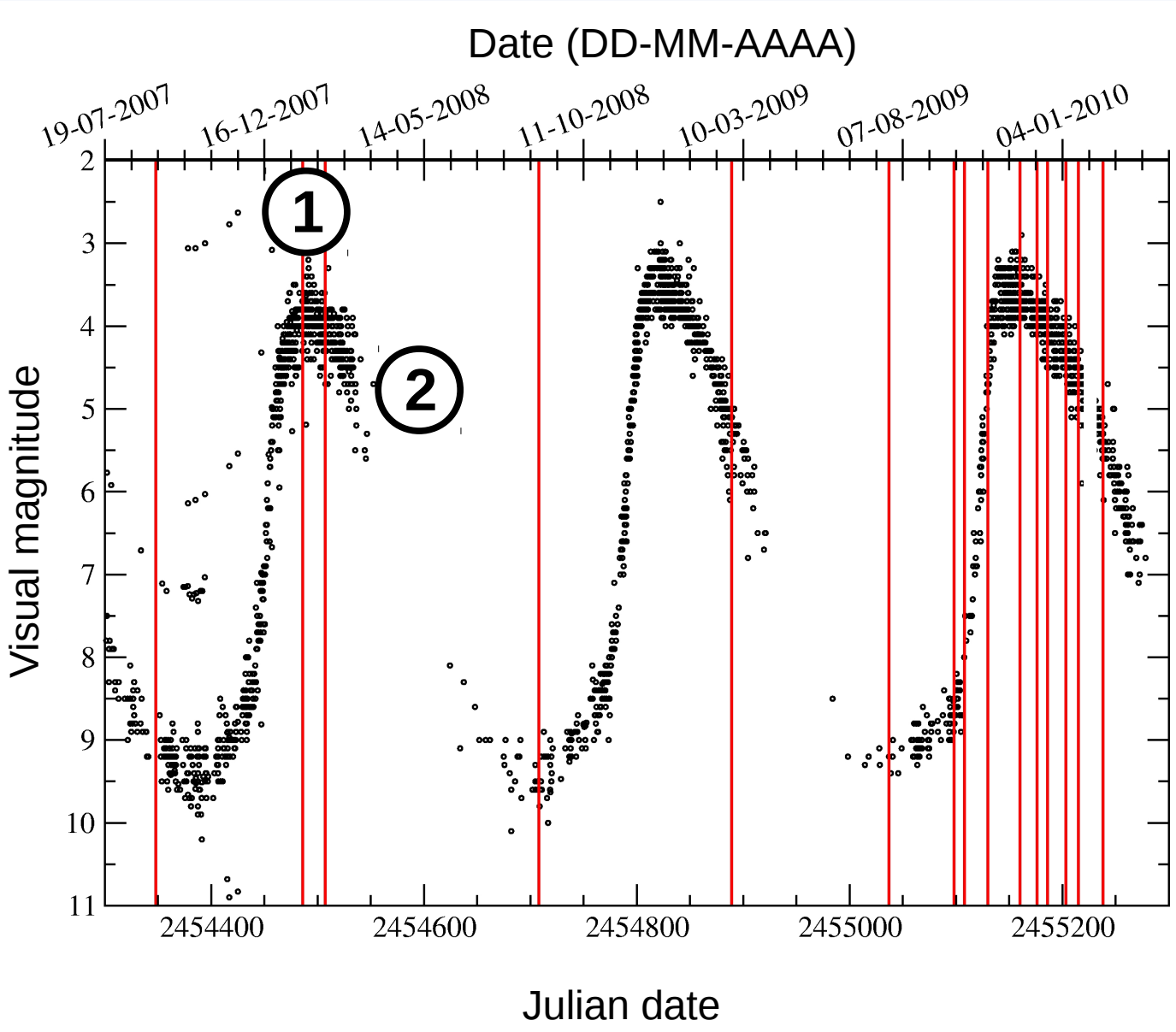
1. Spectropolarimetry of Mira stars
2. Origin of the polarization
3. Modelization
4. Investigation with AMBER
5. Prospects with VEGAS
6. Global Project
7. Summary

1- Spectropolarimetry of Mira Stars

- Observations of several Mira stars (mainly omicron Ceti) during time
- Focus on the Balmer lines
- Propagation of the shock waves
- Polarization related to the shock

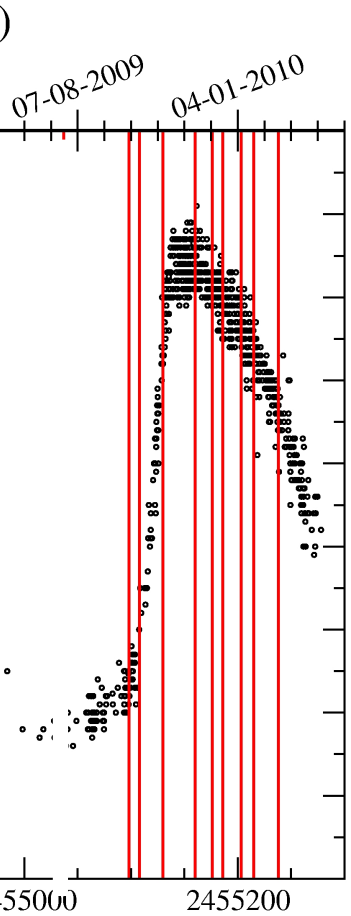
Spectropolarimetric observations of omicron Ceti with NARVAL

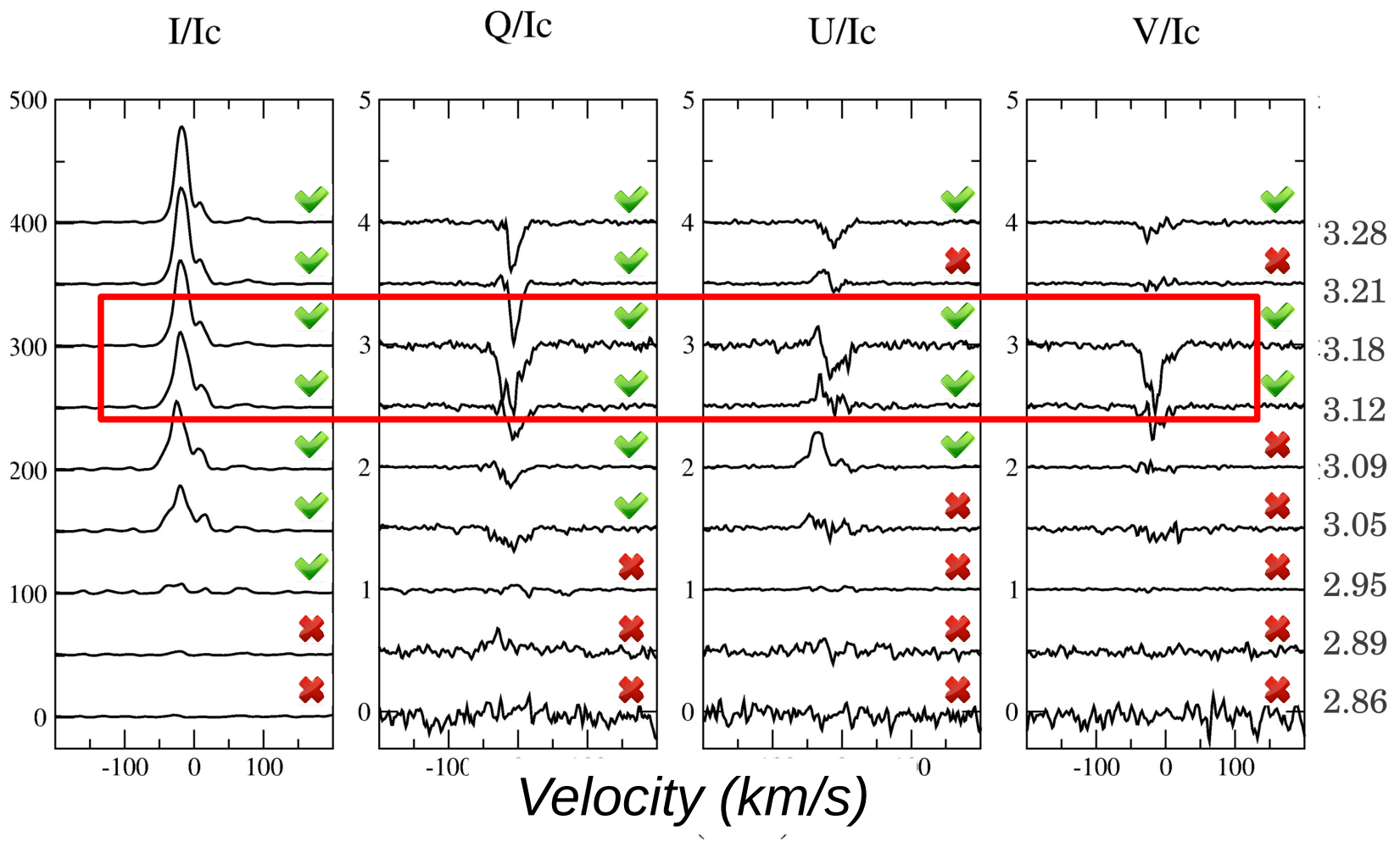




Light curve : July 2007 to February 2010 (AAVSO)

3rd cycle : Hδ





- Polarization **increases** when the shock propagates outwards and accelerate and is mainly **linear**
- Angle of linear polarization **not constant** in time

2- Origin of the polarization

Polarization in spectral lines likely due to scattering of light on the atmospheric particules, when the incoming radiation field is anisotropic.
(see e.g. *Manso Sainz & Trujillo Bueno 2011*)

When a weak magnetic field (<1G) is present, it induces a depolarization and a modification of the angle of linear polarization: this is the Hanle effect.

2- Origin of the polarization

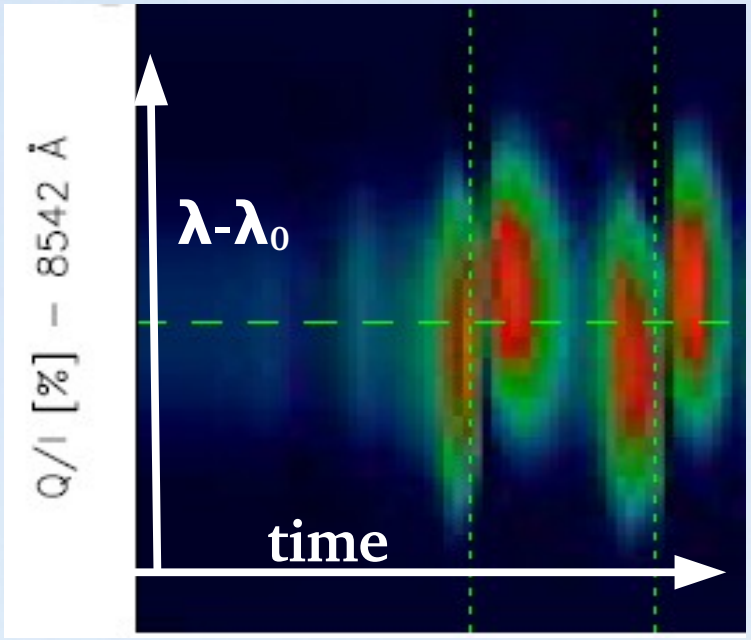
Velocity gradients

→ effect on the anisotropy of the radiation field

→ shocks can produce line polarization

(Carlin et al 2012, 2013)

work on the chromospheric lines of Ca on the Sun



CaII 8542 Å, Stokes Q, Sun's chromosphere

2- Origin of the polarization

Global asymmetry

Low gravity induces large convective cells
(Schwarzschild 1975)

↓

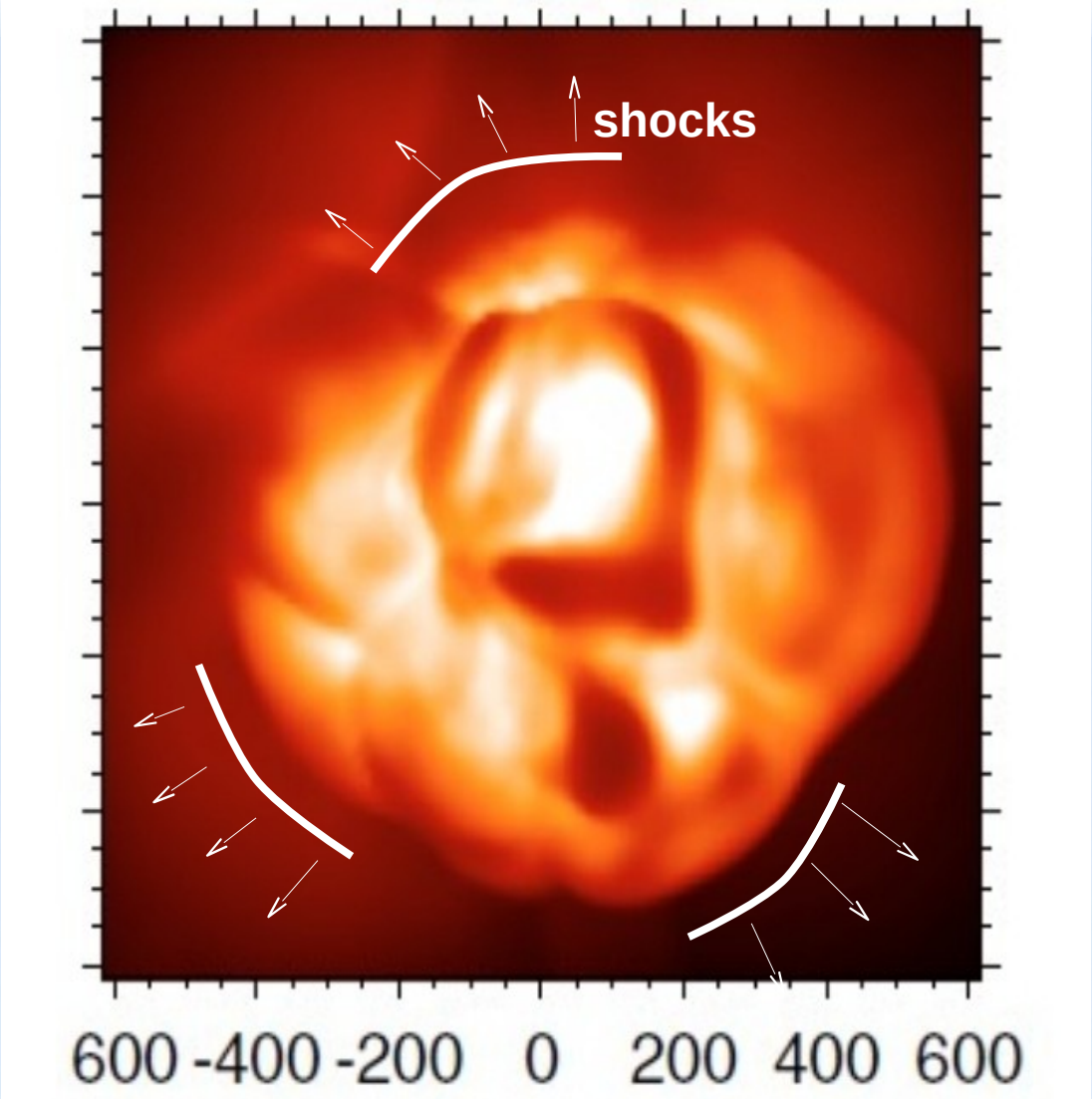
Shocks induced by large convective cells

↓

Production of a global asymmetry

↓

Global polarization

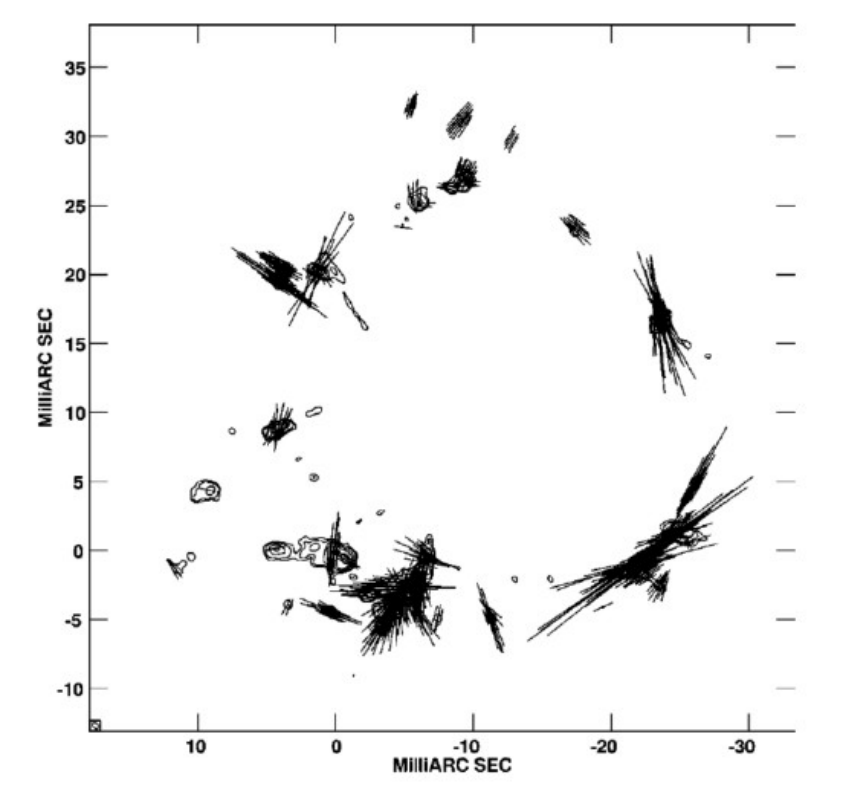


Convective surface of an AGB star
(3D simulation, bolometric intensity map, distance in solar radii, *Freytag & Höfner 2008*)

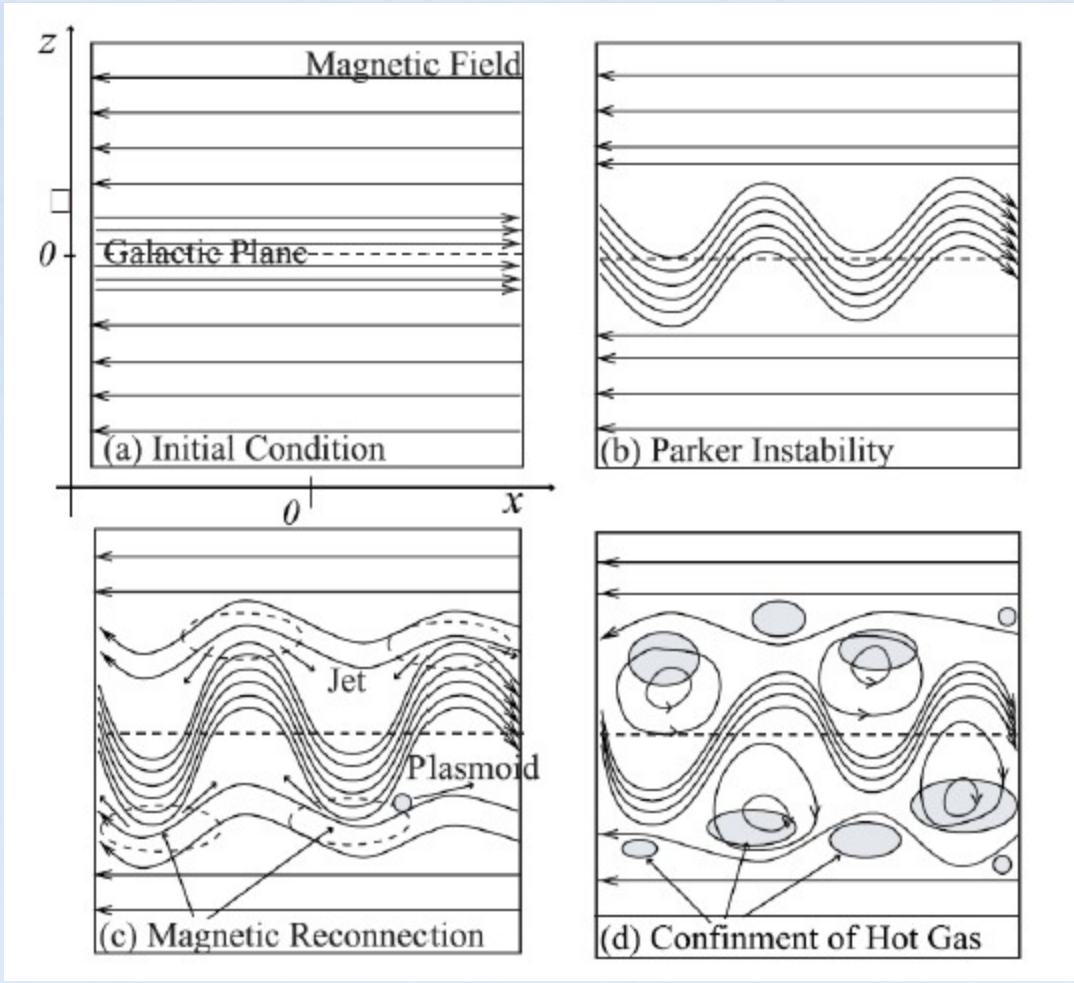
2- Origin of the polarization

Clumps

Hartquist & Dyson (1997) :
Shock-induced Parker instability



Masers in the clumps of TX Cam (+polarization) Kemball & Diamond 1997



The Parker instability (Galactic Case) Tanuma et al. 2003

3- Modelization

Input: Synthetic atmospheric profile

Hydro code for extended atmospheres dynamics adapted for Mira (*A. Fokin, see e.g. Fokin 1990*)

- No piston
- Spherically symmetric

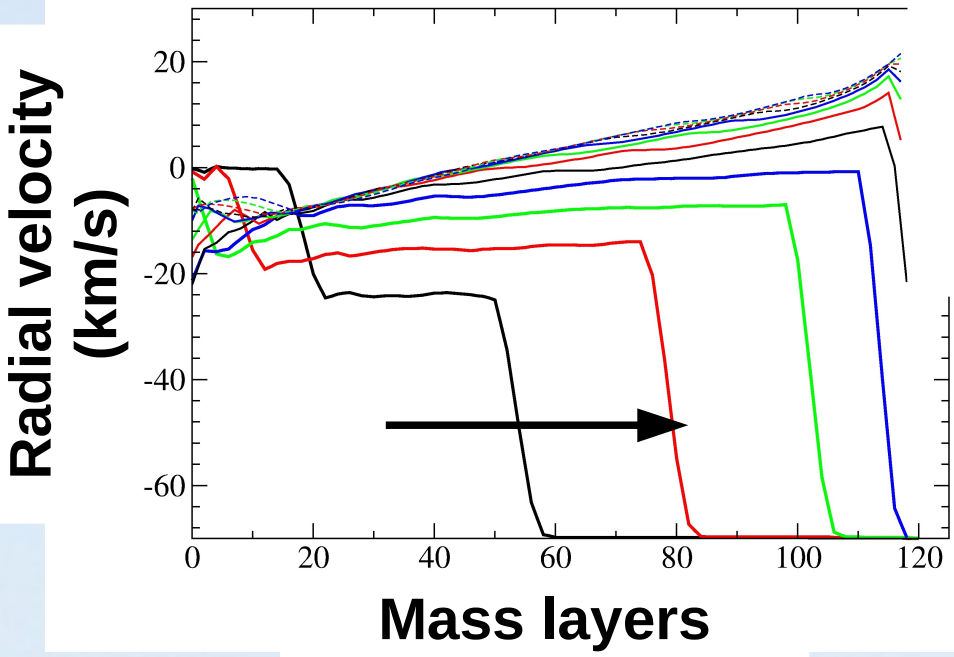
Stellar parameters:

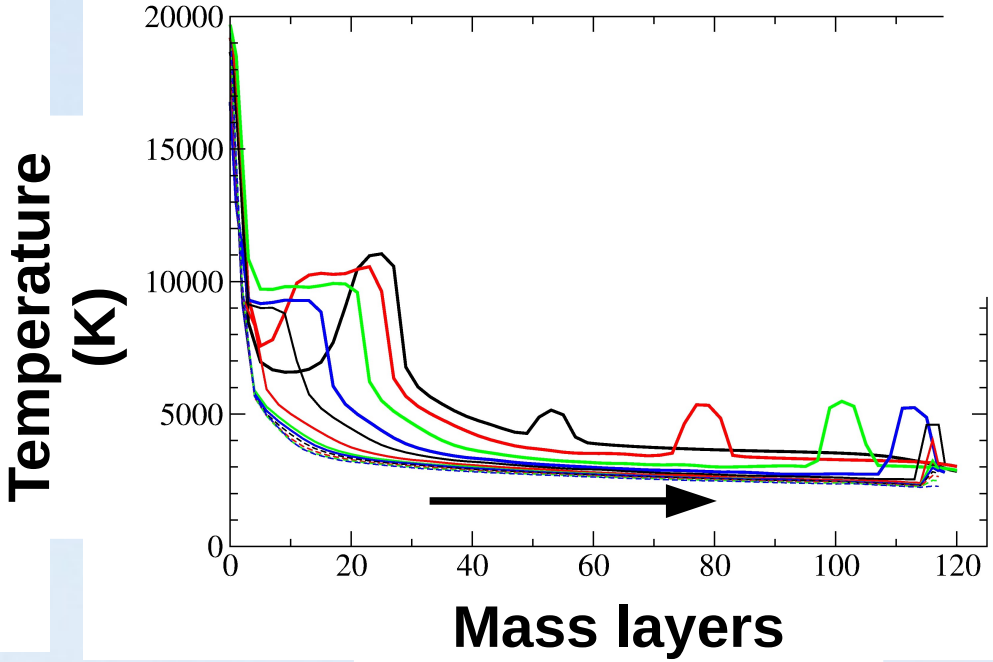
$M = 0.8\ M_{\odot}$

$L = 2000\ L_{\odot}$

$T_{eff} = 3160\ K$

Time step : 1.15 days





3- Modelization

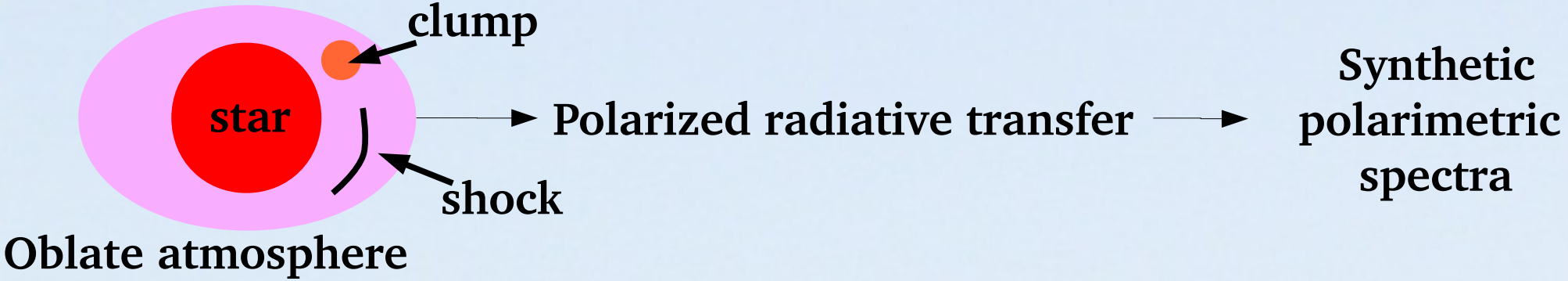
1D modelling:

- plane-parallel
- spherical symmetry

Polarized radiative transfer code:
Static case: *Manso Sainz & Trujillo Bueno 2003*
Dynamic case: *Carlin et al. 2012*

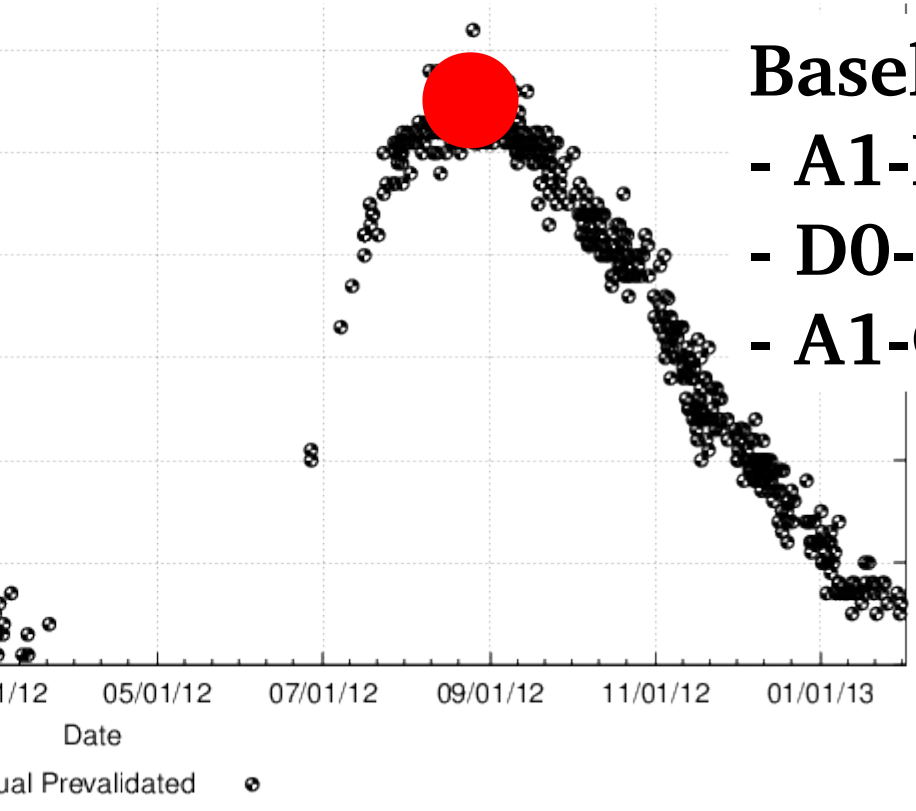
2D modelling:

- one more integration over all possible directions
- creation of a simple 2D model of atmosphere



4- Investigation with AMBER

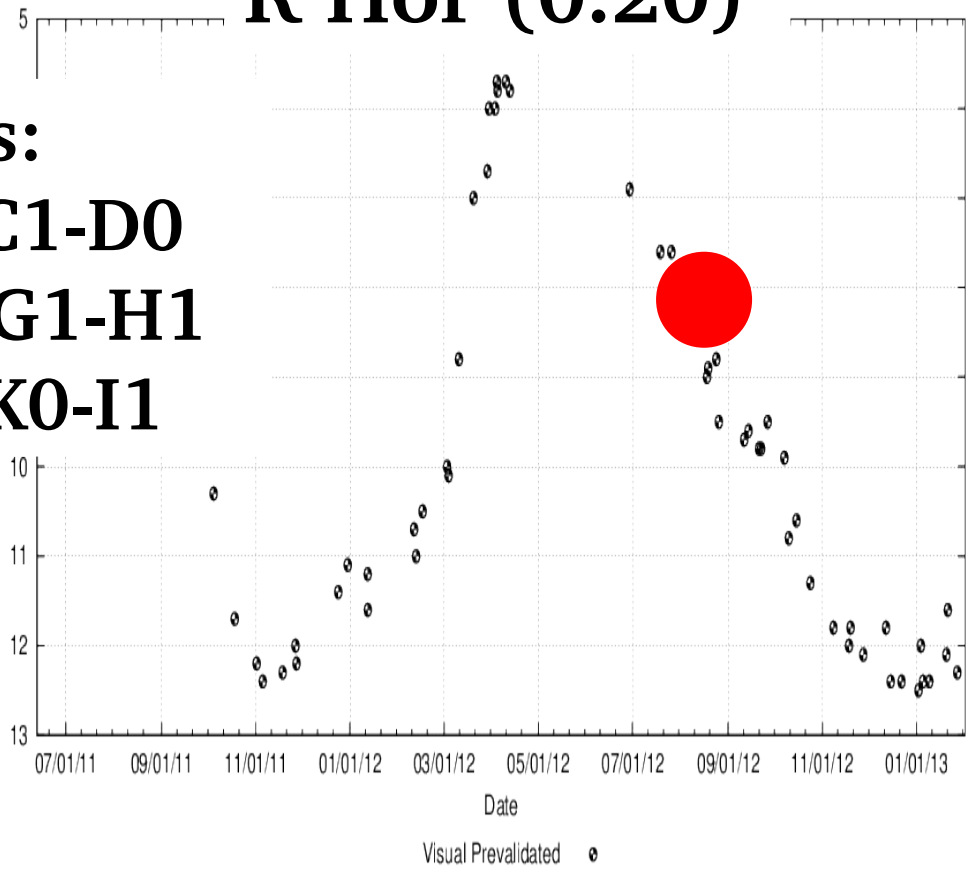
Omicron Ceti (0.00)



Baselines:

- **A1-B2-C1-D0**
- **D0-H0-G1-H1**
- **A1-G1-K0-I1**

R Hor (0.20)



- **Compare photospheric geometry (continuum) and shock wave geometry (spectral lines)**
- **Using observations to constrain models**

5- Prospects with VEGAS

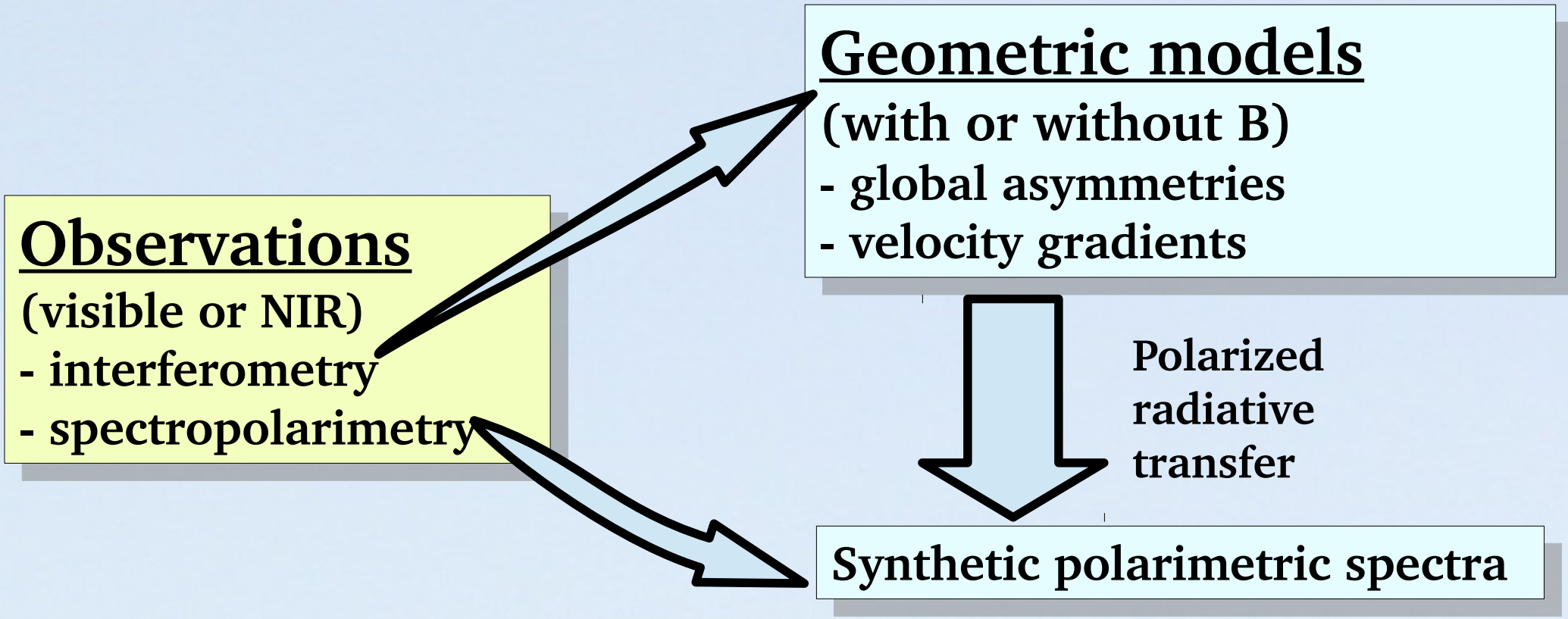
Observation of the geometry in the Balmer lines

→ Miras with low magnitudes observable

→ Possibility to measure linear polarization

6- Global Project

Characterization of asymmetries and weak magnetic fields in Mira stars' atmospheres



6- Global Project

Observational Resources (present and near future)

	Spectropolarimetry	Interferometry
Visible	• **NARVAL**(TBL) • **ESPADONS**(CFHT) • **ISIS**(WHT) • **SARG**(TNG) • **FORS2**(VLT)	•**VEGAS**(pol., CHARA)
Near IR	• **LIRIS**(WHT) • **NICS** (TNG) • **SPIROU**(CFHT)	•**AMBER**(VLT)
Radio		•**IRAM** (pol.)

7- Summary

We use spectropolarimetry to track the propagation of shock waves in Mira stars and its geometry. This method is meant to be an alternative to interferometric measurements with, in addition, the possibility to detect a magnetic field.

Objectives

- **Characterization of the link between atmospheric geometry and polarimetric spectra**
- **Possibility of measuring a magnetic field through the Hanle effect ?**
- **Extension of this study to other type of evolved objects, such as symbiotic stars (Binary systems often including a Mira), planetary nebulae or any pulsating star with an extended atmosphere and shocks.**