PLANET-HOSTING STARS: A MAGNETIC STUDY

Rim Fares

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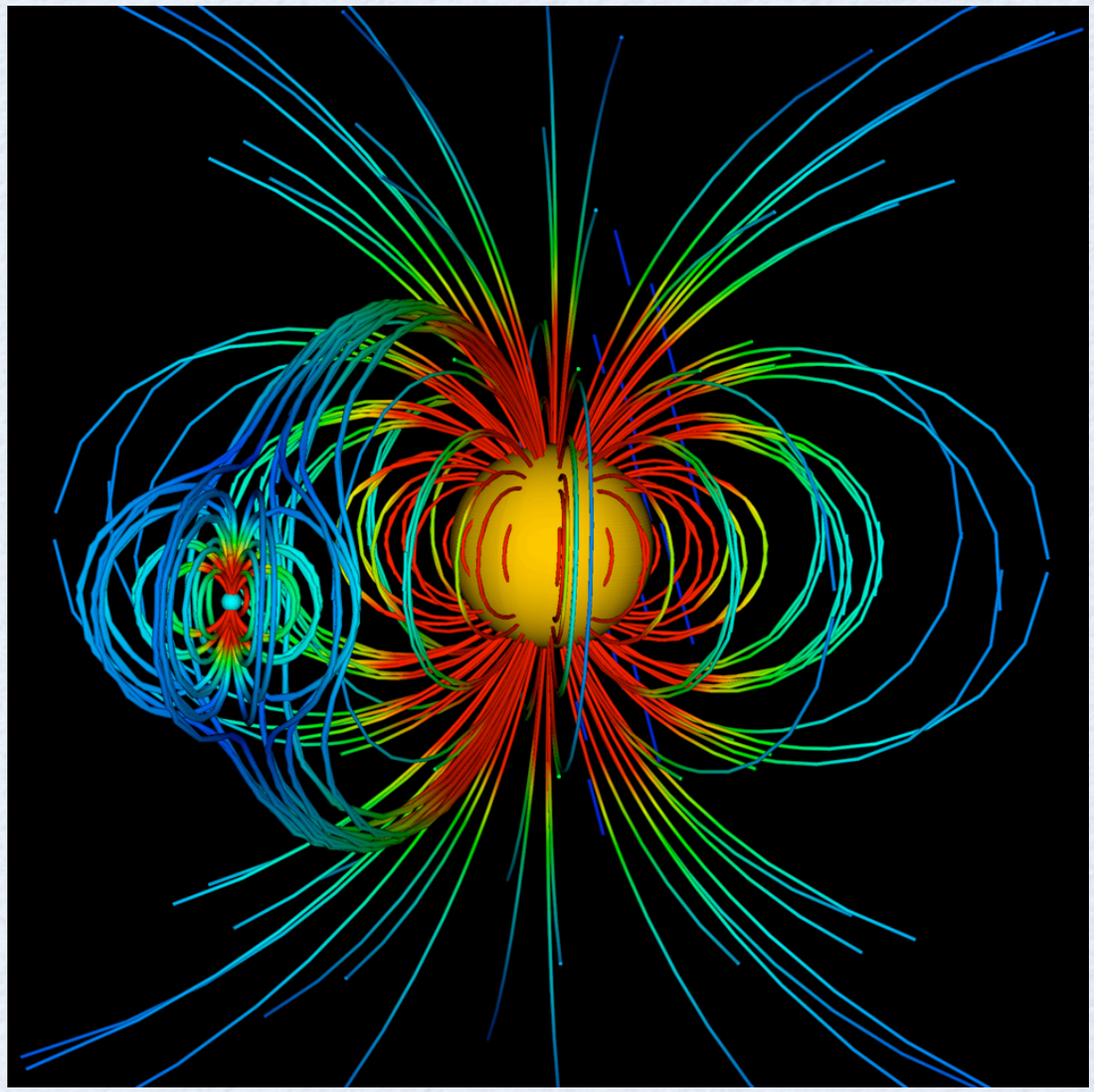
INTRODUCTION

★ Magnetospheric interactions

(e.g. Shkolnik et al 2003,2005,2008, Kashyap et al 2008, Zarka et al 2007, Smith et al 2009, Lanza 2013)

★ Tidal interactions

(e.g. Pont 2009, Ibgui et al 2010, Winn et al 2010, Brown et al 2011, Cebron et al 2014)

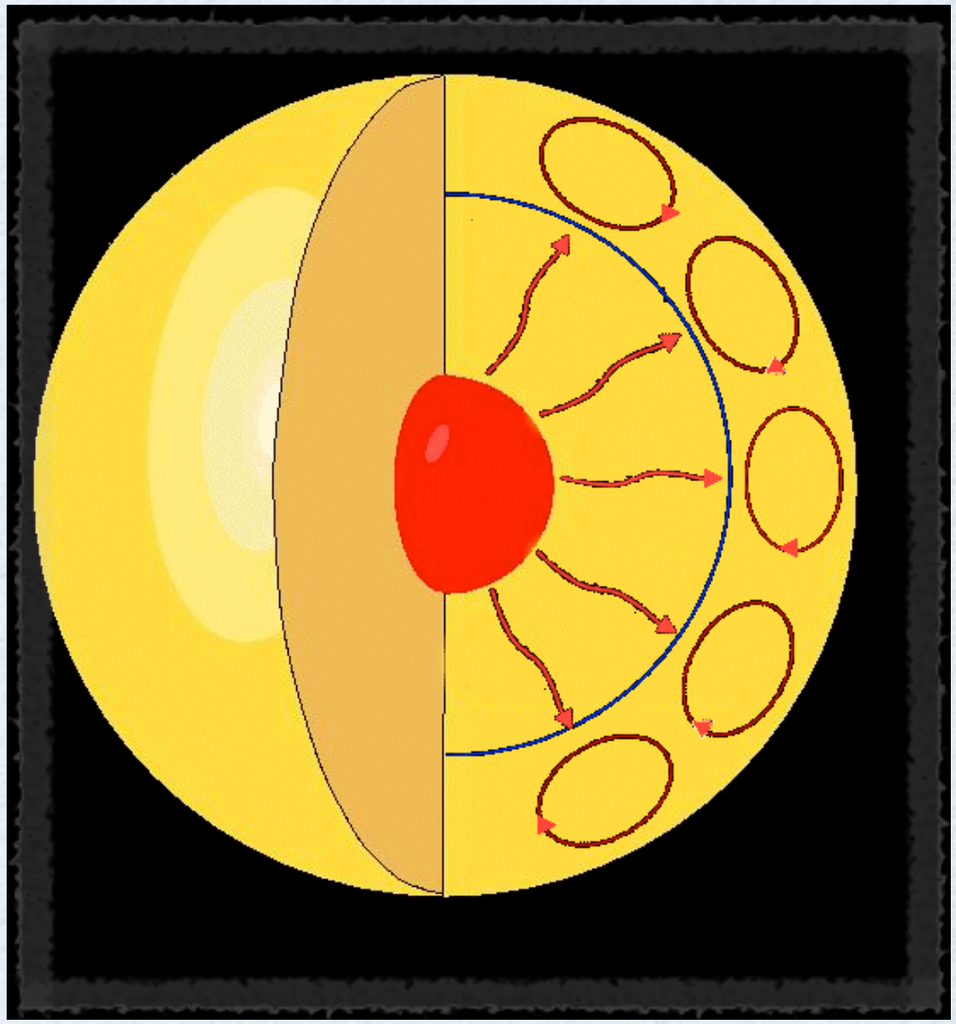


CREDIT: A. Strugarek

INTRODUCTION

Cool F-G-K stars

- Outer convective envelope
- Dynamo --> magnetic field



SURVEY

10 Hot-Jupiter host stars

- F, G and K stars
- P_{rot} : 3 -- 40 days
- Planetary Mass: 0.2 -- 12 M_{Jup}
- Semi-major axis < 0.1 AU

SURVEY

10 Hot-Jupiter host stars

- F, G and K stars
- P_{rot} : 3 -- 40 days

3 stars with no detection of large-scale magnetic field
(Corot-7, HAT-P-2, XO-3)

7 stars with detection
(Tau Boo, HD179949, HD189733, HD73256, HD102195, HD46375, HD130322)

3 stars with multi-epoch obs

ZDI - MAGNETIC MAPPING

Direct Problem

Magnetic field on the surface — Zeeman effect — Polarization in spectral lines

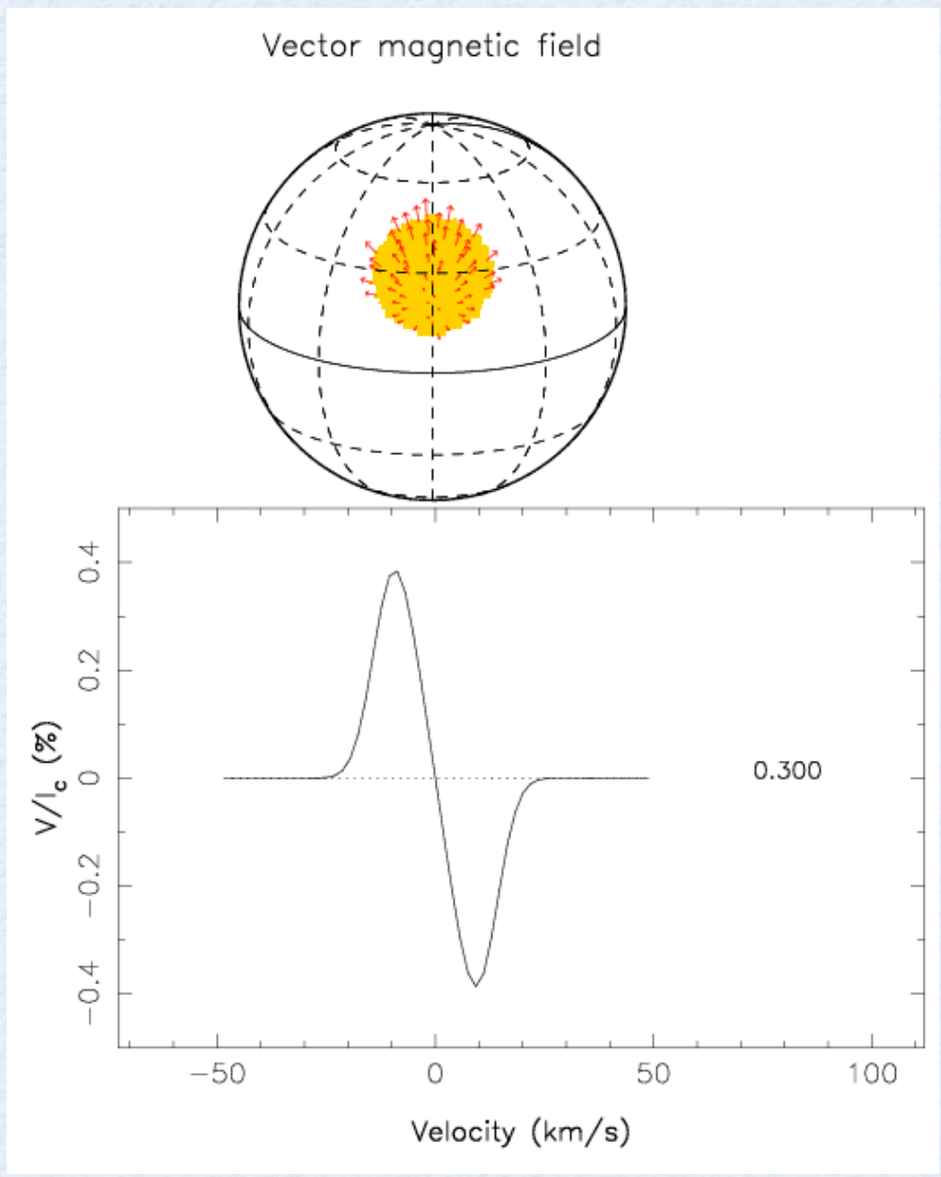
Inverse problem: Zeeman-Doppler Imaging

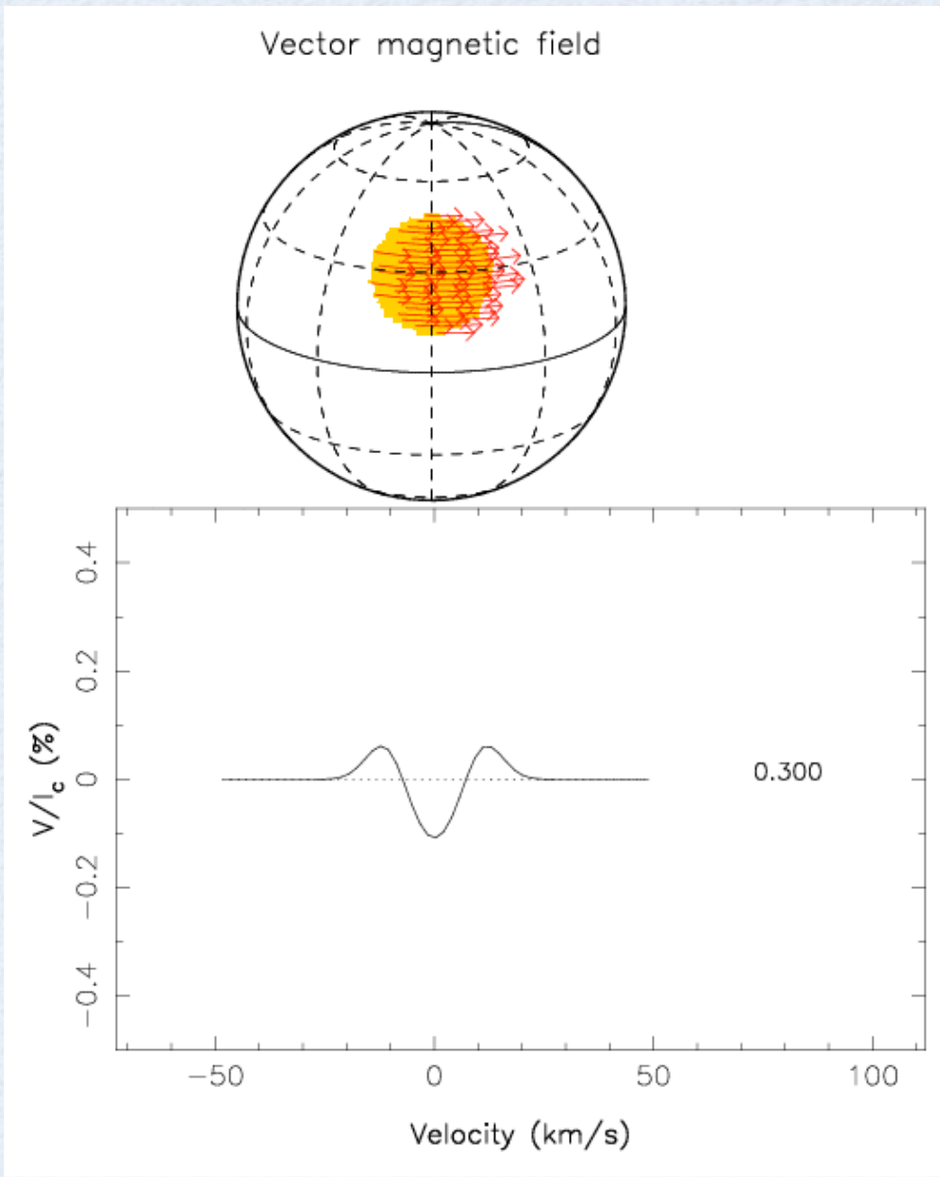
(Donati et al 1997, Donati et al 2006)

ZDI - MAGNETIC MAPPING

Different field orientations : different Stokes V signatures

(Vogt et al 1987, Semel et al 1987)





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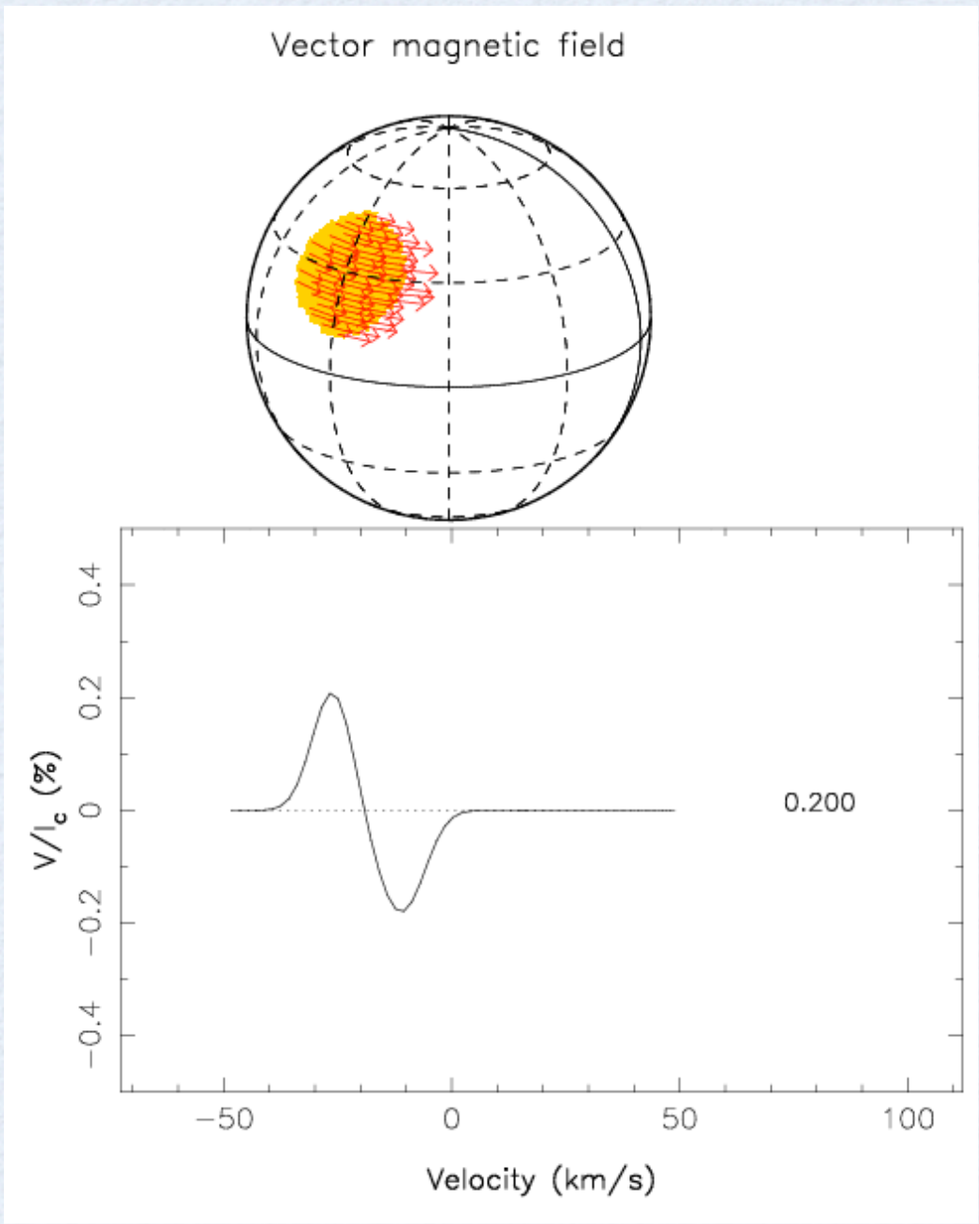
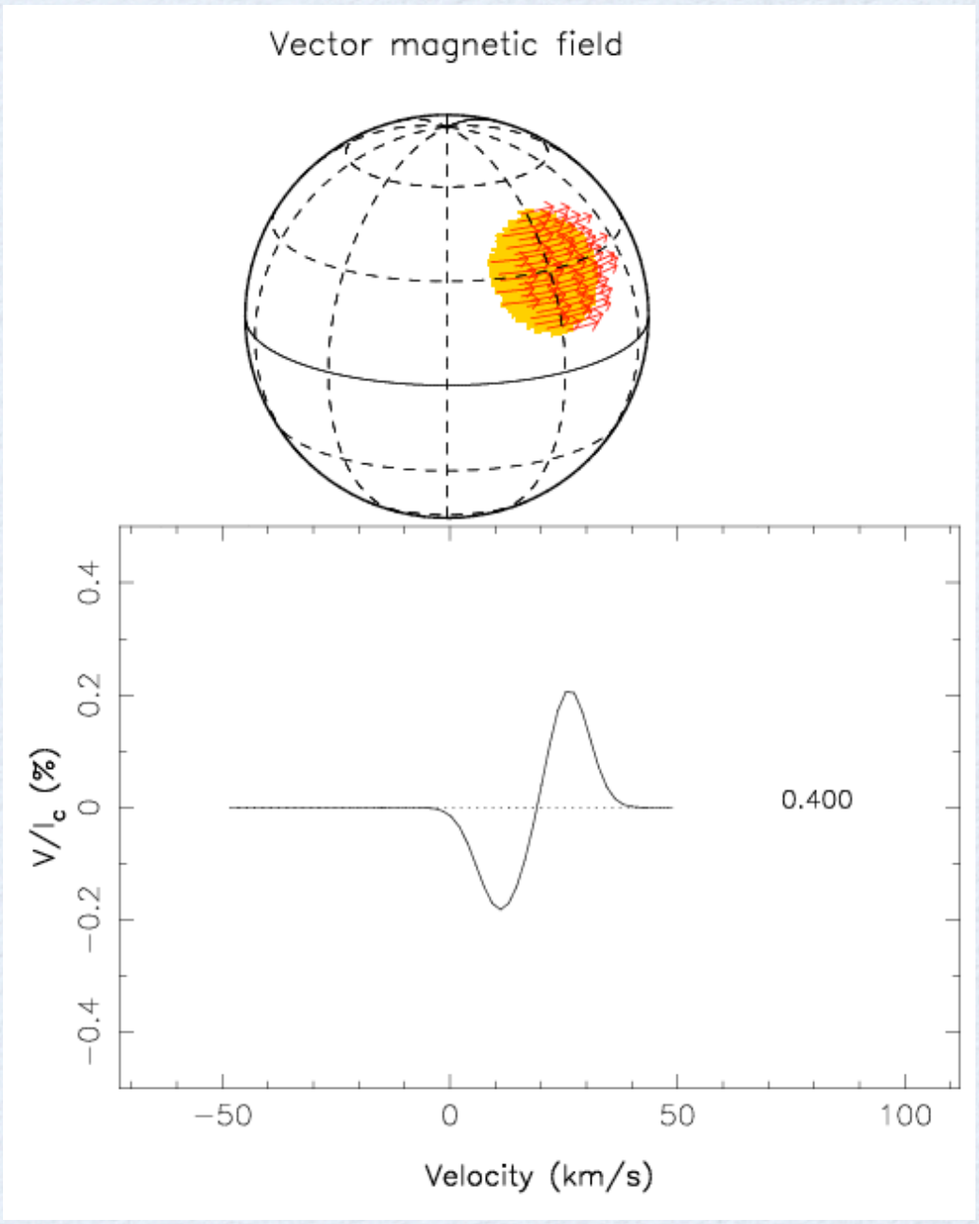
ZDI - MAGNETIC MAPPING

Different rotation phases : different Stokes V signatures





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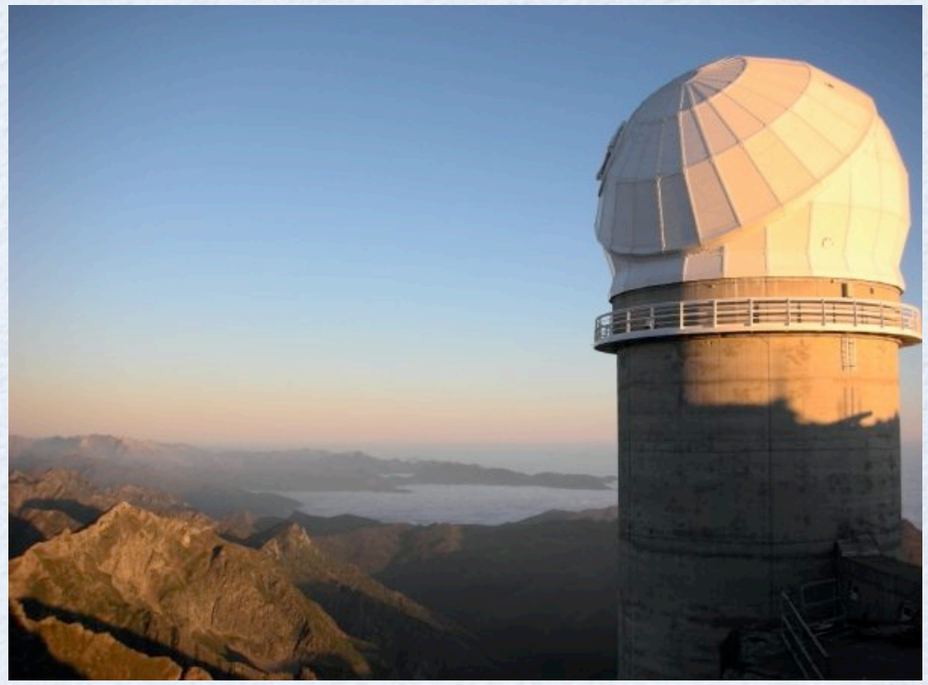
ZDI - MAGNETIC MAPPING

Tomographic Imaging - ZDI

Time series of
polarized spectra

Magnetic properties
Stellar inclination
Differential Rotation

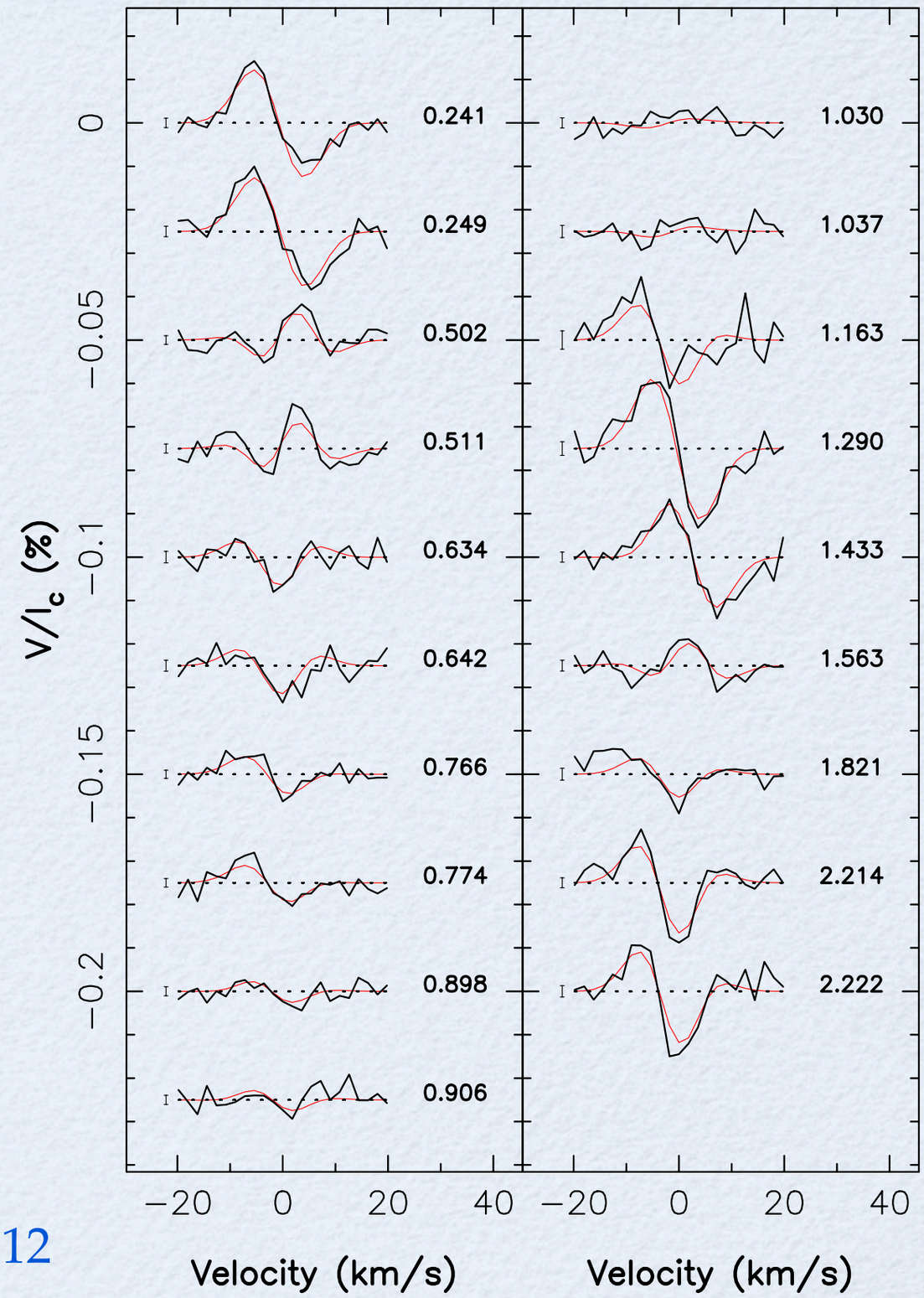
Instruments
ESPaDOnS/CFHT - Narval/TBL
HARPSpol/La Silla



SPECTROPOLARIMETRIC OBS

HD179949, September 2009

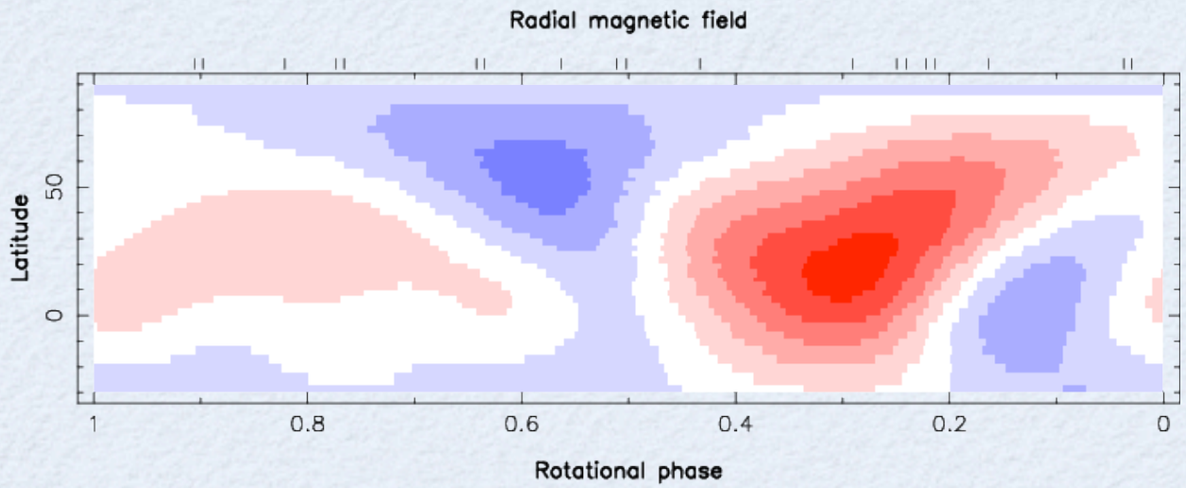
- $T_{eff} = 6120$ K (Nordstrom et al 2004)
- v sini = 7.0 km/s (Valenti & Fischer 2005)
- $P_{rot} = 7.6$ - 10.3 days (Fares et al, 2012)
- $d\Omega = 0.22$ rad/d



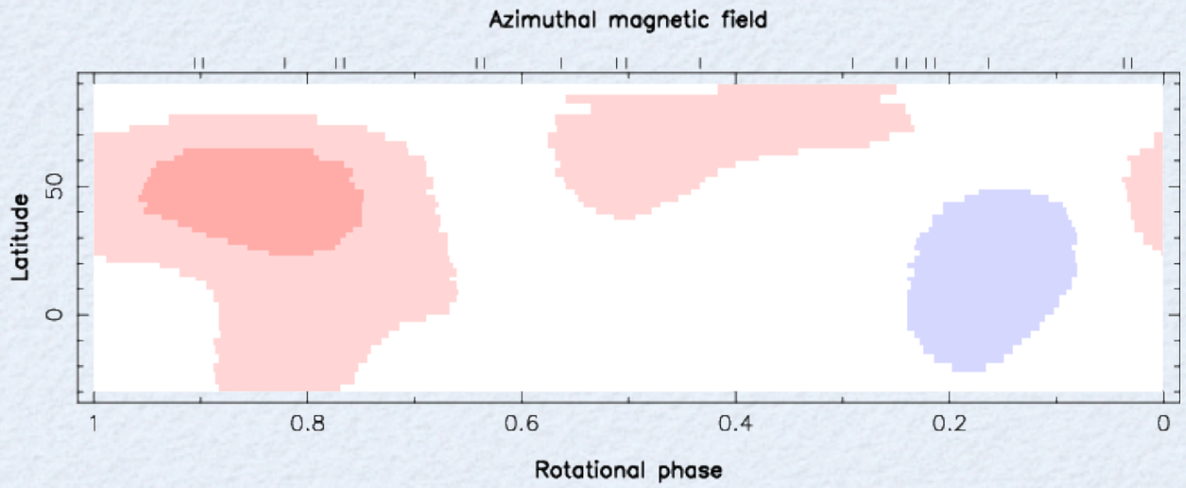
Fares et al., 2012

HD179949, SEP 2009

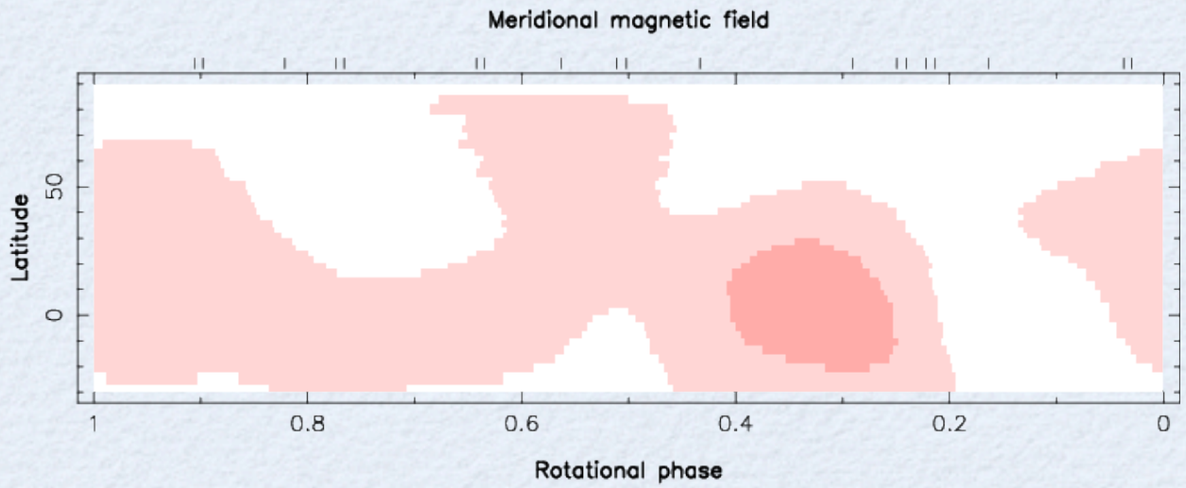
B_{rad}



B_{azim}



B_{mer}



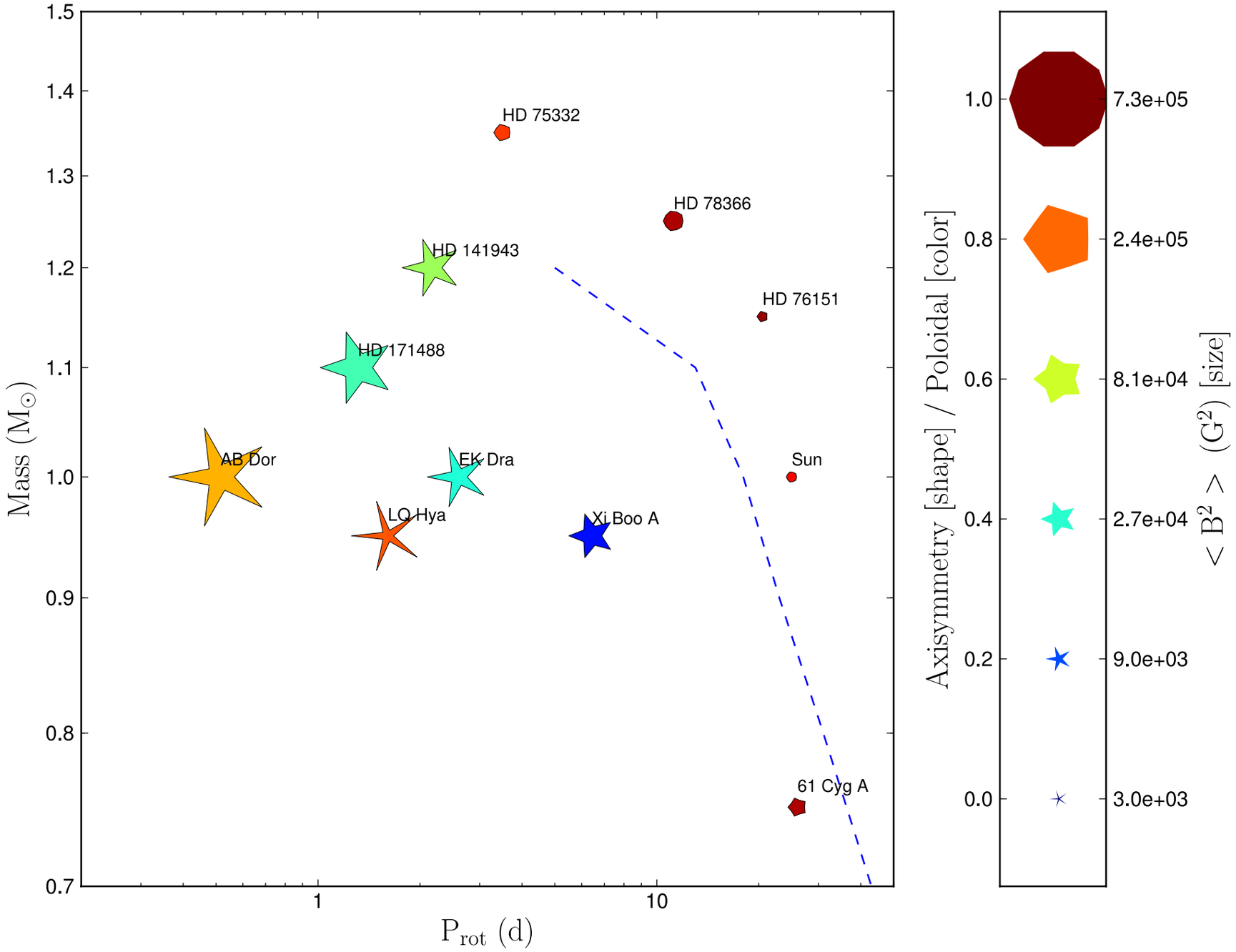
- Three components of the field
- Poloidal/toroidal Energy
- Degree of axisymmetry

B_{mean} ~ 4 Gauss

90% Poloidal - mainly radial

Fares et al., 2012

FIELD TOPOLOGIES



size: field intensity

colour: poloidal
toroidal

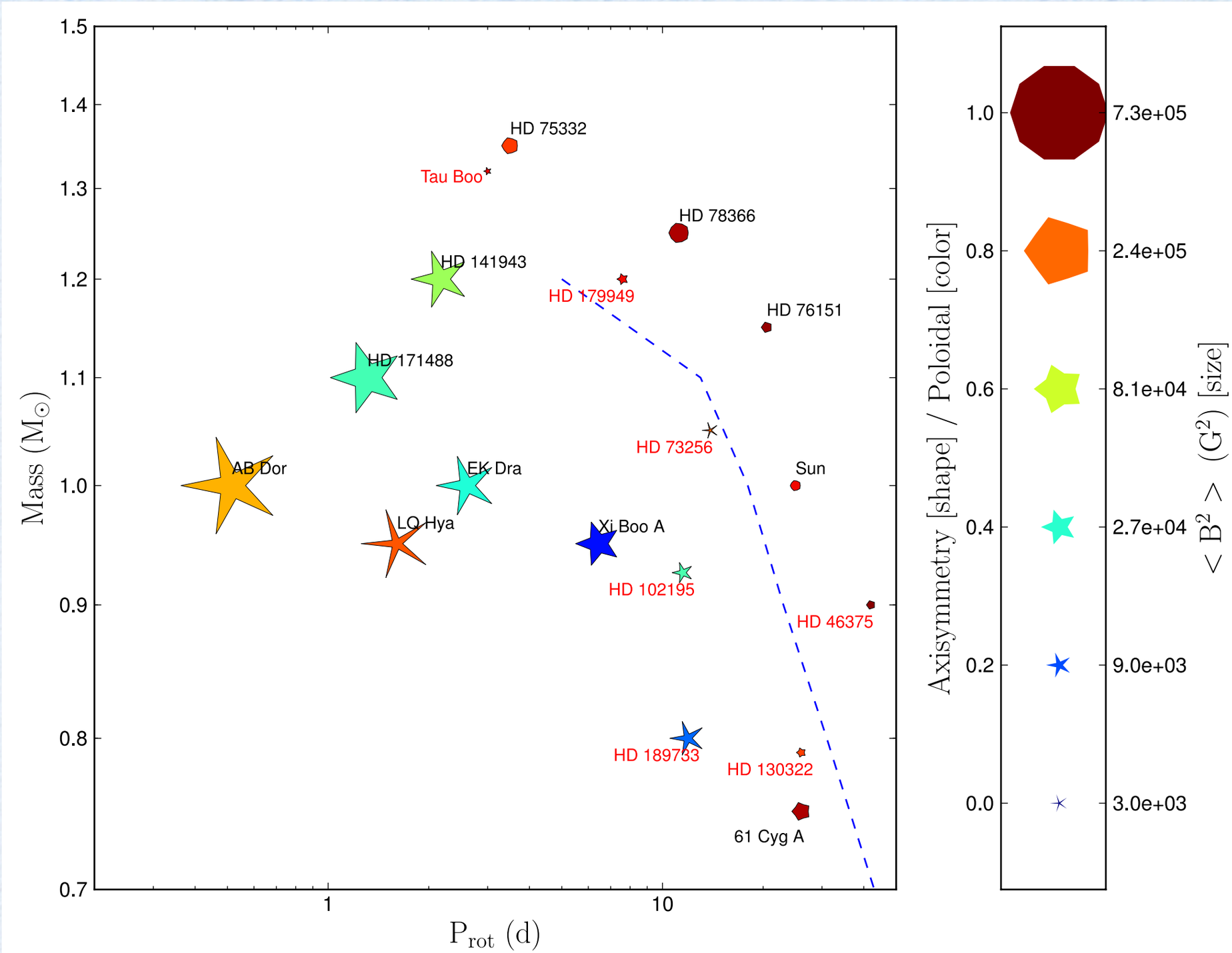
shape: pol axisym ●
pol non-axisym ★

Rossby Number

$Ro = P_{rot}/\tau_{conv}$

Morgenthaler et al 2012; Marsden et al 2011; Petit et al 2011,2008; Moutou et al 2009; Donati et al 2009,2008,2003; Jeffers et al 2008)

FIELD TOPOLOGIES



Fares et al 2013

Hot-Jupiter host stars do not have peculiar magnetic properties

FIELD EVOLUTION

Tau Boo

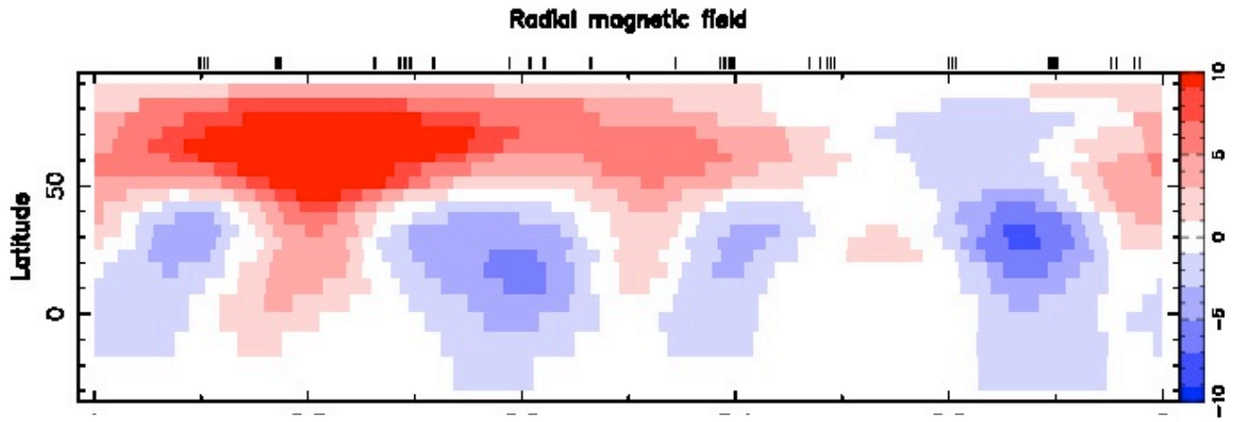
Star:
- F7V
- P_{rot} ~ 3.3 days
- v sini = 15.0±0.5 km/s

(Valenti &Fischer 2005)

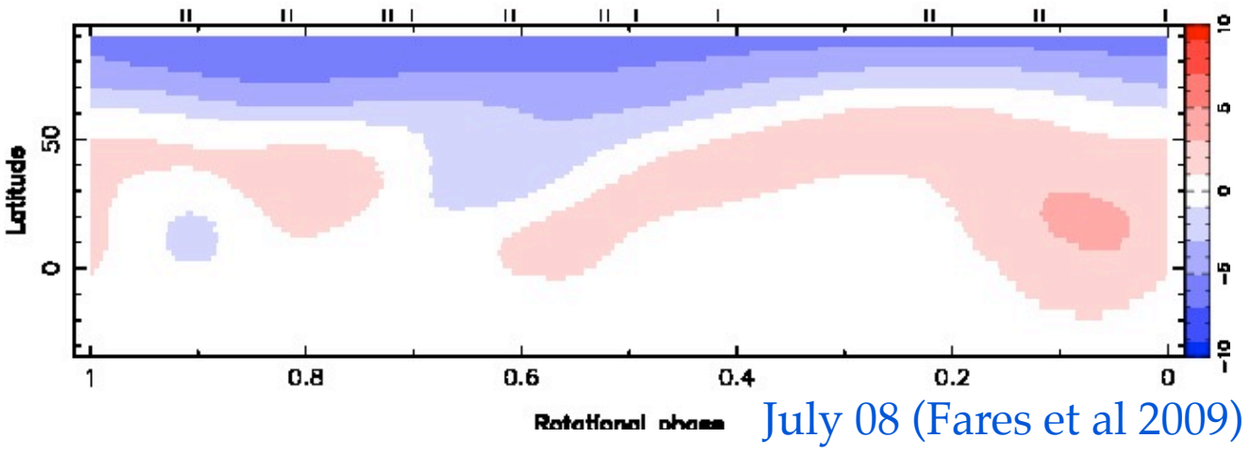
Planet:
- Mass ~ 6 M_{Jup}
- P_{orb} = 3.31 days
- a = 8.5 R_*

11 epochs of observations

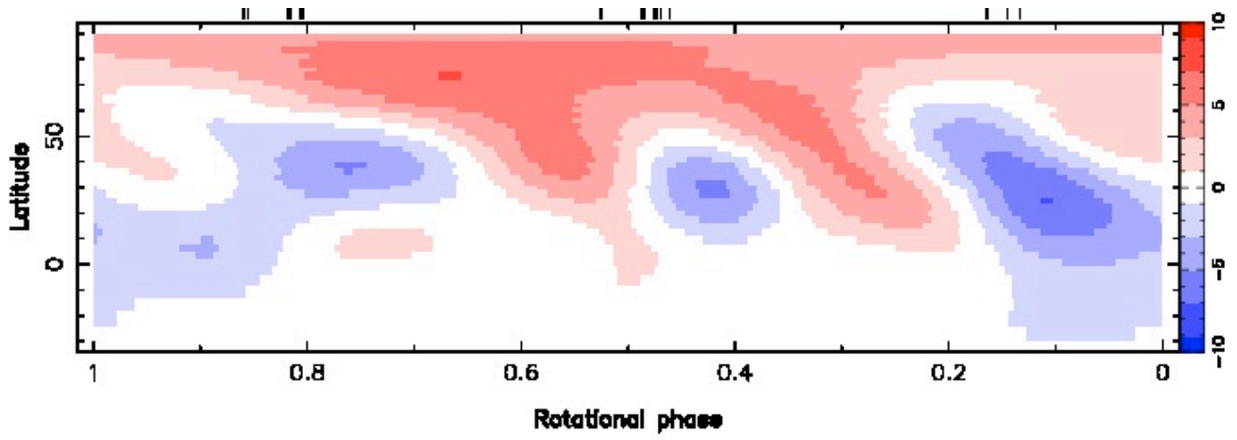
CYCLE: τ BOO



June 07 (Donati et al 2008)



July 08 (Fares et al 2009)

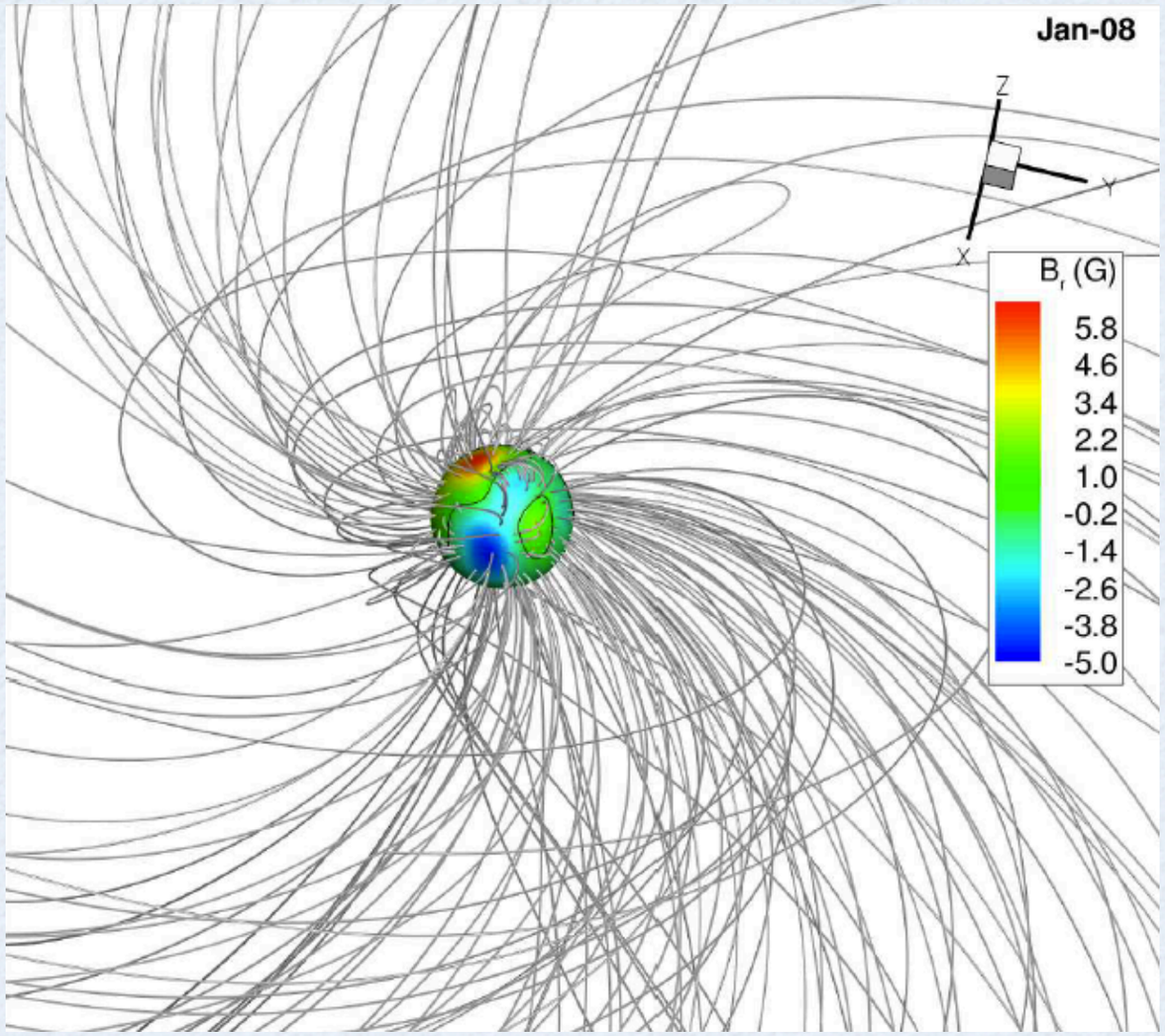


June 09 (Fares et al 2013)

- $P_{rot} = 3.0 - 3.9$ days $= P_{orb}$ (Fares et al 2009)
- $d\Omega = 0.4$ rad / d
- $i = 40$ deg

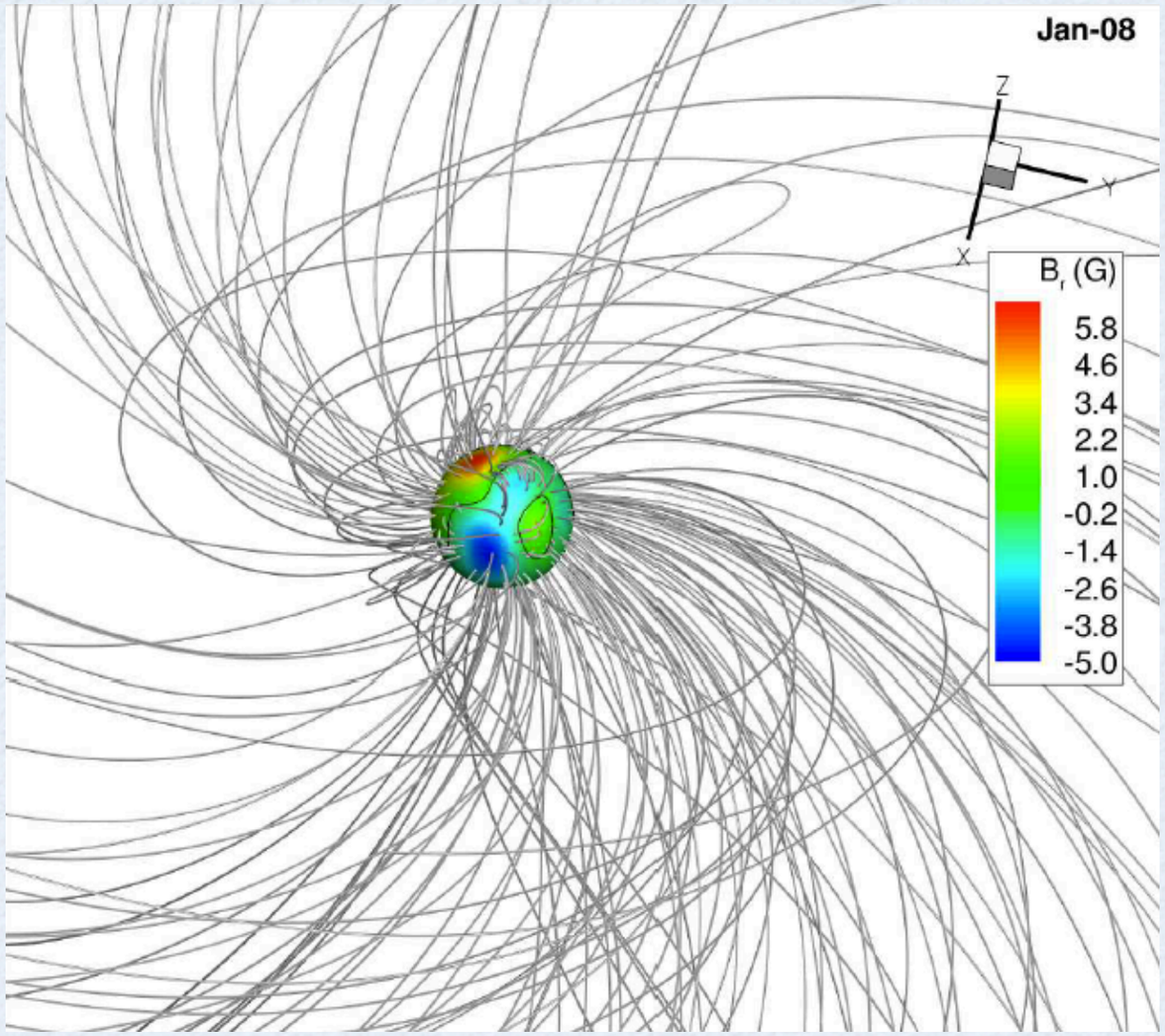
Magnetic cycle of
2 years / 8 months

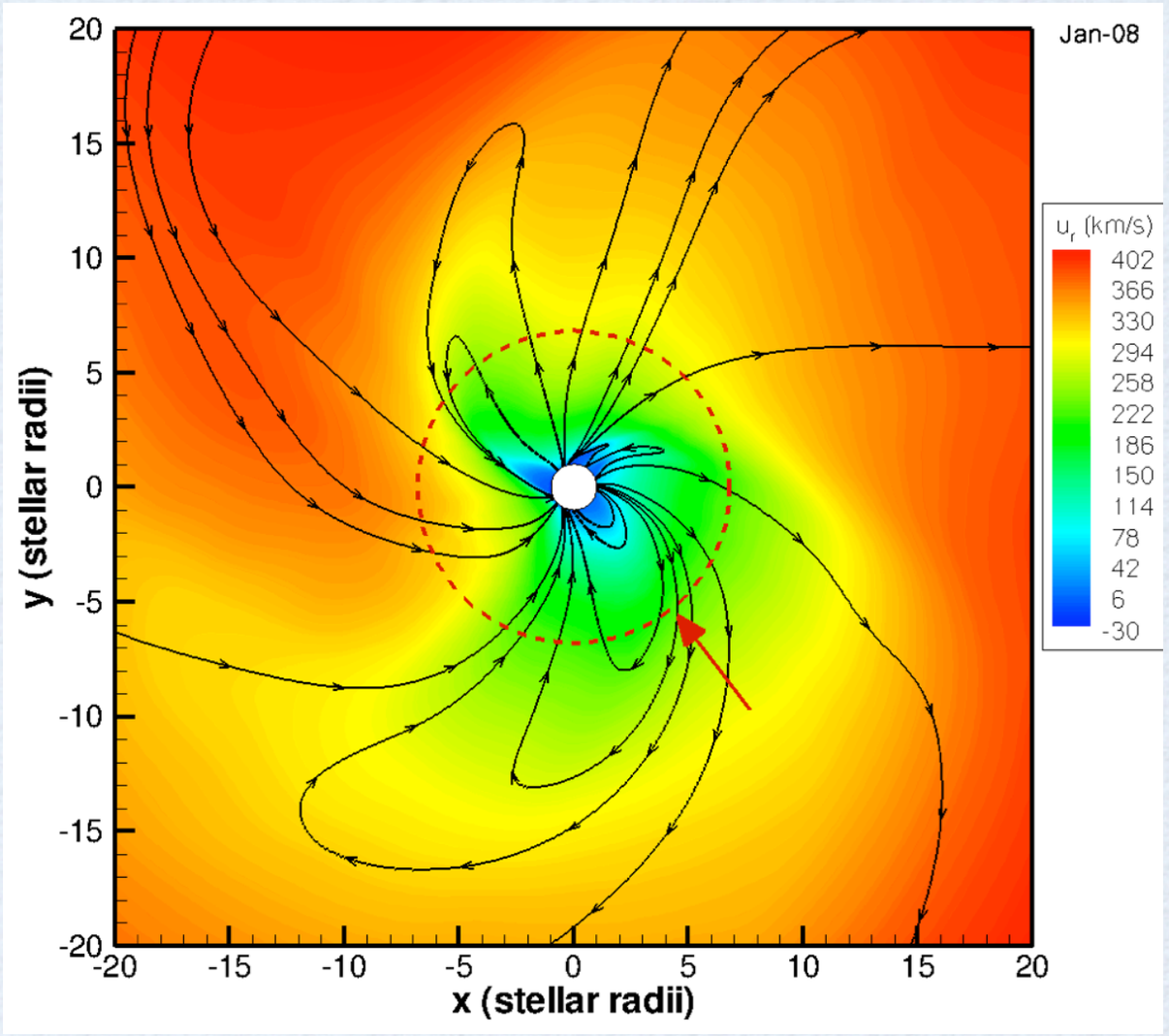
STELLAR CORONA



Vidotto et al, 2012

STELLAR CORONA





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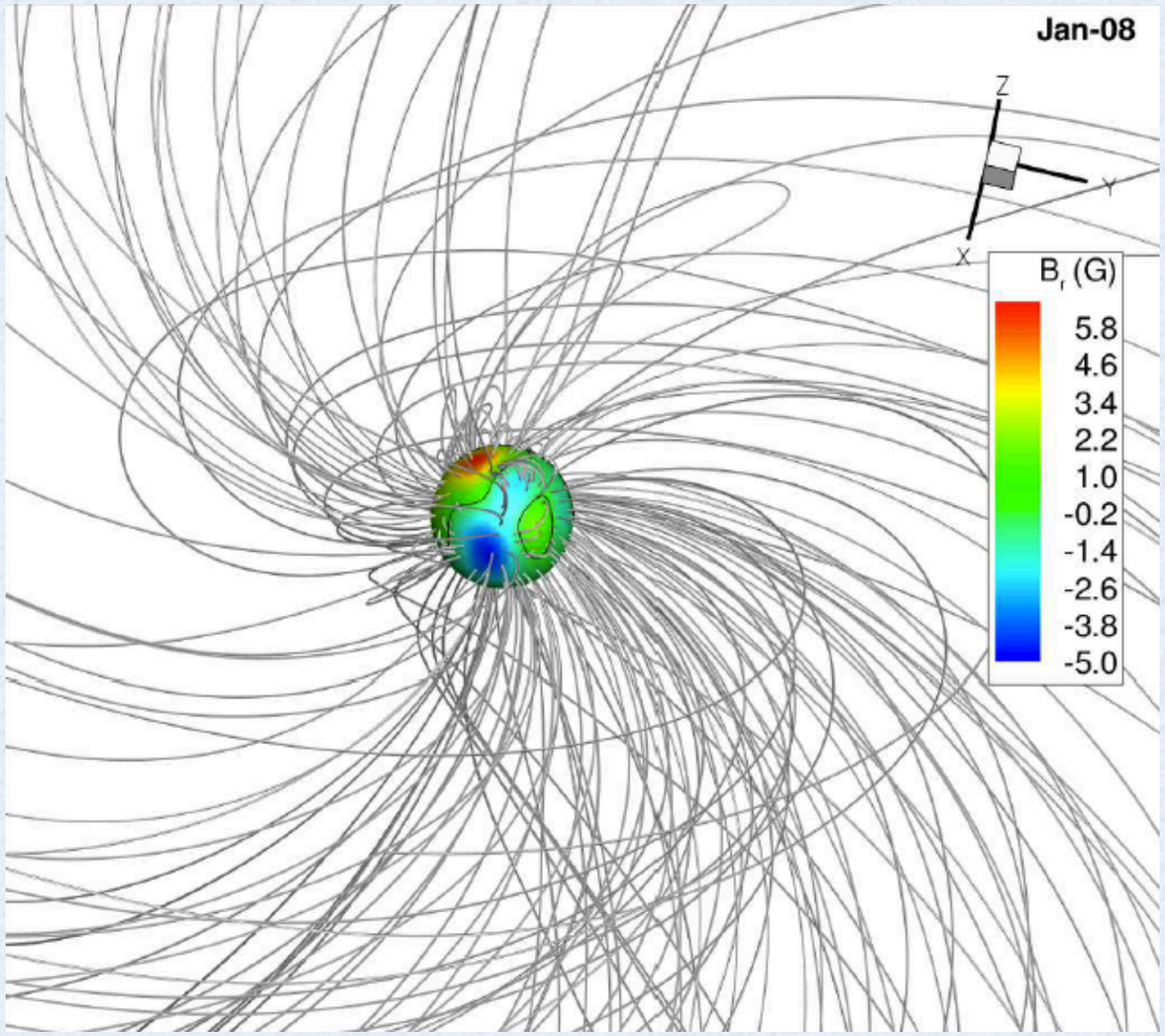
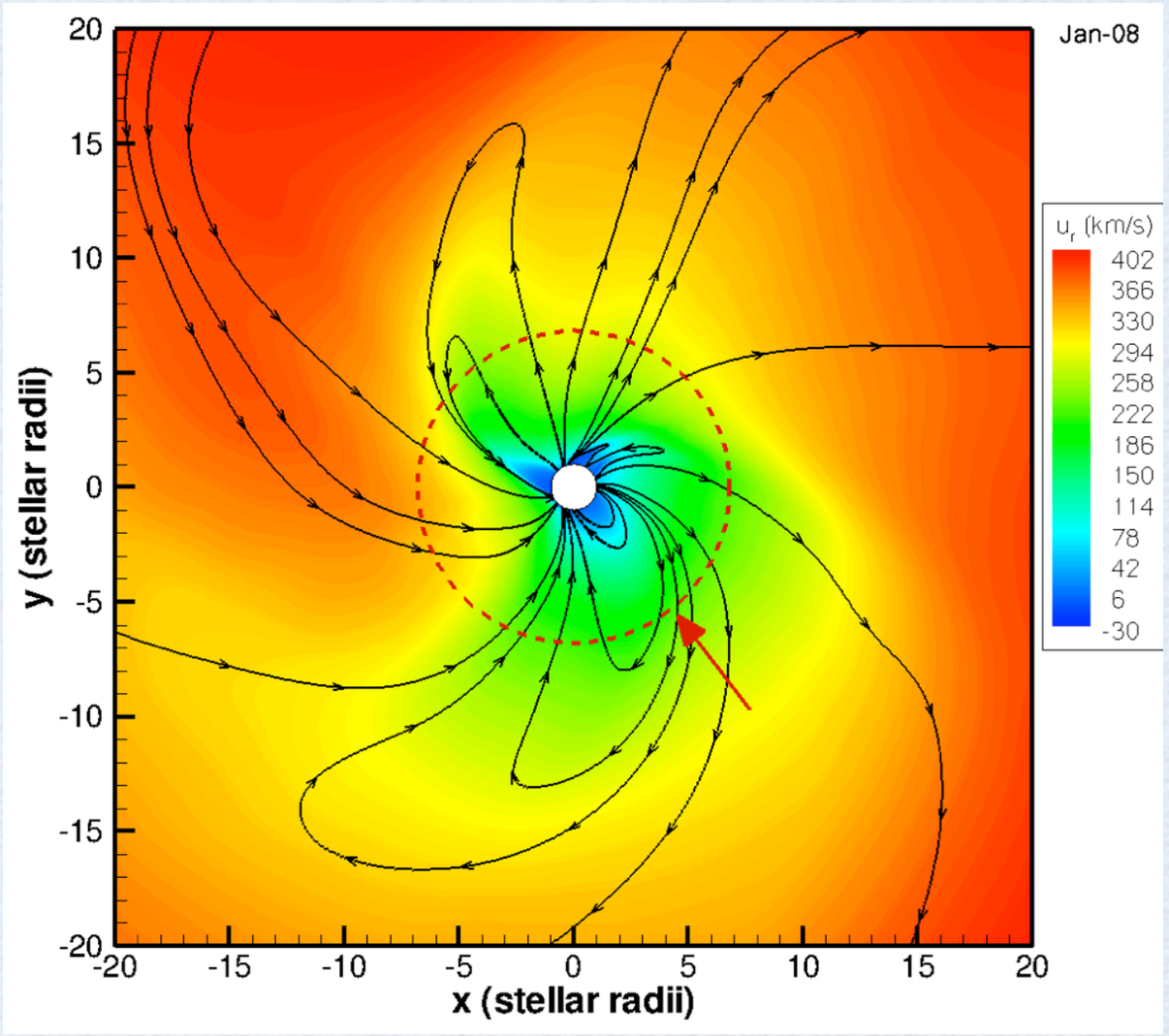
STELLAR CORONA



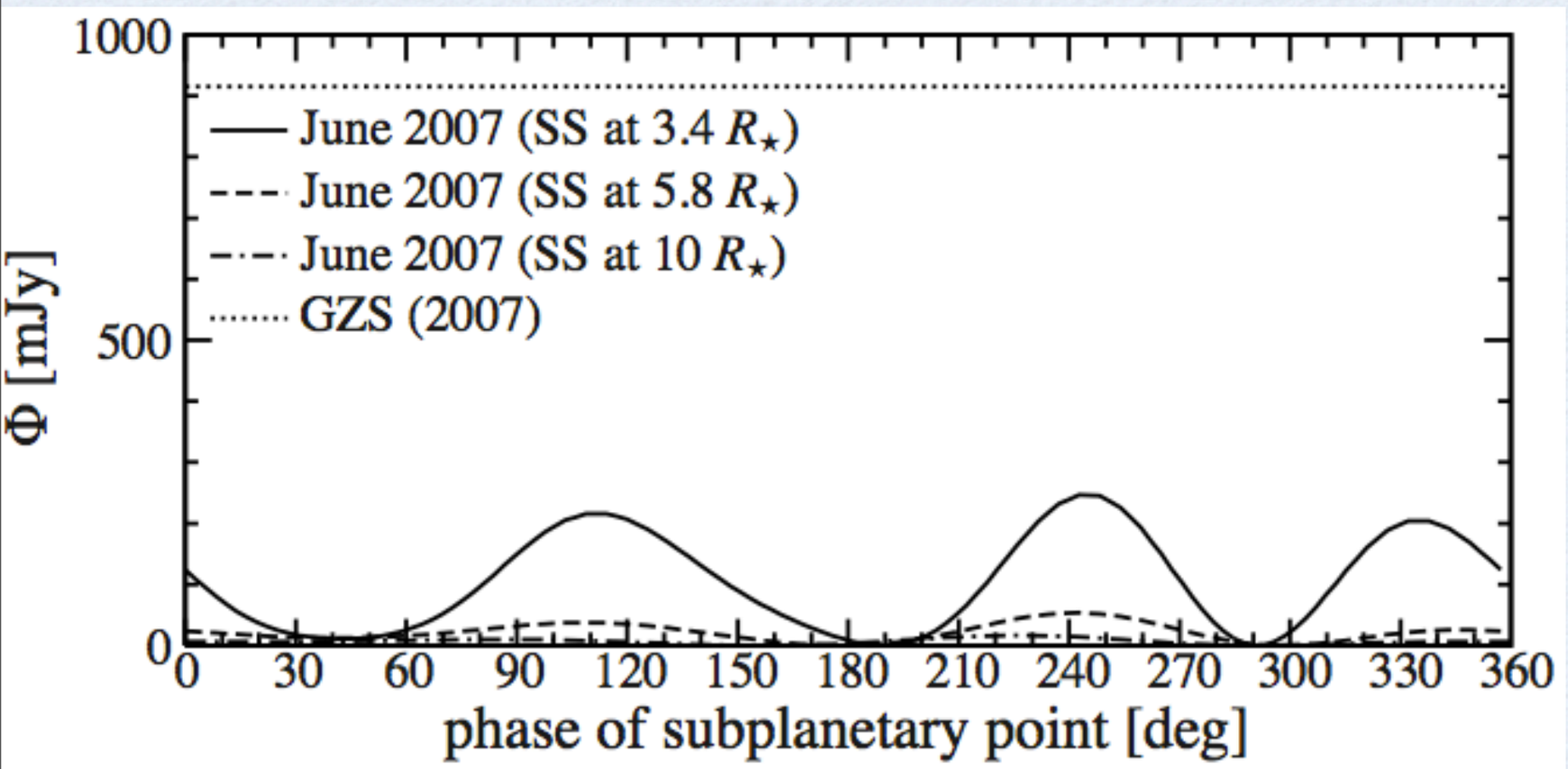


Vidotto et al, 2012

Planetary environment: not uniform

RADIO EMISSION

HD 189733



Fares et al, 2010

RADIO EMISSION

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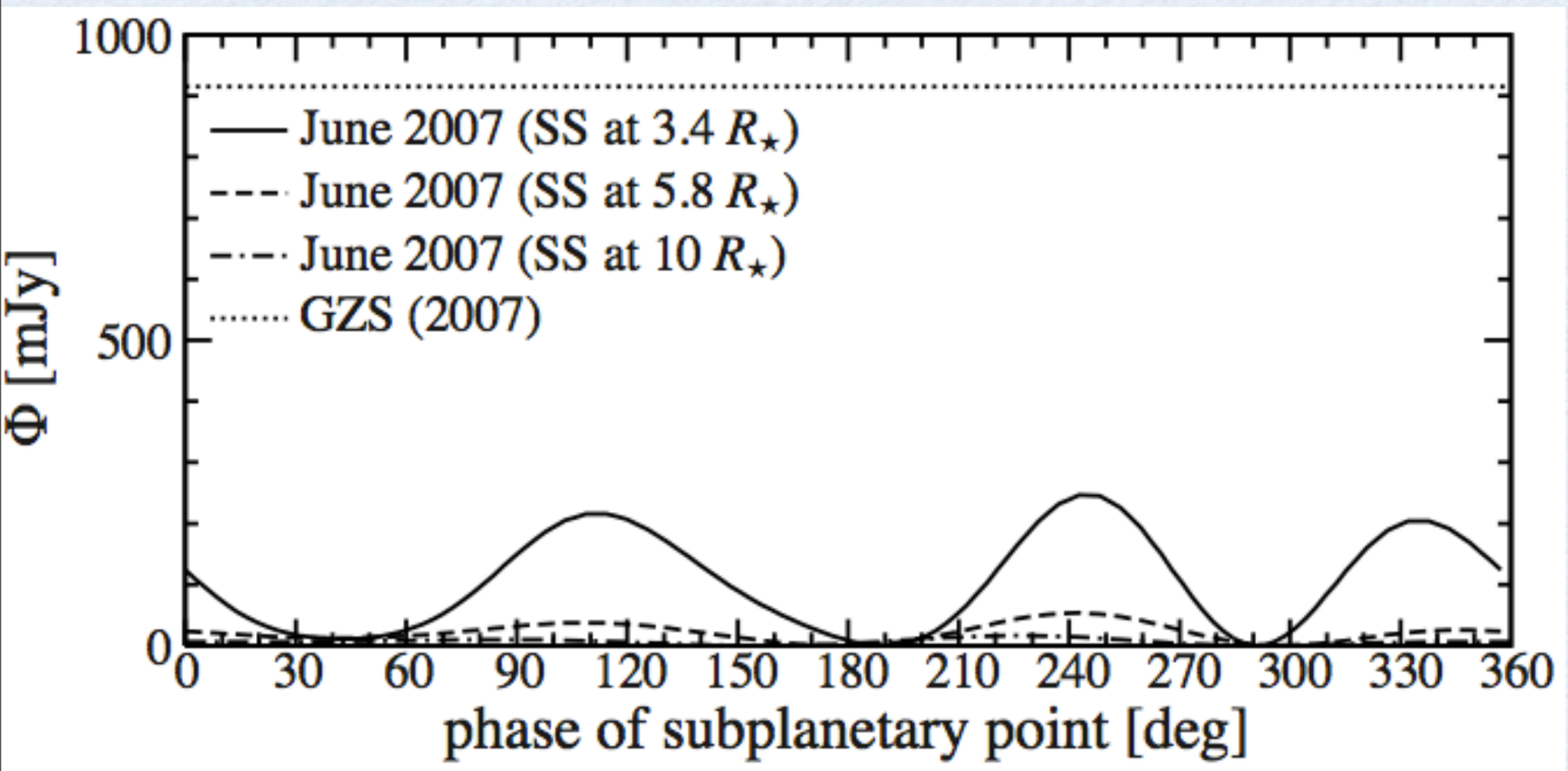


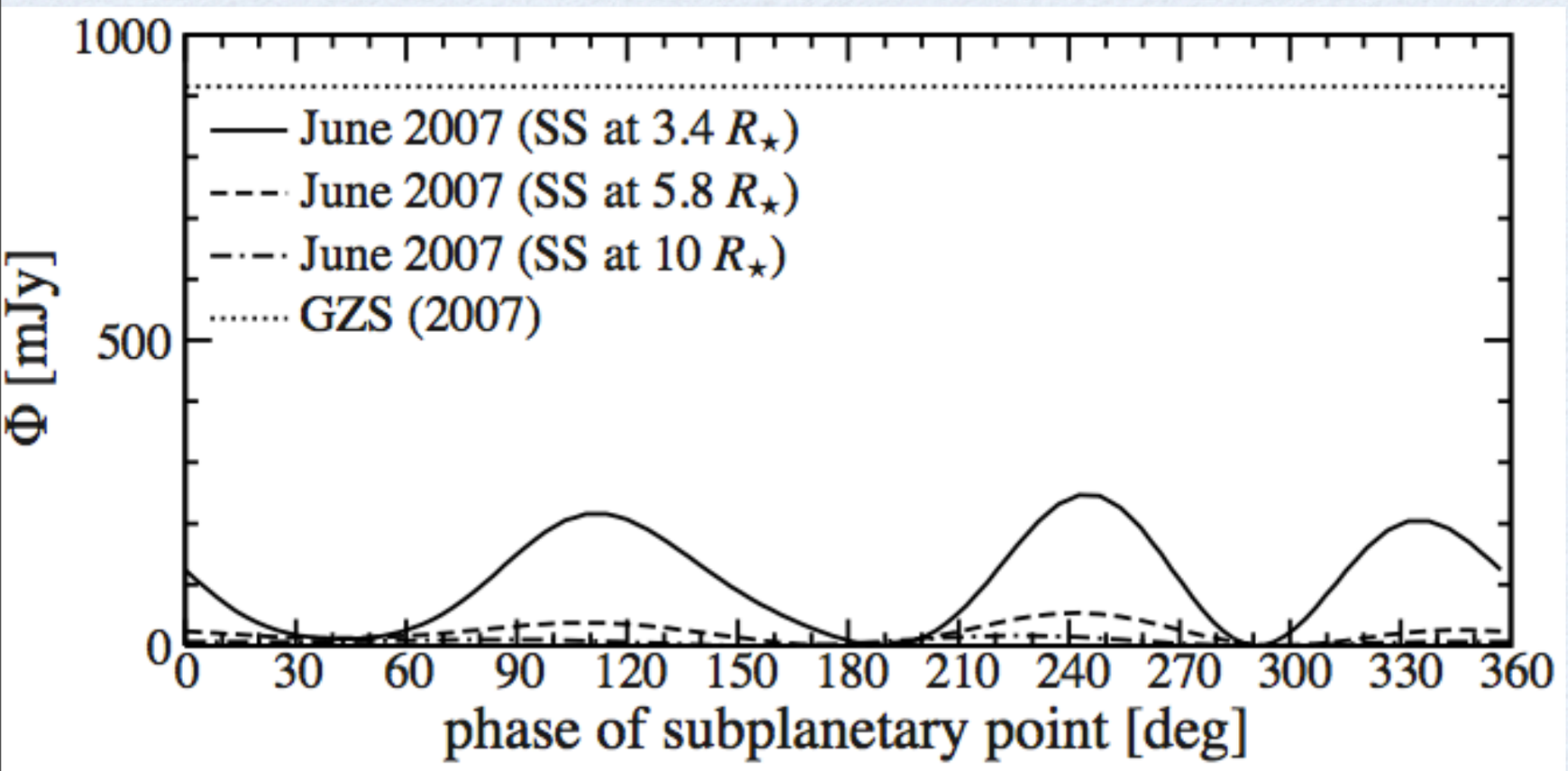
Fares et al, 2010

Radio flux :

- variable on the orbit
- modulated by the synodic period

RADIO EMISSION

HD 189733



Fares et al, 2010

Radio detection ⟶ Planet magnetic field

WHAT NEXT?

Snapshot survey: 54 planet-hosts so far...

2 F

32 G

44 K

6

4

44

SUMMARY

- The magnetic fields of hot-Jupiter hosting stars seem to have properties similar to stars without HJ

- Tau Boo: fast magnetic cycle due to tidal interactions?

- Study of HJ environment: need of ZDI

- Simultaneous multi-wavelength observations: sepctropol, XMM, HST, radio --> planetary magnetic field