The BCool project: Studying the magnetic activity of cool stars

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with
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Habitability - February 2016

What is BCool?

International collaboration to study the magnetic activity of low-mass stars

Aim to understand how cool stars generate magnetic fields and what impact this could have on their space environment and exoplanets

- Solar-type stars
- Star-Planet interactions
- M dwarfs
- Evolved stars
- Numerical modelling
- …

BCool project website:
bcool.ast.obs-mip.fr

The Solar-type Star Snapshot Survey

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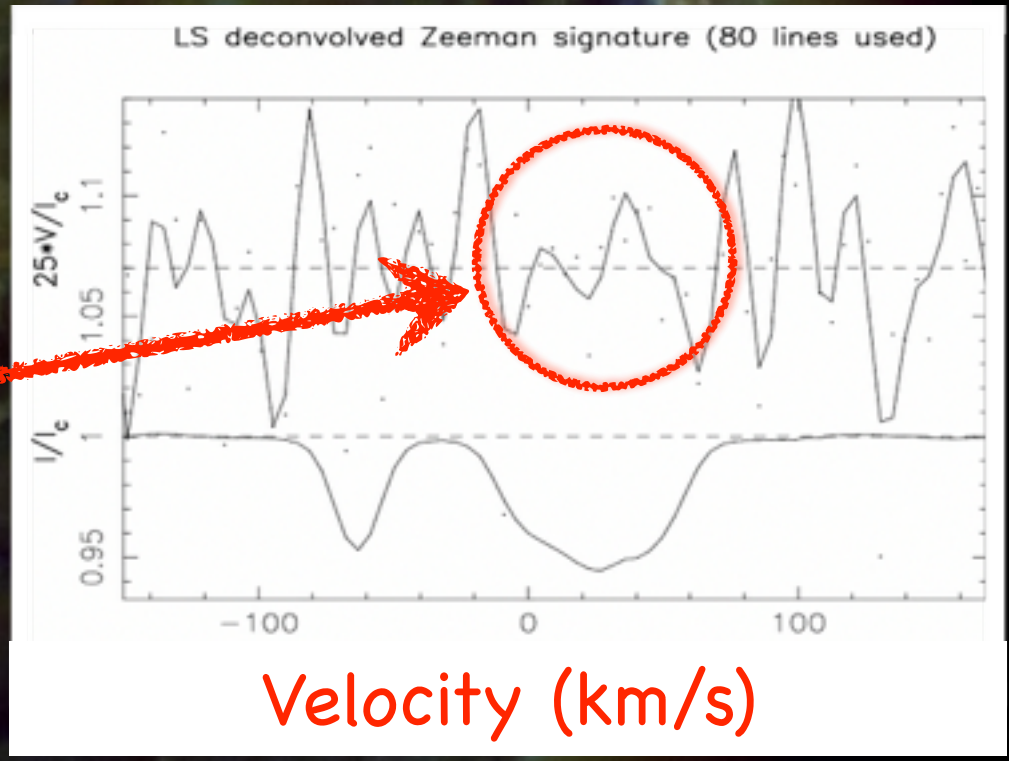
Snapshots of Solar-type Stars

Have spectropolarimetric (circular polarisation) observations for 200+ solar-type stars

- Mid-F to Mid-K
- Range of ages
- Mostly dwarfs
- Use LSD to enhance signal

Magnetic field detections for ~40% of targets



Credit: Pascal Petit

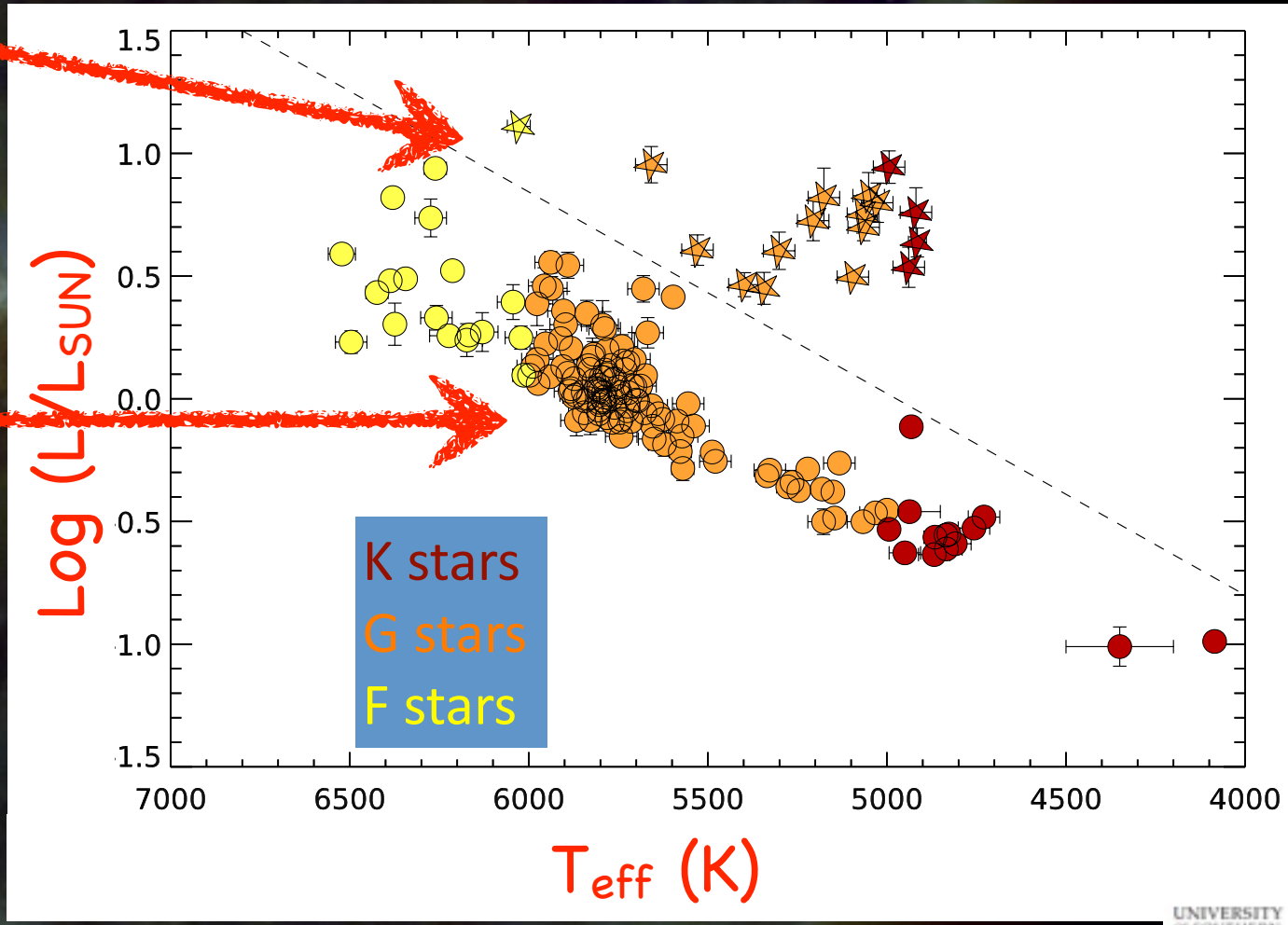
The Solar-type Stars Sample

Marsden et al. (2014)

Subgiants (small fraction magnetic)

A large number of solar-type

Sample is always being updated

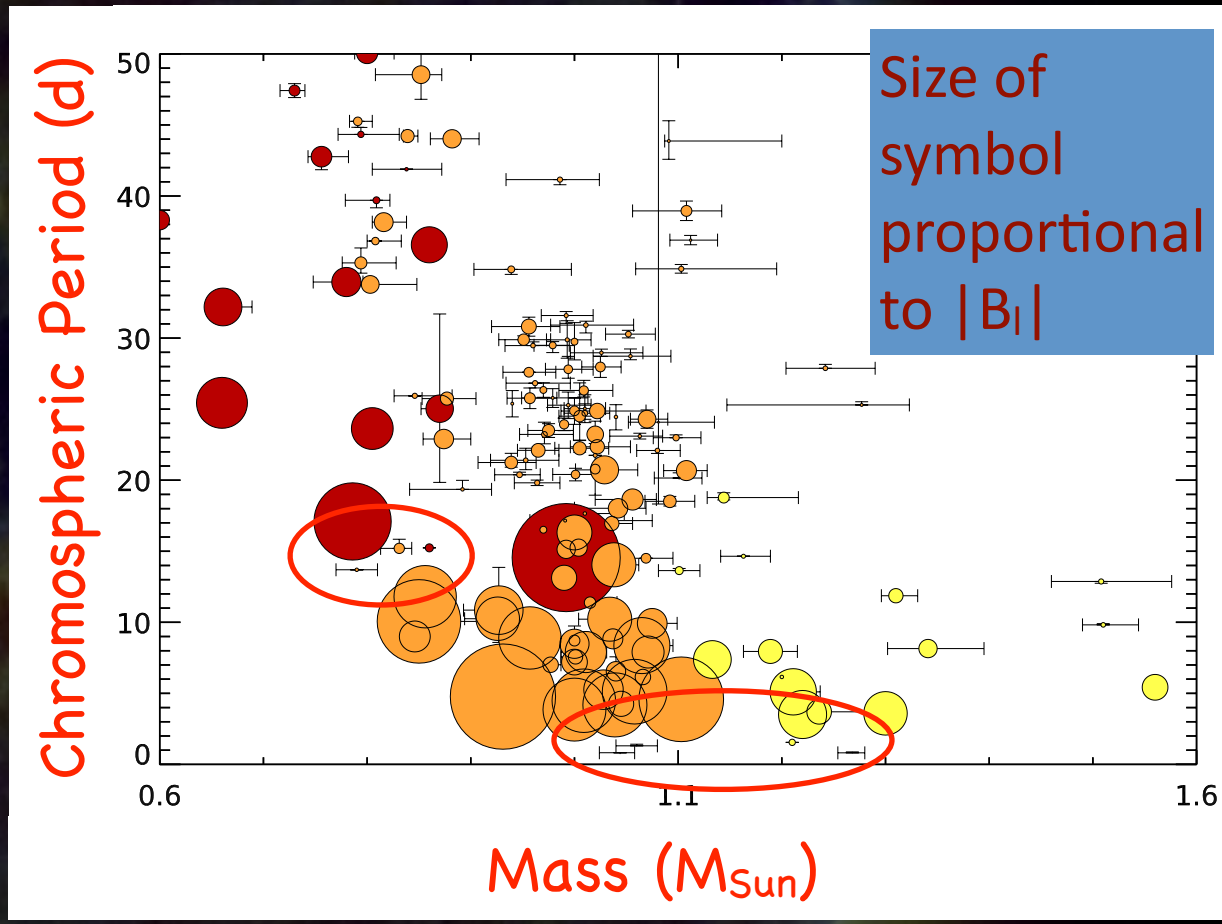


Magnetic Activity

Marsden et al. (2014)

Measured:

- Longitudinal magnetic field
- Ca HK index
- Ha emission
- Ca IRT emission



20 new mature solar-type stars with detections (a four-fold increase)

The Magnetic Topology of Solar-Type stars

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Magnetic Mapping

In addition to the snapshot survey over 20 of our targets have had their magnetic topologies mapped

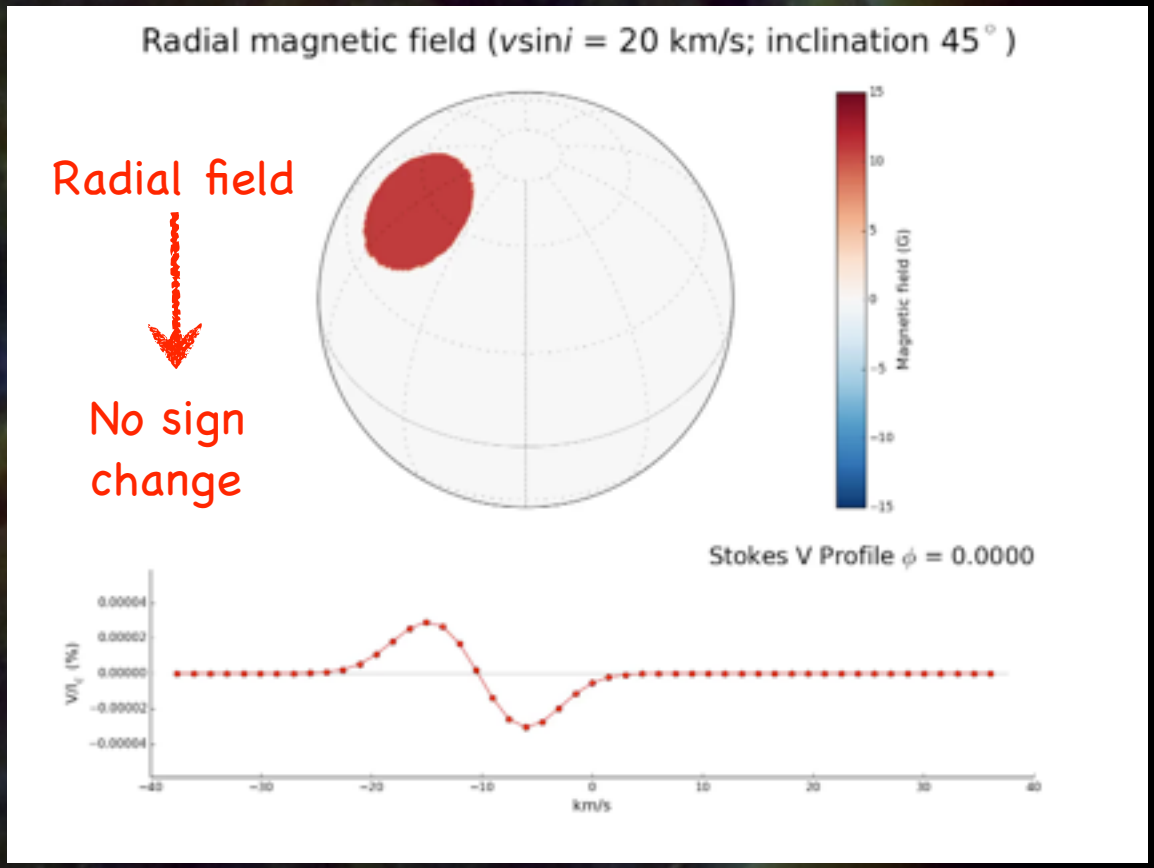
ZDI recovers the global/large scale magnetic field of these stars

A number of these stars have been observed at multiple epochs so we can look for cyclic activity

Zeeman Doppler Imaging

A time series of LSD observations is inverted to create magnetic maps

Different field orientations give different profiles



Credit: M Mengel

Zeeman Doppler Imaging

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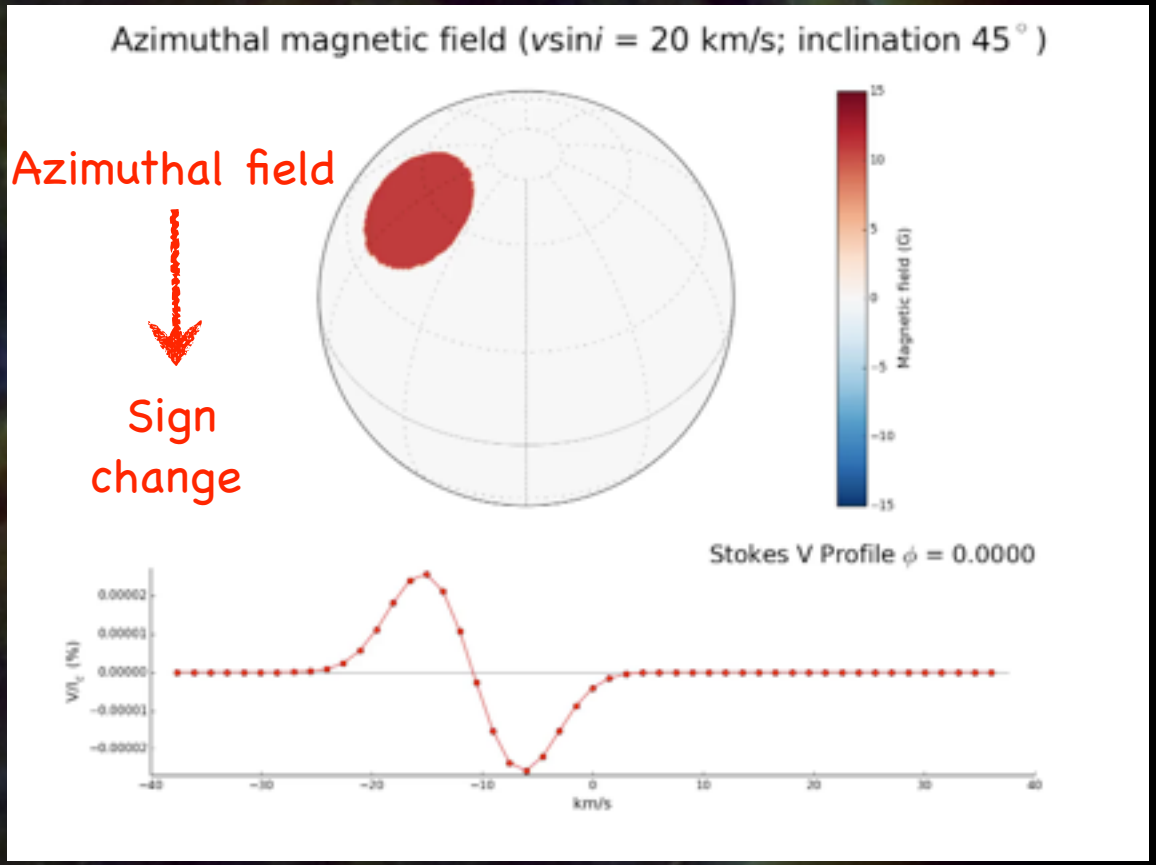
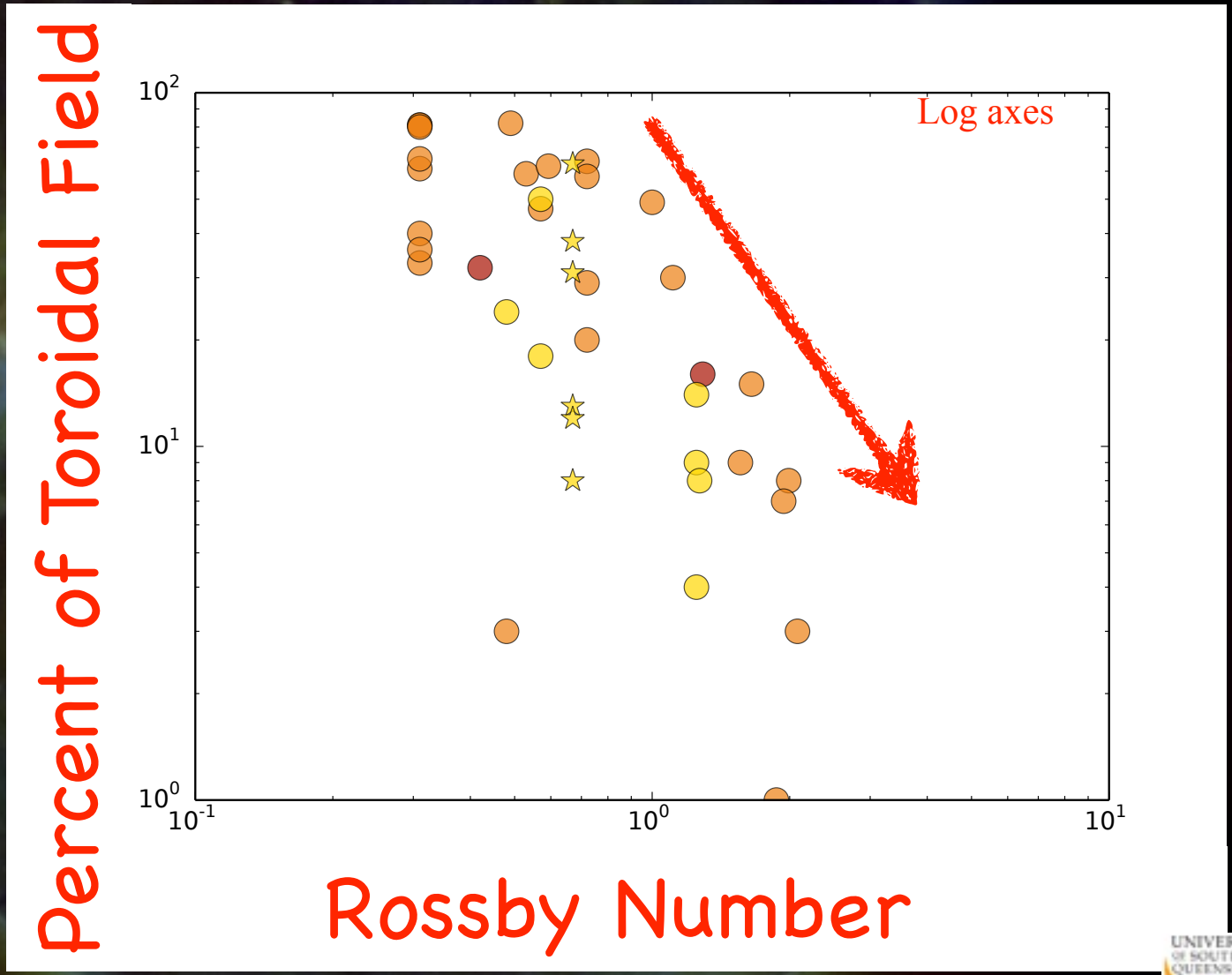


Credit: M Mengel

Toroidal Field

Petit et al. (in prep.)

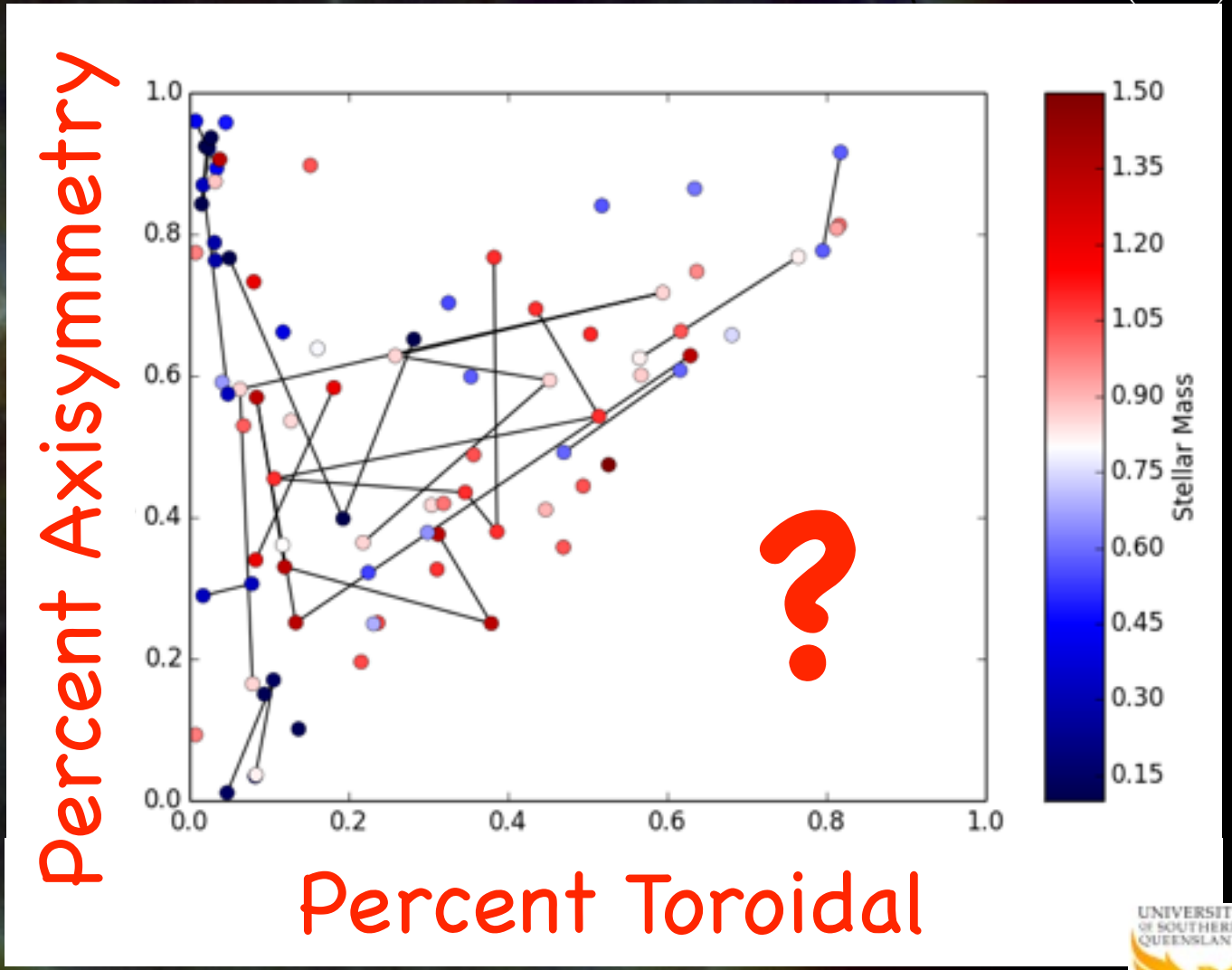
Percent of the Toroidal field appears to decrease with Rossby Number



Axisymmetry

See et al. (2015)

Increased Toroidal field appears to be Axisymmetric



Magnetic Cycles in Solar-Type Stars

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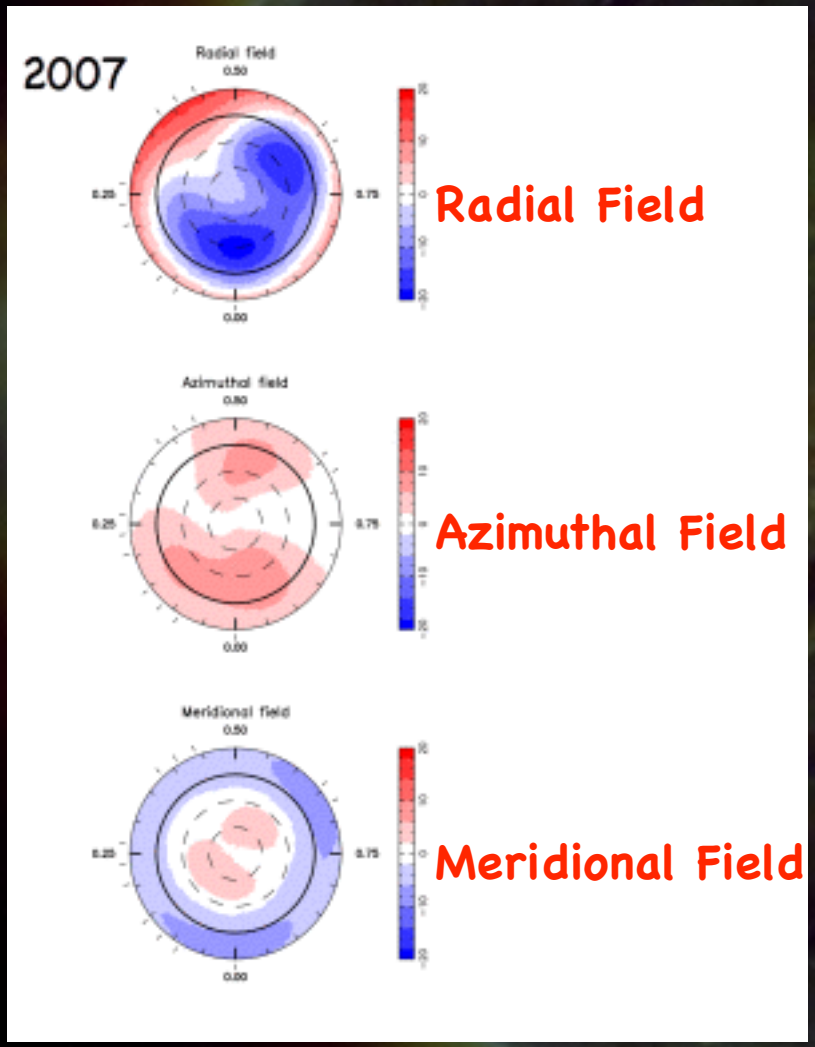
Boro Saikia et al. (submitted)

HD 201091
M = 0.66 M_{Sun}
P_{rot} ~ 34 days
T_{eff} = 4545 ± 40 K
vsin(i) ~ 1.0 km/s



Radial Field

Azimuthal Field

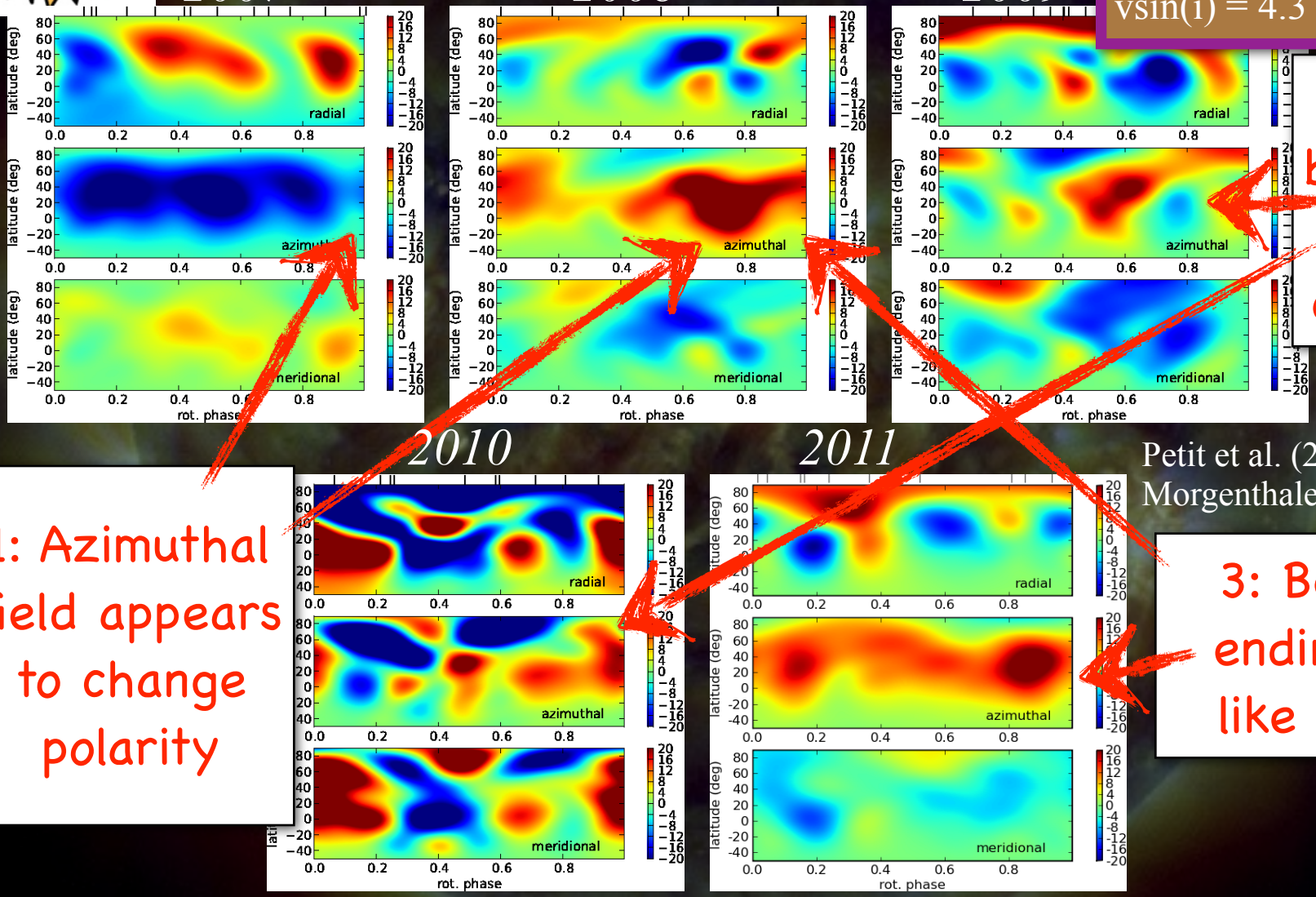
Meridional Field

Shows a simple magnetic cycle :

- Polarity reversal in both Rad. and Azi. fields
- Follows Ca HK cycle
- Increased complexity before reversal

Complex Variability

HD 190771
$M = 0.96 \pm 0.13\ M_{Sun}$
$P_{rot} = 8.8 \pm 0.1$ days
$T_{eff} = 5834 \pm 50$ K
vsin(i) = 4.3 ± 0.5 km/s



1: Azimuthal field appears to change polarity

2: Then becomes more complex

3: Before ending up like 2008

Petit et al. (2009), Morgenthaler et al (2011)

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Space Weather

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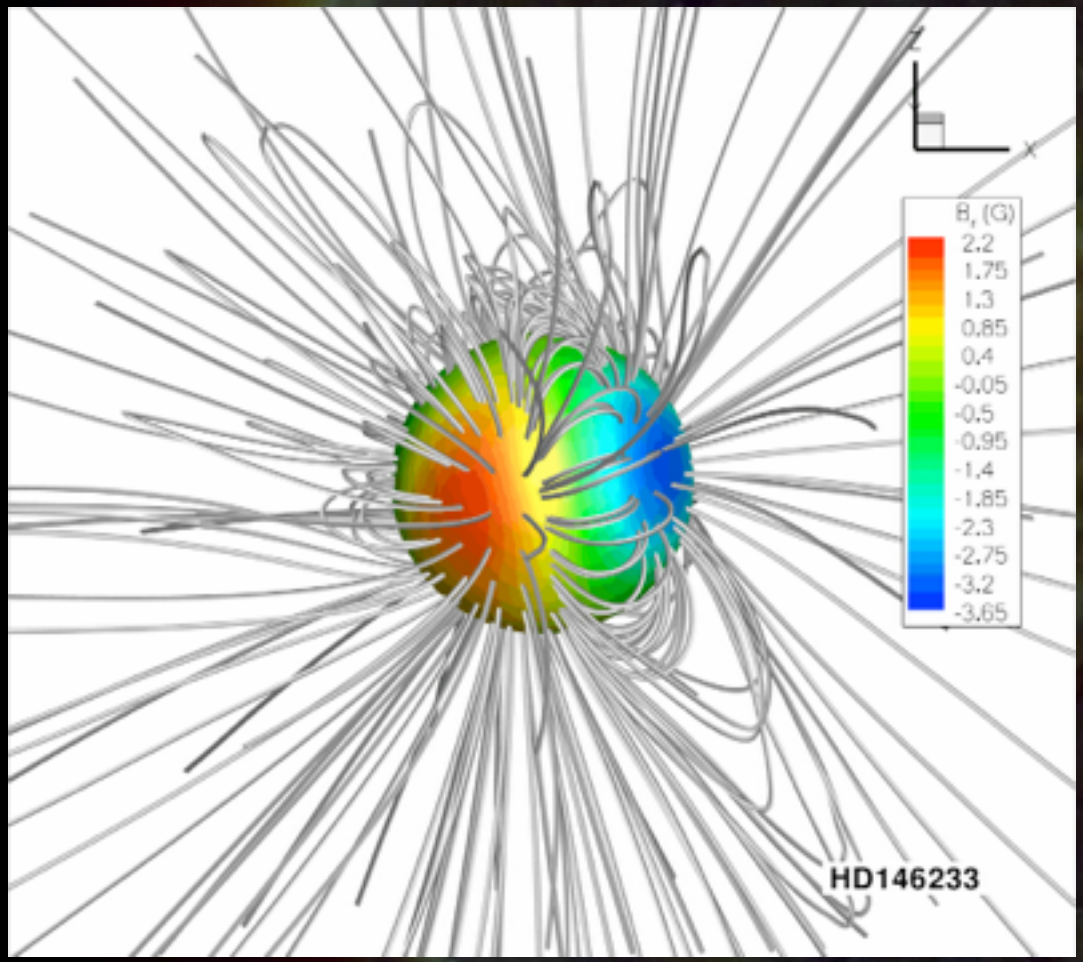
MHD models



Vidotto et al. (in prep.)

From the radial field maps the fields lines are extrapolated into the corona

From these we can use MHD models to model the stellar wind

HD 146233 (18 Sco)
$M = 0.98 \pm 0.13\ M_{Sun}$
$P_{rot} = 22.7 \pm 0.5$ days
$T_{eff} = 5791 \pm 50$ K
$v\sin(i) = 2.1 \pm 0.5$ km/s

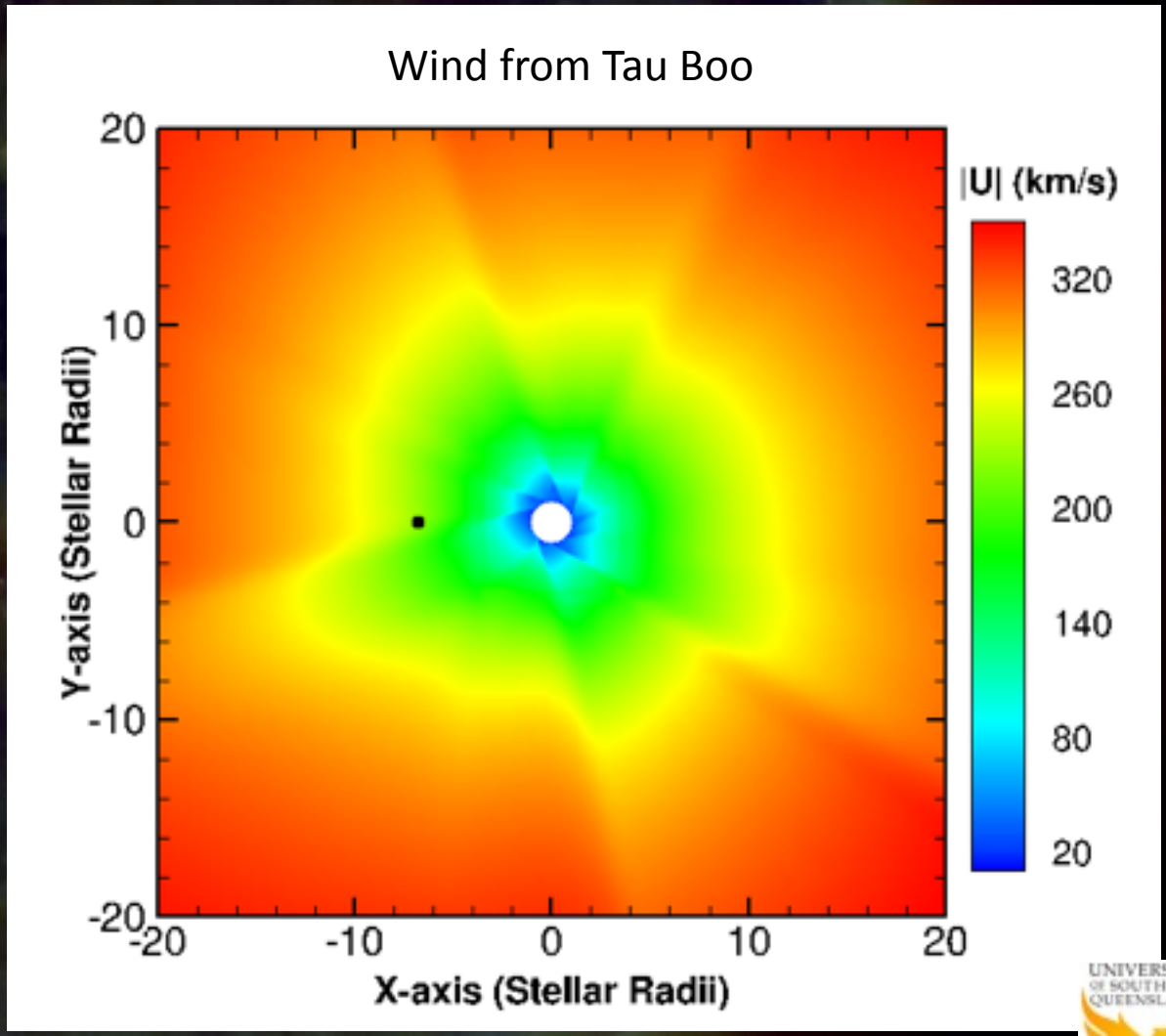
Space Weather

Nicholson et al. (submitted)

Extending the magnetic field lines outwards

Stellar wind map

This wind impacts on the evolution and habitability of exoplanets (talk by Vidotto)



Solar-type star Results (so far)

Over 200 solar-type stars observed in the "snapshot" survey, with ~40% with magnetic detections

20 new mature age stars with magnetic field detections

Different types (simple, complex, etc.) of cycles may be evident in these stars

It would appear that fast polarity switches occur on more rapidly rotating stars

BCool Future Plans

Currently concentrating on expanding the time-base for stars with magnetic maps to look for cycles

In the future we wish to expand the snapshot survey to all bright (V ~ 7.5, ~ 500 targets) solar-type stars

Looking at planet-hosting stars for detections (see poster by Mengel et al.)

We are also focusing on exoplanet host stars so that we can model the effect of stellar winds on real exoplanets (see poster by Nicholson et al.)

Thank you for your attention!

Questions?