Evidence for a bimodal distribution of magnetic fields in cool stars

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T. Gastine, U. Christensen	*MPI for Solar System Research*

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"Angular momentum evolution of cool stars"

Institut für Astrophysik Göttingen

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Outline

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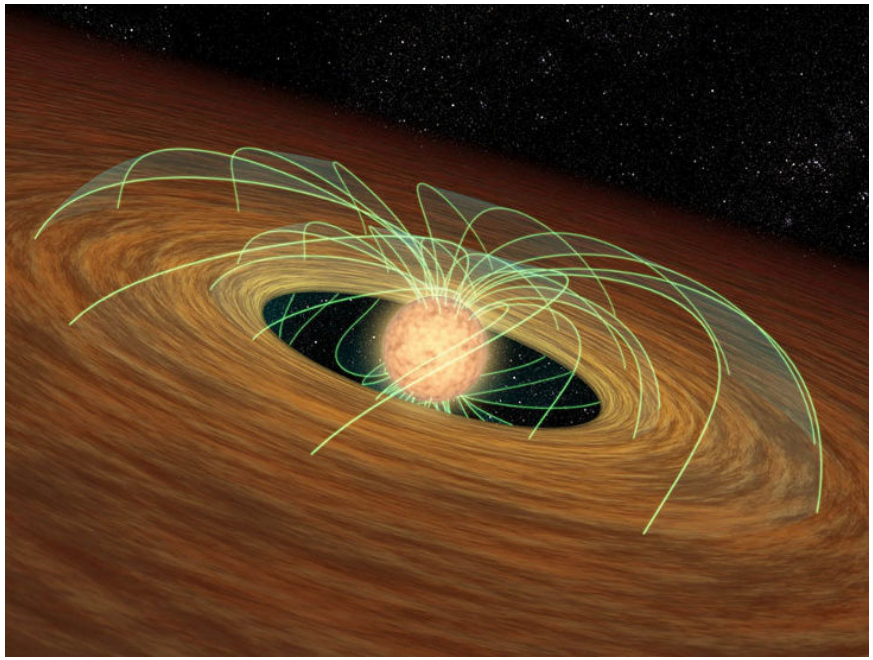
The key role of magnetic fields in rotational evolution

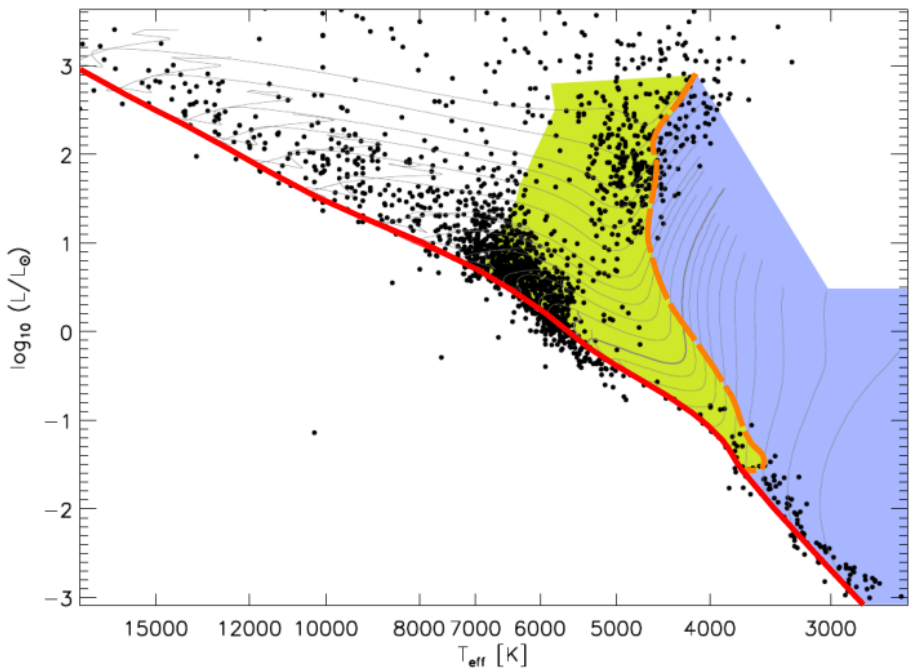
- Magnetospheric accretion
- Braking torque
- Winds/outflows



Credit: NASA / JPL-Caltech / R. Hurt

Dynamo action in cool stars

- **B**(stellar params)
  - Mass, age, rotation
  - Stellar structure
    - Depth of convection zone
    - Partly- *vs* fully- convective
- Fully-convective stars
  - Main sequence M dwarfs
  - Young T Tauri stars
  - ~~Tachocline~~ ➔ ~~solar dynamo~~?



Adapted from Reiners (2007)
from Siess et al. (2002) models

Outline

Measuring stellar magnetic fields

Zeeman effect

- Line splitting/broadening
  - $\Delta\lambda_B = 4.67 \times 10^{-12}\, \lambda_0^2 g_{eff} B$
- Polarization

Unpolarised spectroscopy

- Total field *Bf*
- ~~Geometry~~

Spectropolarimetry

- Field orientation + polarity
- Large-scale component only

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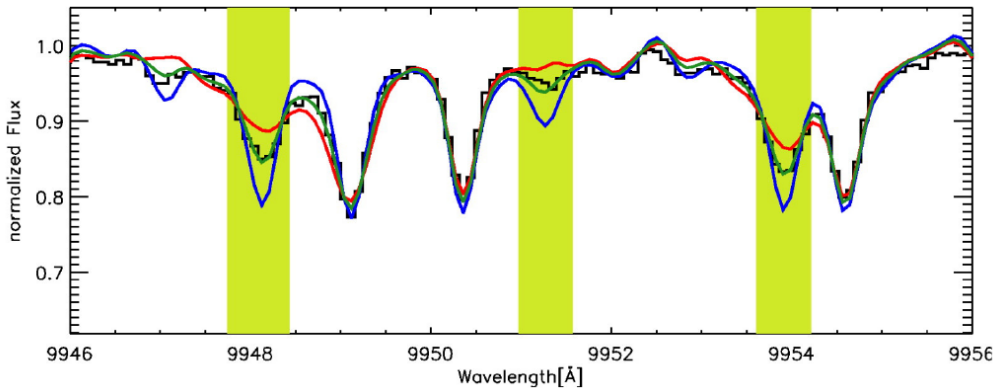

GJ 729, FeH Wing-Ford band

Reiners & Basri (2006)

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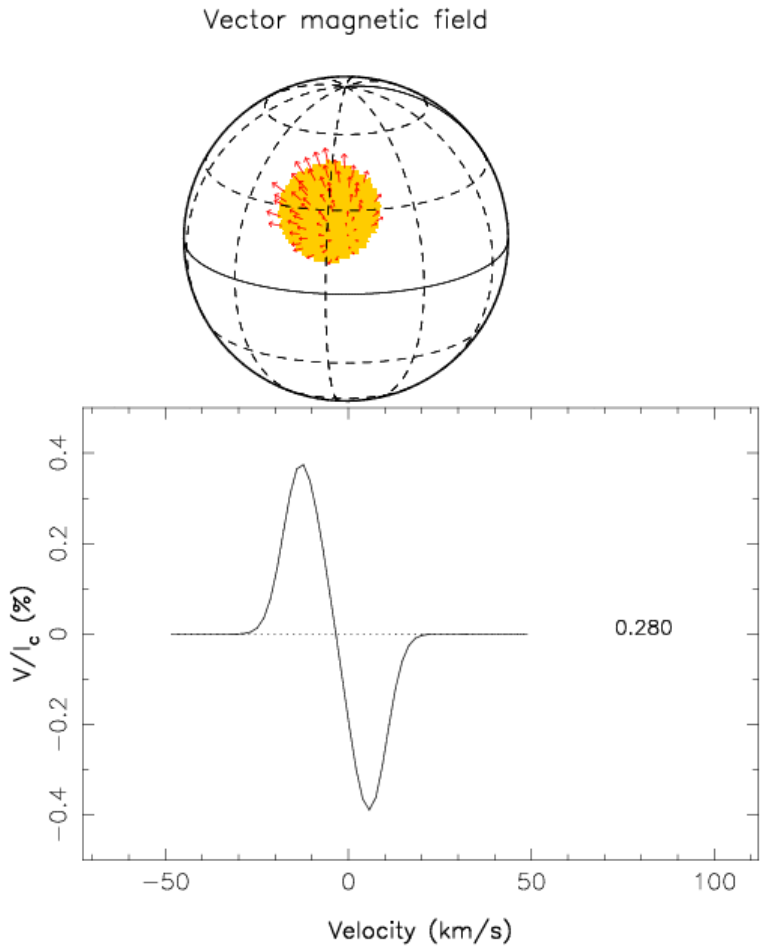

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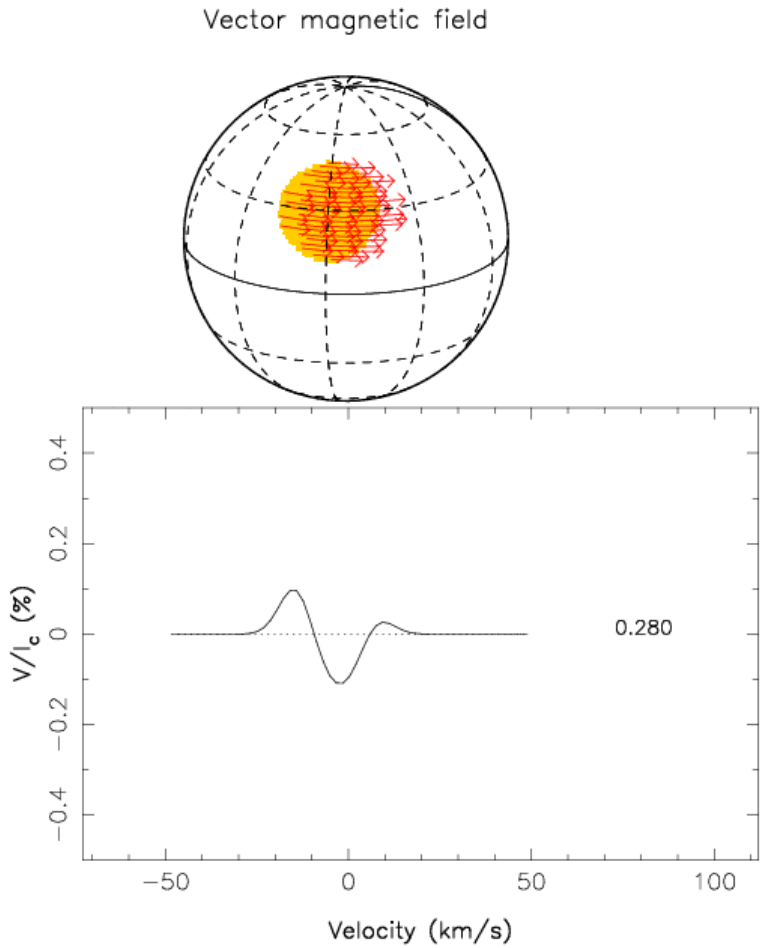
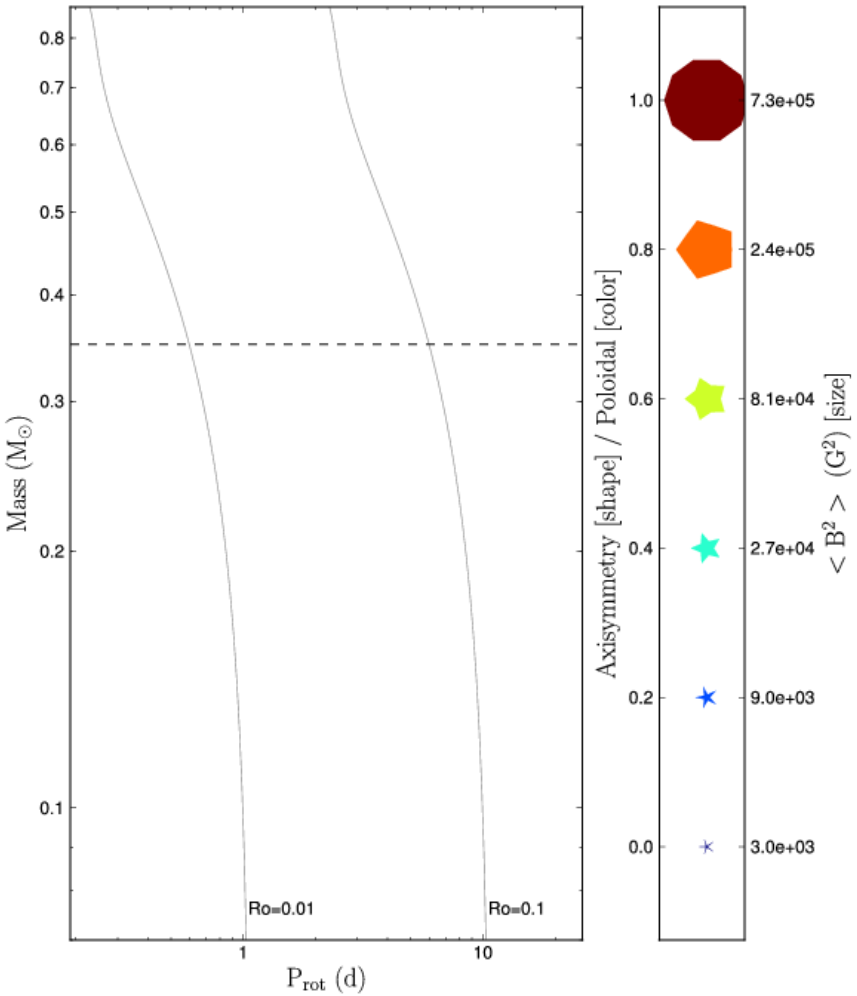


Magnetic fields of M dwarfs



- Spectropolarimetry
  - Fully-convective stars
    - Stronger large-scale **B**
    - Stronger dipolar component
  - Very low mass stars
    - Similar stellar parameters
    - Two distinct magnetisms

  ➥ strong/weak dipole

  Morin, Donati et al. (2008–2010)
- Unpolarized spectroscopy
  - No difference fully-/partly-conv.
  - No bimodal distrib. in spectropol. sample

  ➥ Only large-scale **B** affected

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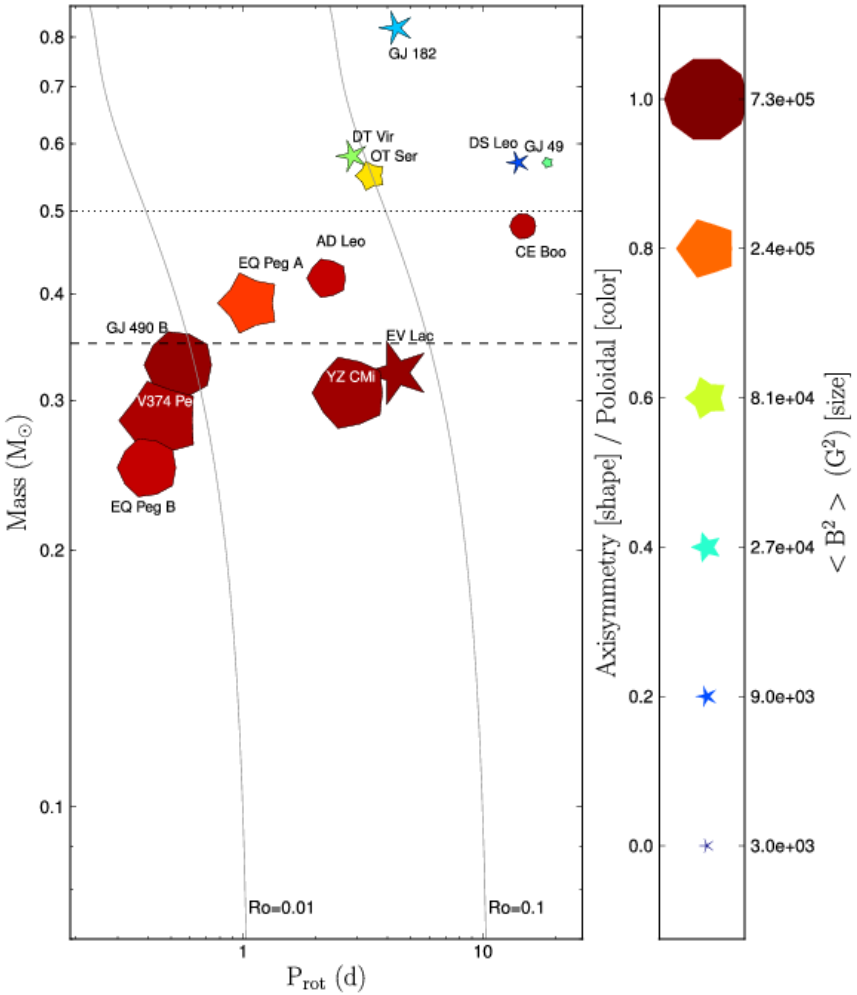

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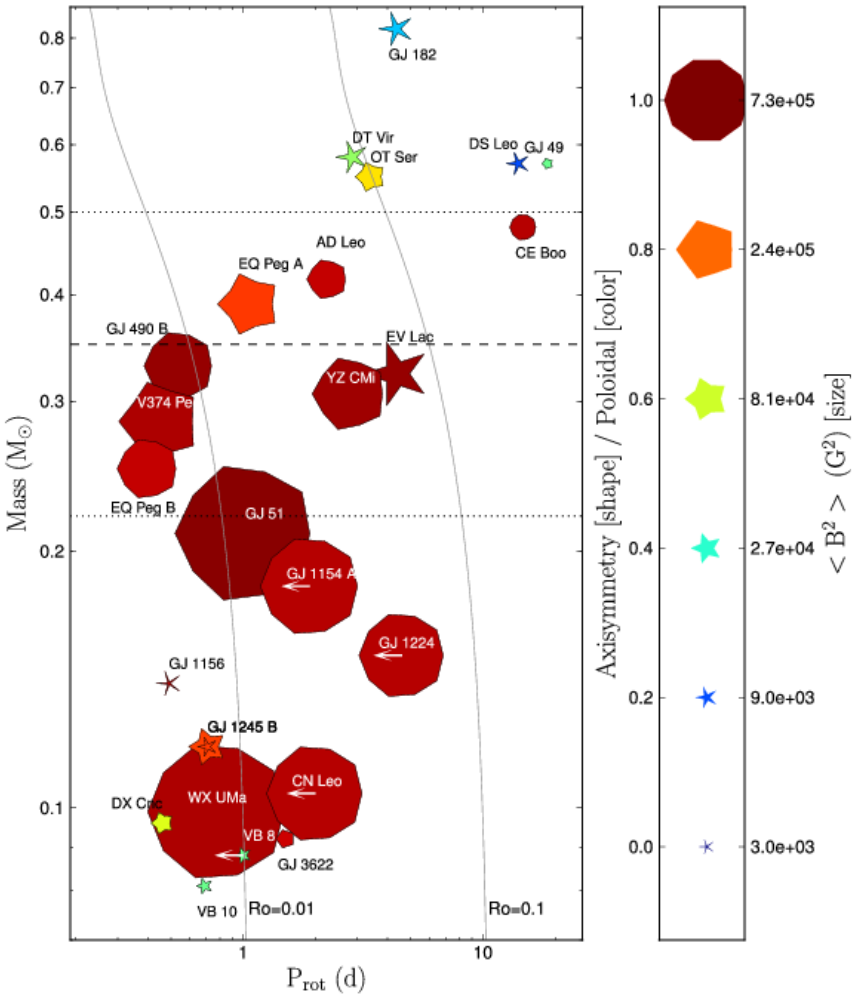

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Dynamo bistability: theory and simulations

- Weak- and strong- field dynamos
  - 2 branches: $\neq$ force balances
  - *Morin, Dormy, Schrinner & Donati (2011)*
- Effect of inertia in DNS
  - Transition to dipole at low Ro_ℓ
    - *Christensen & Aubert (2006)*
  - $\exists$ dipolar and multipolar branches at low Ro_ℓ
    - *Schrinner et al., Gastine et al. (2012)*
  - How does Ro_ℓ depend on stellar params ?
  - New observational constraints
    - Spectropolarimetric observations of M dwarfs, TTS, PMS/ZAMS
    - Relationship dynamo / DR

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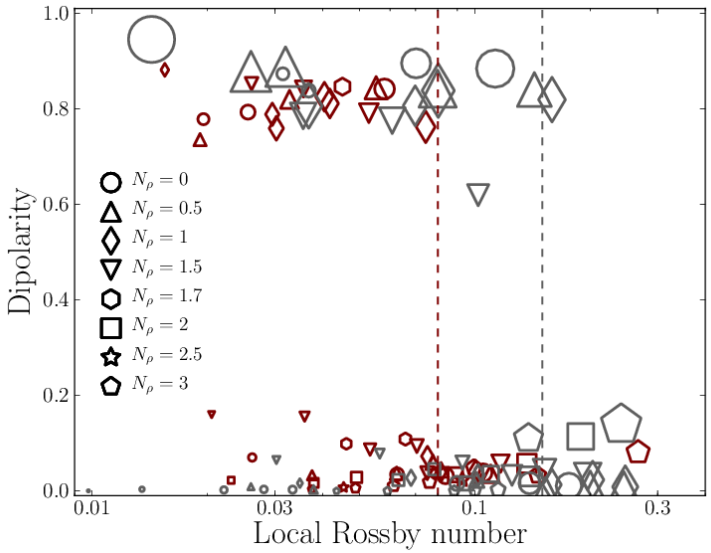
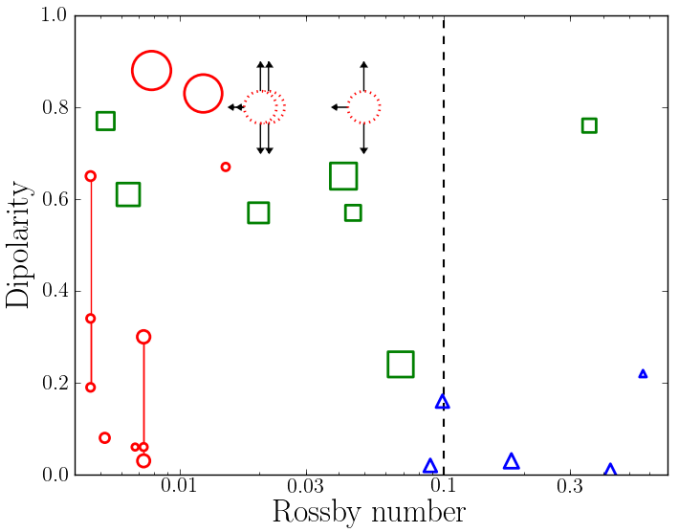


Gastine et al.(2012)



Gastine, Morin et al., in prep.

Outline

Concluding remarks: bimodal distribution of **B** and evolution of angular momentum

- Evidence for dynamo bistability
  - Observations
  - Numerical simulations support
- Which regime of stellar parameters?
  - VLMS fast rotators (low Ro)
  - cTTS? *Donati et al. (2011), Gregory et al. (2012)*
  - Relation w/ *Reiners & Basri (2010)*?
- Importance of small-/large-scale **B** for angular momentum evolution?

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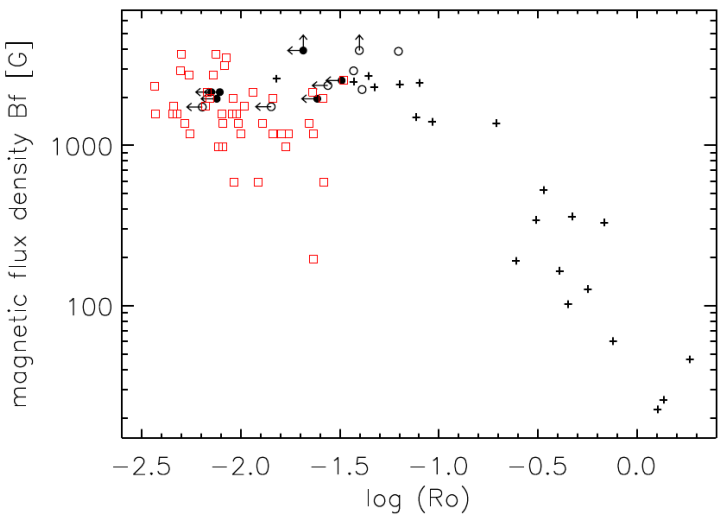

Reiners & Basri (2010)

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➔ Talk by A. Reiners

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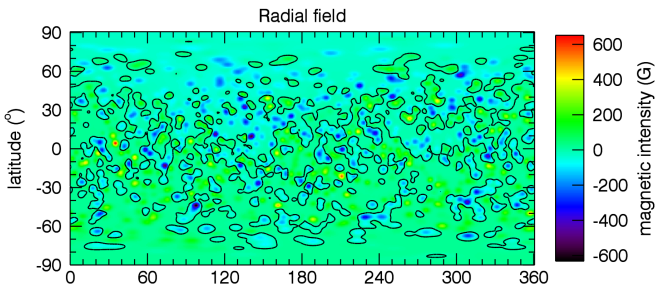

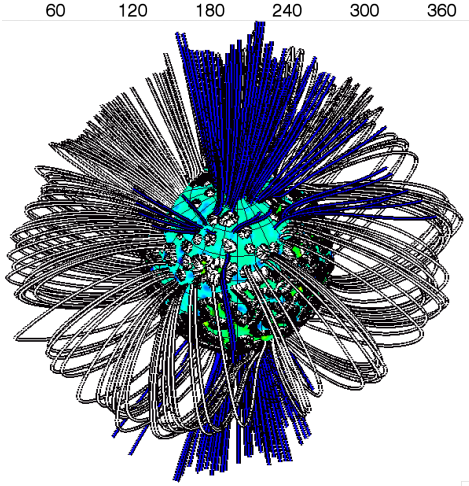

➔ Posters by M. Jardine and A. Vidotto