Connecting the large- with the small-scale surface magnetic field of solar-like stars

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Magnetic field properties of cool stars

Donati (2011)
Magnetic field properties of cool stars

Donati (2011)
Spherical harmonics

Dipole
- $l = 1$
- $m = 0$

Quadrupole
- $l = 2$
- $m = 0$

Single Harmonics

$cos(m\phi) \ P_l^m(cos \theta)$

atmos.albany.edu
What is the magnetic topology of the Sun observed as a star?

- Large scale field up to $l=190$
- Large + small scale field up to $l=5$ or $10$
Magnetic field simulations

- Magnetic flux transport model
- Non-potential coronal evolution
- Magnetofrictional technique
- Flux emergence model based on averaged solar data from 2010/01 – 2011/01

Video Gibb et al. (2016)
Stellar properties

Differential Rotation

Flux Emergence Rate
Magnetic field geometry of the simulations

Lehmann et al. (2017)

compare the simulations with the observation
The observations including results from the Bcool and Toupies survey were published by Petit (in preparation), Boro Saikia et al. (2015), do Nascimento et al. (2014), Donati et al. (2003, 2008), Fares et al. (2009, 2010, 2012, 2013), Folsom et al. (2016), Morin et al. (2008a,b, 2010), Jeffers et al. (2014), Petit et al. (2008), and Waite et al. (2011).
... for different field scales

\[
\langle B^2_{\text{tor}} \rangle \quad (G^2)
\]

\[
\langle B^2_{\text{pol}} \rangle \quad (G^2)
\]

\[
\begin{align*}
\text{Simulations} & \\
& l \leq 3 \text{ to } l \leq 28 \\
& l \leq 2 \\
& l = 1
\end{align*}
\]

Lehmann et al. subm.
Axisymmetry vs. Toroidal

Lehmann et al. subm.

Lisa T. Lehmann - Magnetic Field Geometry of Solar-Like Stars

29/08/2017
Large-scale magnetic field topology

Lehmann et al. subm.
Magnetic field properties of cool stars

Donati (2011)

Strong field
Weak field
Poloidal
Toroidal
Axi-symmetric
Non axi-symmetric
1. The **flux transport simulations** fit the observed solar-like stars.
   - Show the following trends with:
     - **Differential Rotation**
       - Increases the fraction of toroidal field
       - Increases the axial-symmetry
     - **Flux Emergence Rate**
       - Enhances all field components
       - Enhances the effects of DR

2. We **reconstructed** the **ZDI maps** from the simulations.
   - The reconstruction of the radial and azimuthal field structure is often successful.
Thank you!

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paper:

or as arxiv link:
https://arxiv.org/abs/1610.08314