

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

Lisa T. Lehmann

Moira M. Jardine, Gaitee A. J. Hussain

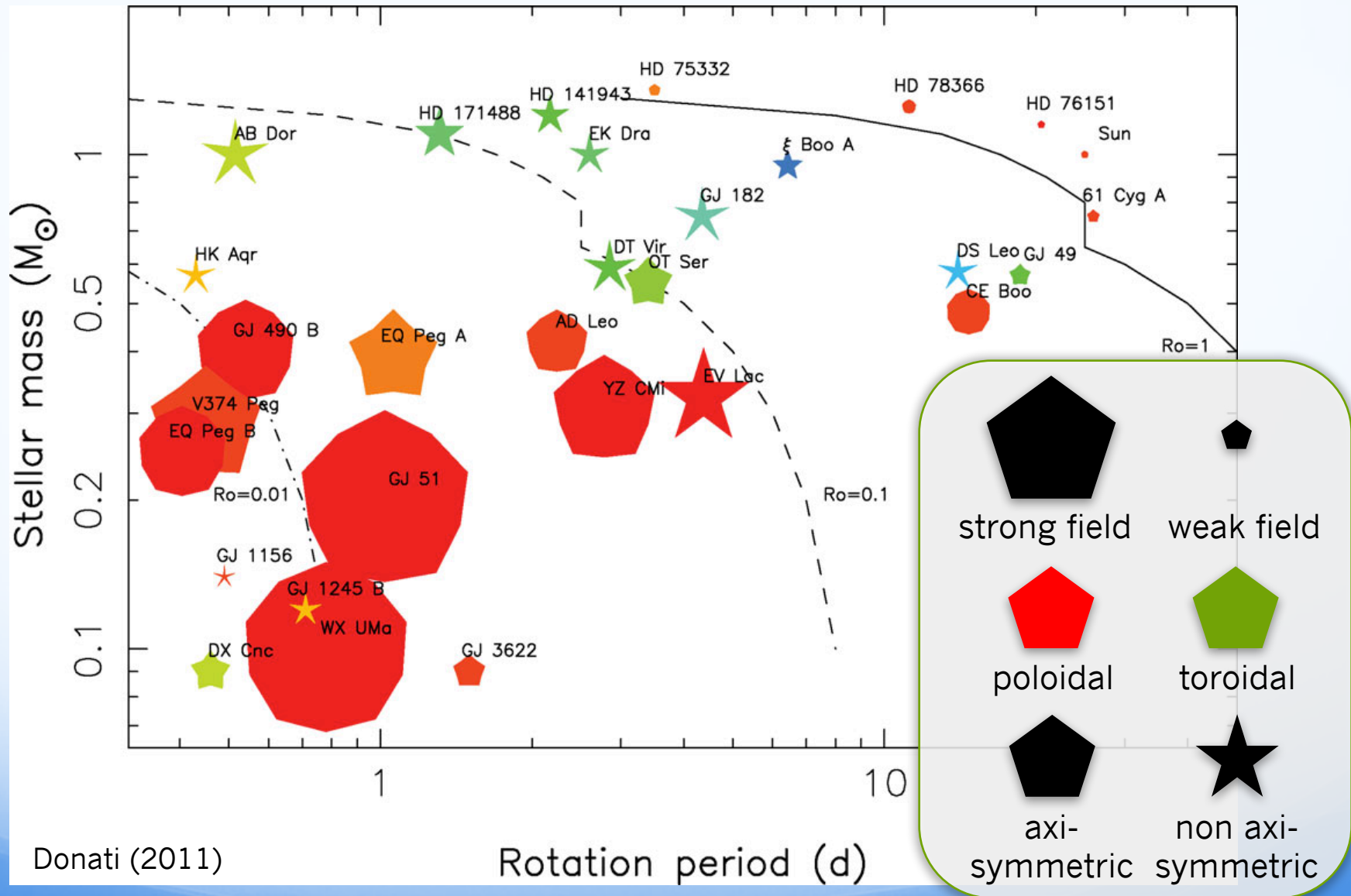
Brno - 29<sup>th</sup> August 2017



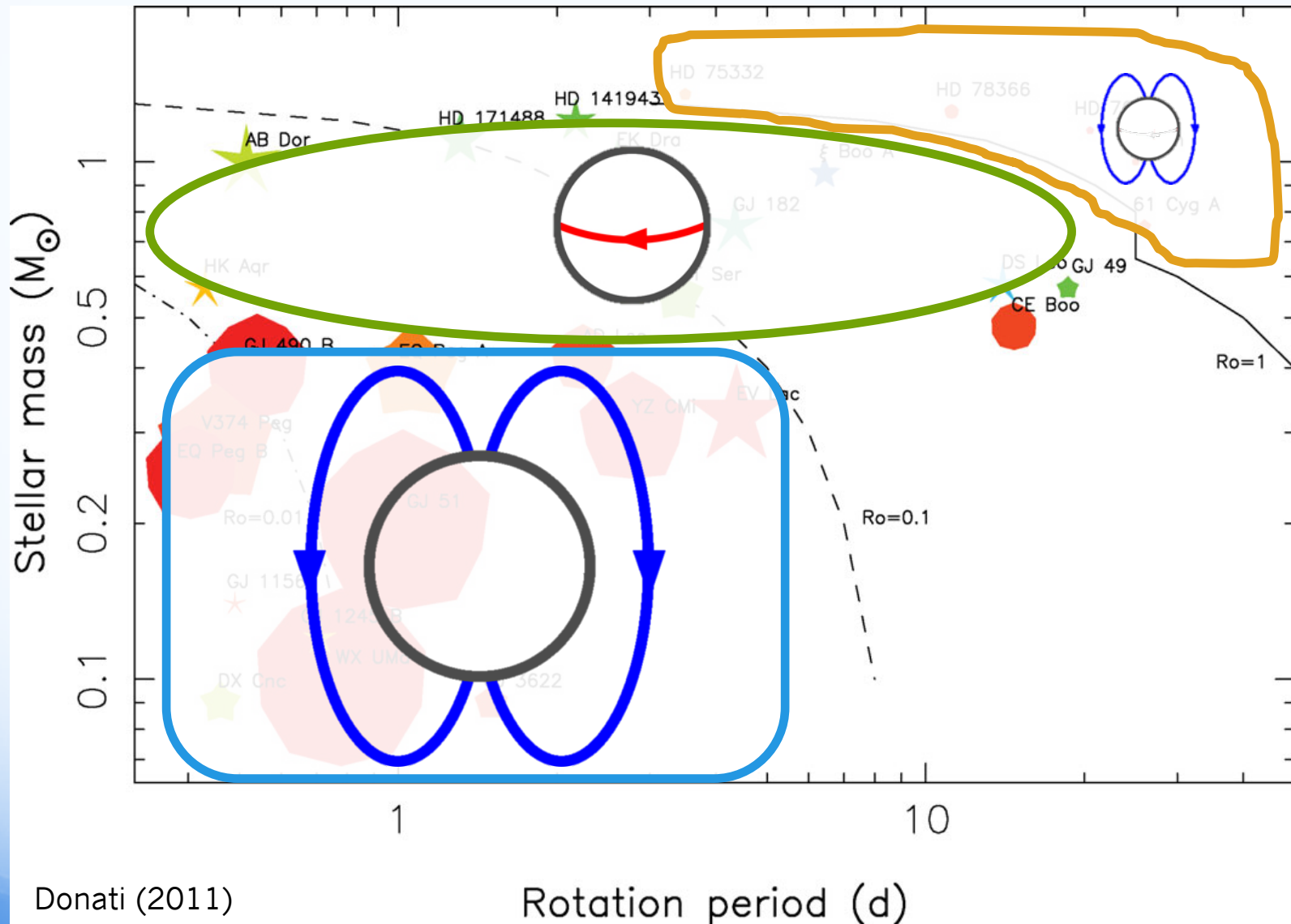
University of  
St Andrews | FOUNDED  
1413 |



# Magnetic field properties of cool stars

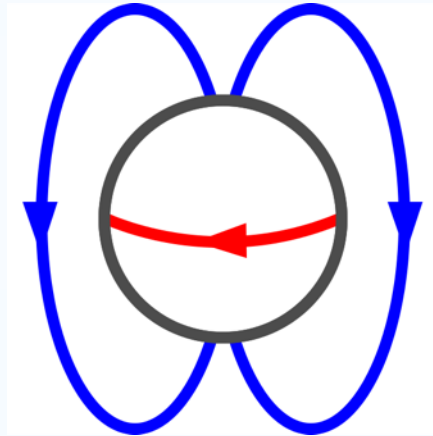


# Magnetic field properties of cool stars

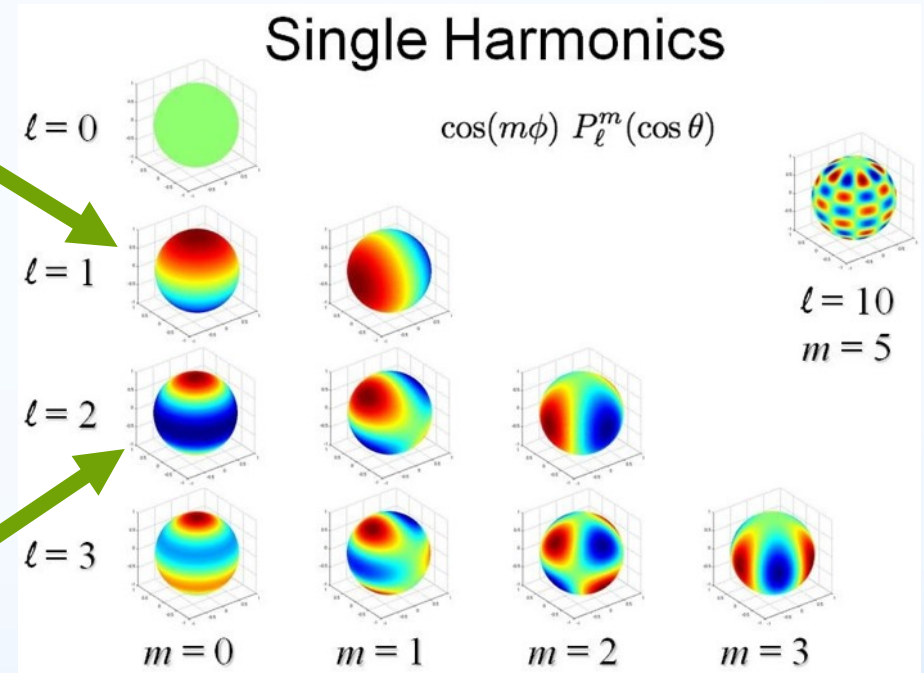
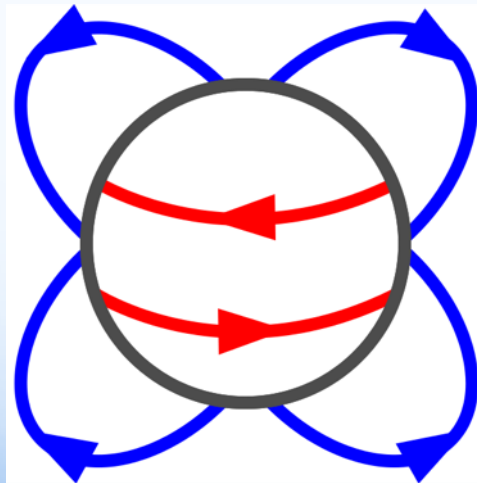


# Spherical harmonics

Dipole  
 $l = 1$   
 $m = 0$



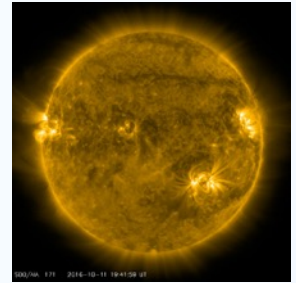
Quadrupole  
 $l = 2$   
 $m = 0$



atmos.albany.edu

# What is the magnetic topology of the Sun observed as a star?

Large +  
small scale  
field up to  
 $l=190$

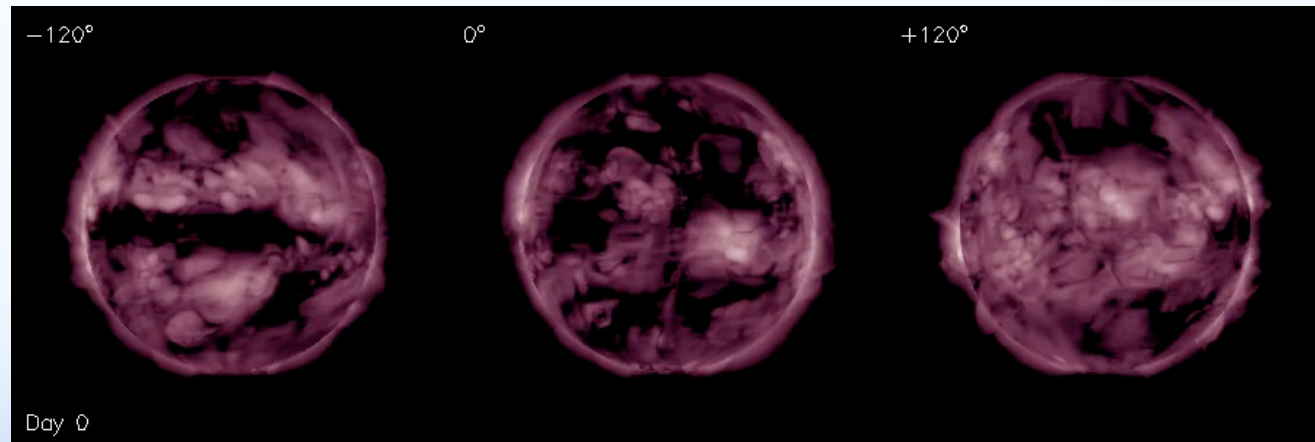
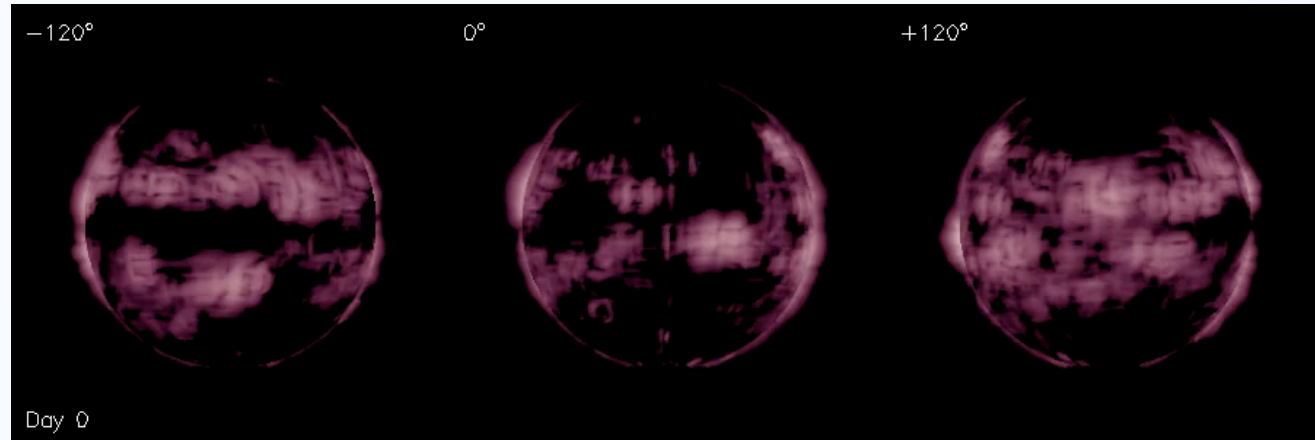


Large scale  
field up to  
 $l=5$  or  $10$



# Magnetic field simulations

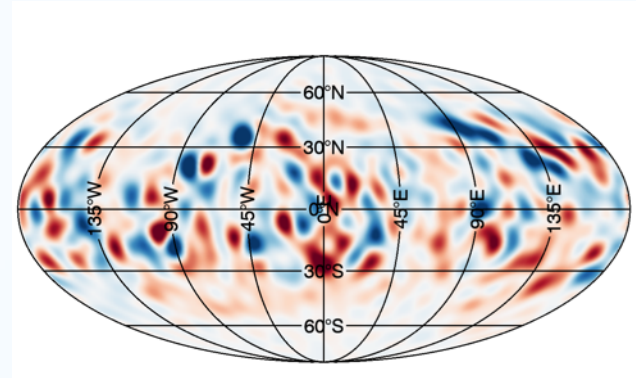
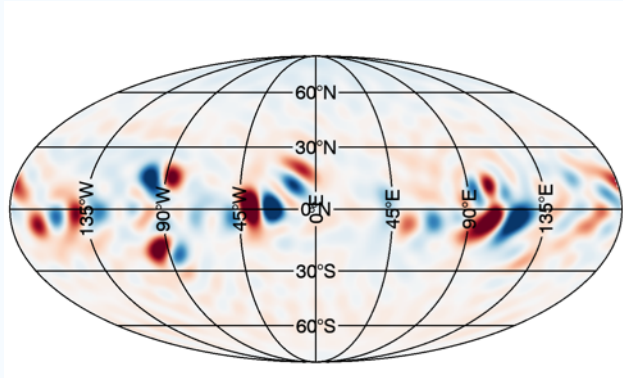
- Magnetic flux transport model
- Non-potential coronal evolution
- Magnetofrictional technique
- Flux emergence model based on averaged solar data from 2010/01 – 2011/01



Video

Gibb et al. (2016)

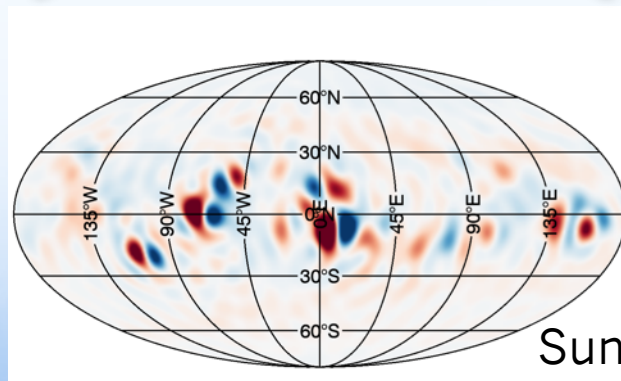
# Stellar properties



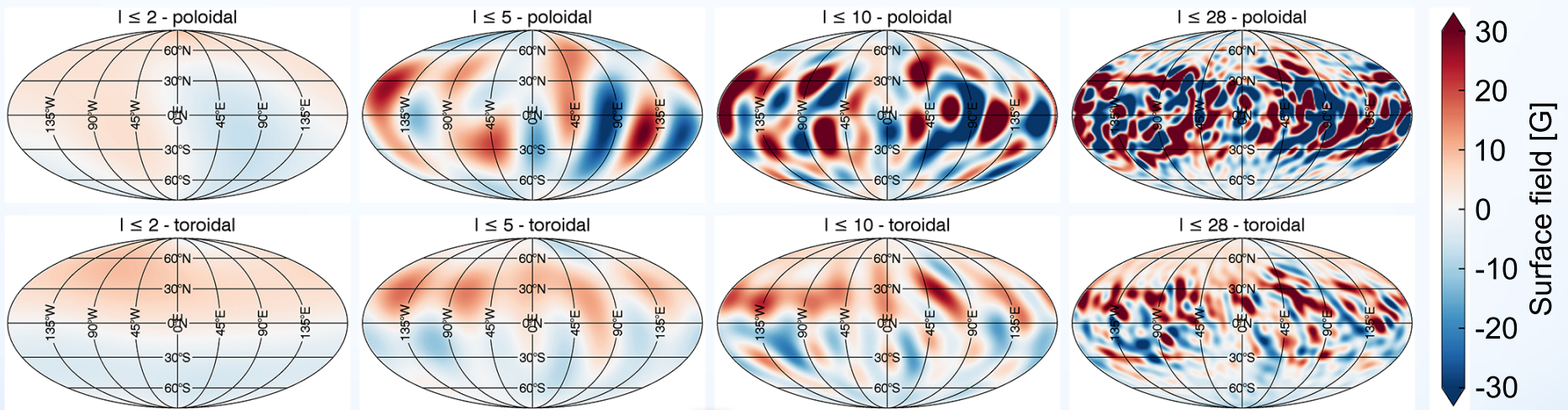
Differential  
Rotation



Flux Emergence  
Rate



# Magnetic field geometry of the simulations



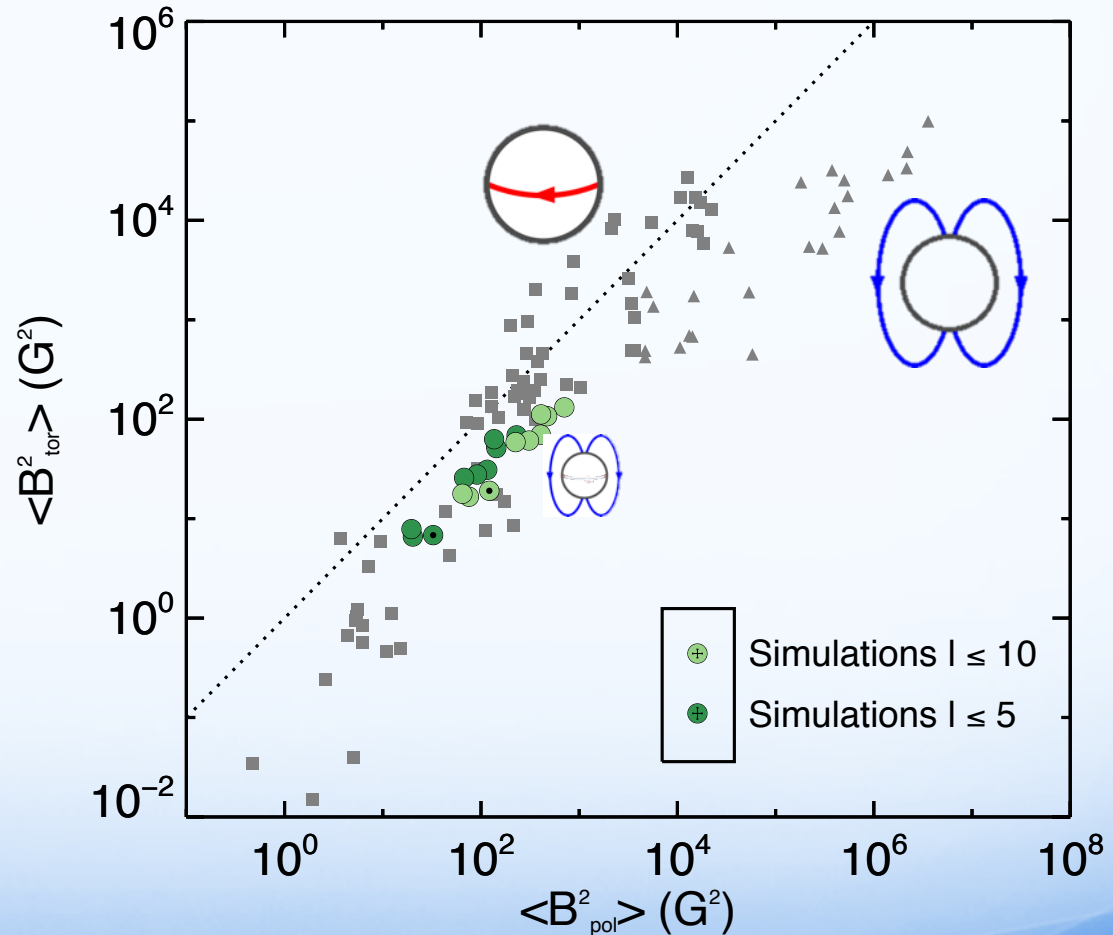
Lehmann et al. (2017)

compare the simulations  
with the observation



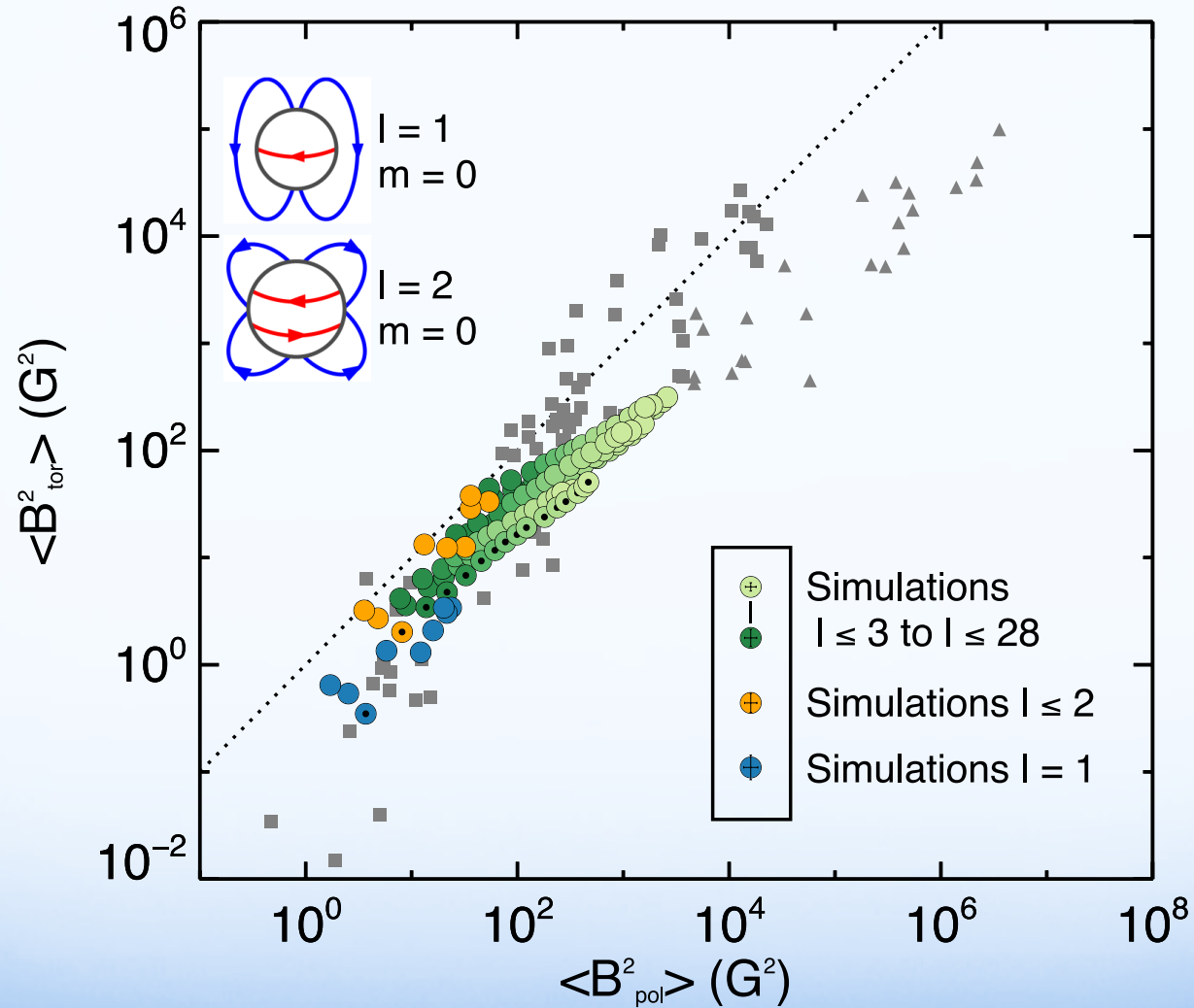
# Magnetic energy in the toroidal and poloidal field

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).



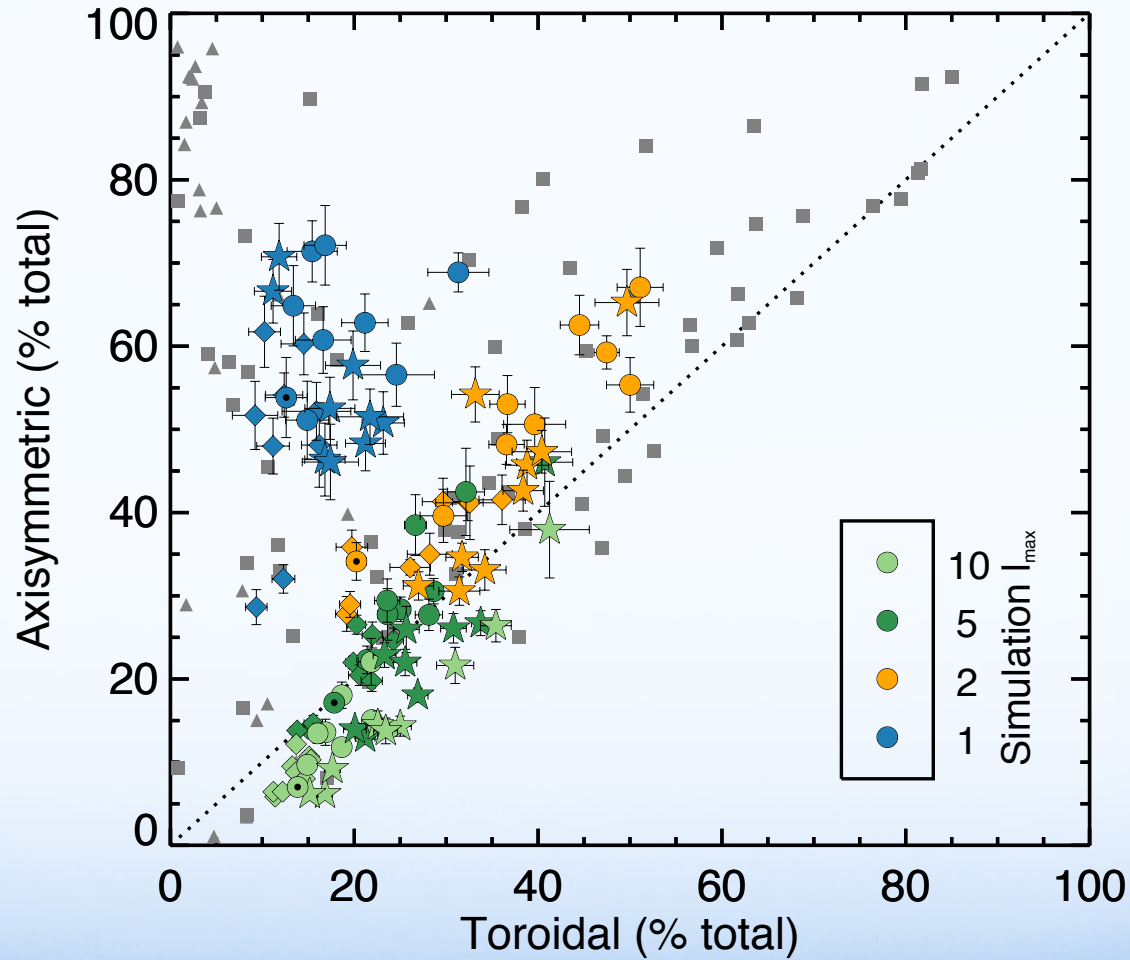
Lehmann et al. subm.

# ... for different field scales



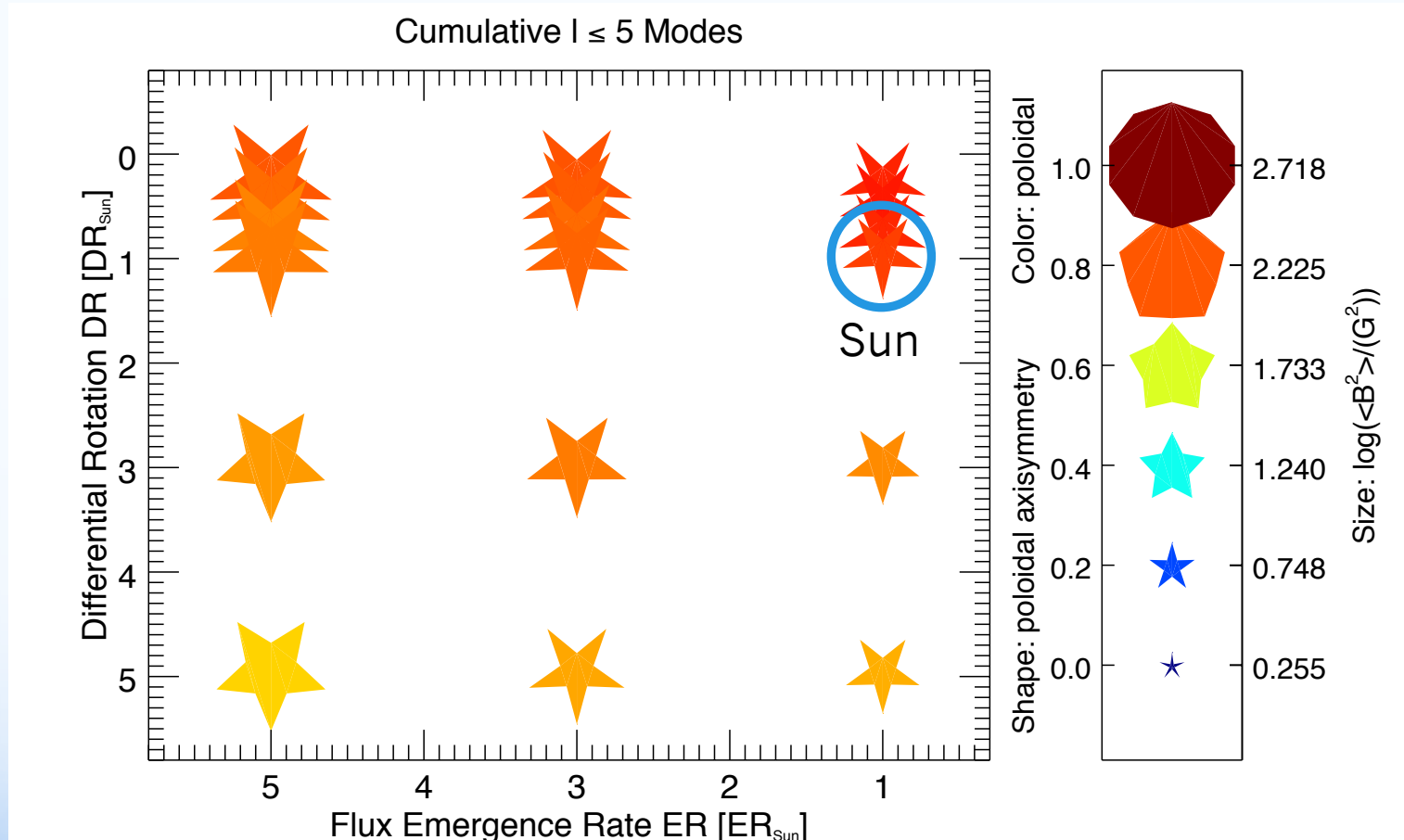
Lehmann et al. subm.

# Axisymmetry vs. Toroidal



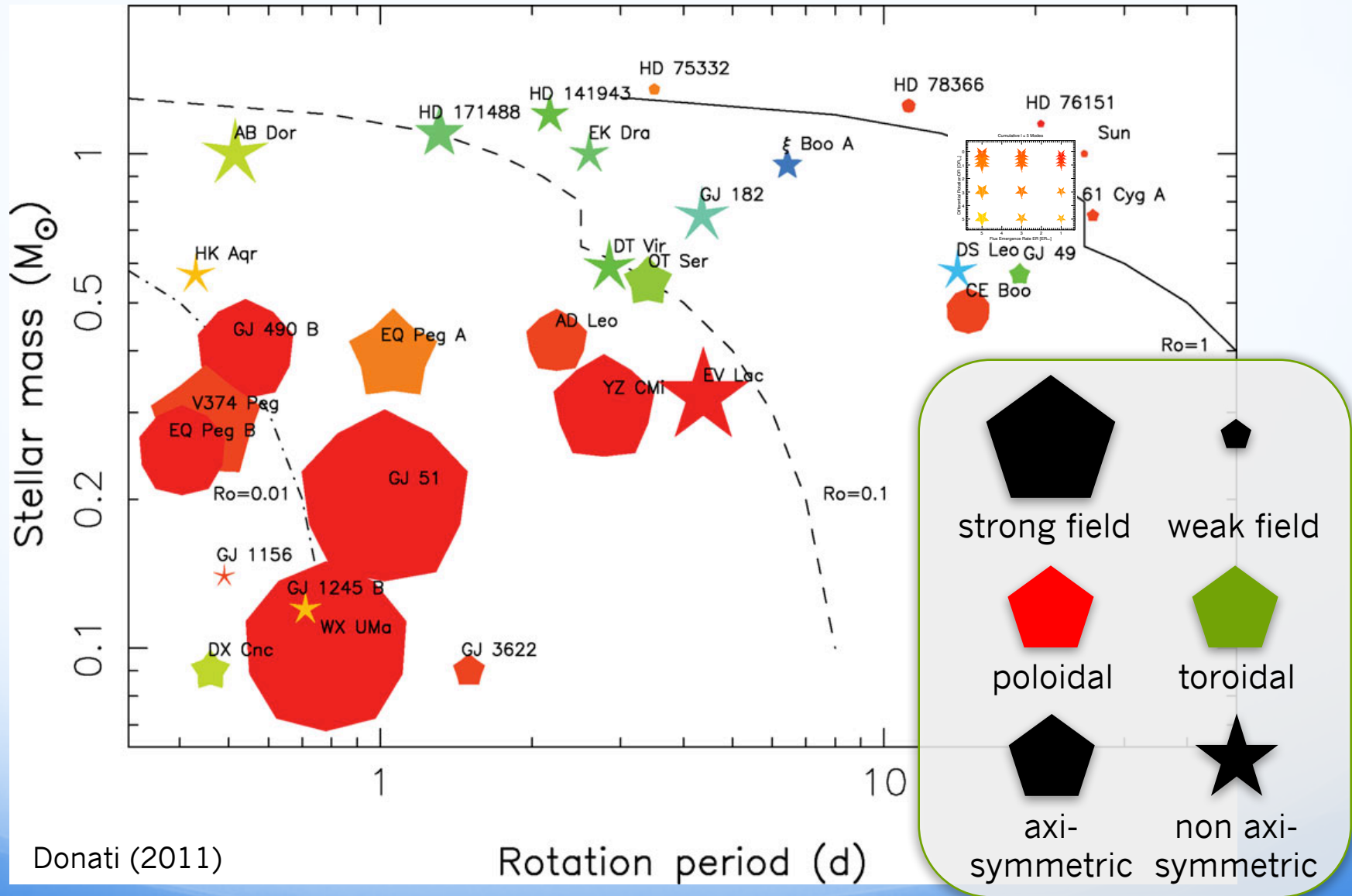
Lehmann et al. subm.

# Large-scale magnetic field topology



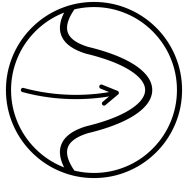
Lehmann et al. subm.

# Magnetic field properties of cool stars



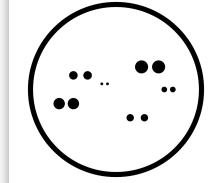
# Summary

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 axisymmetry



Flux Emergence Rate

- Enhances all field components
- Enhances the effects of DR

2.

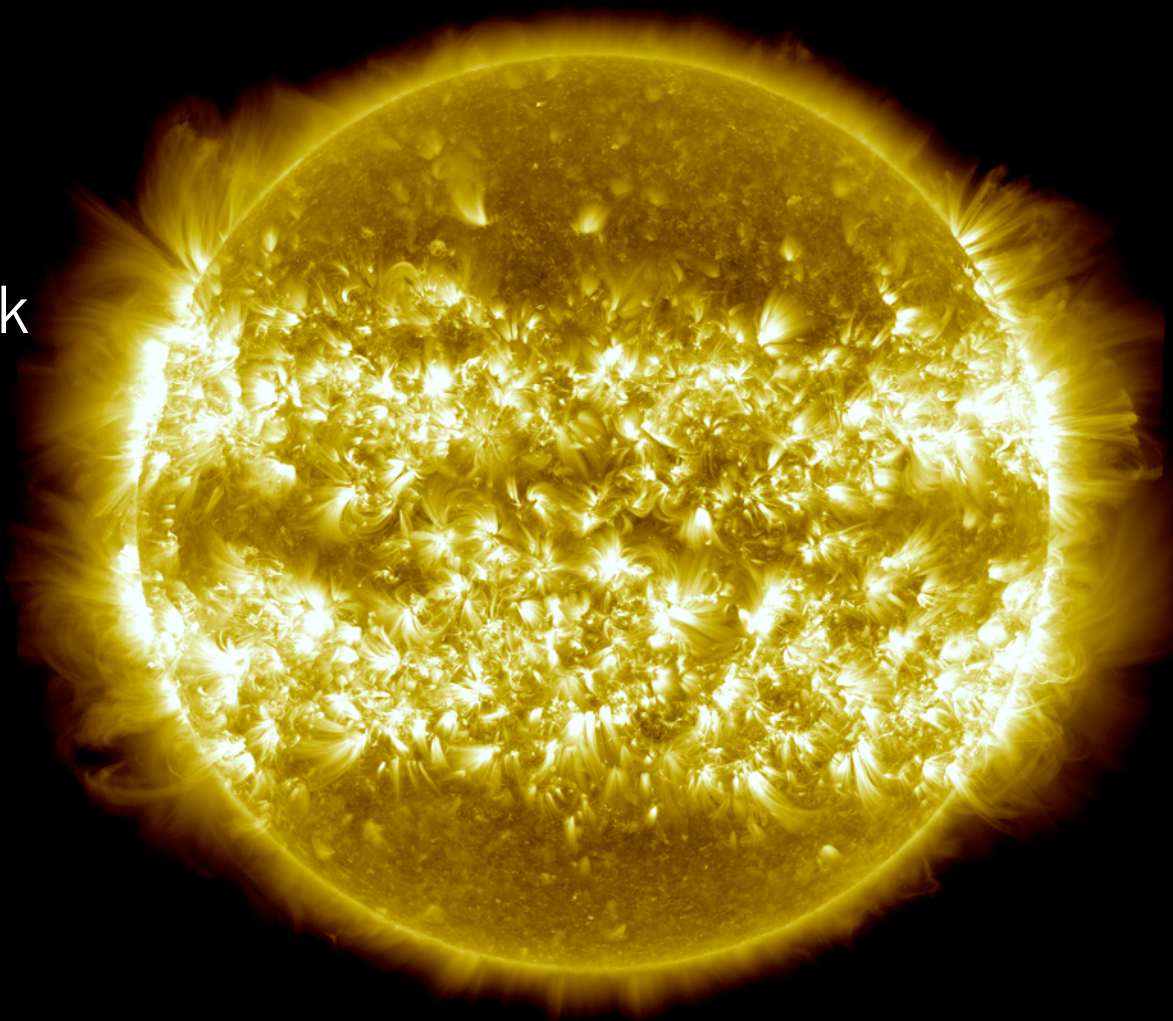
- We **reconstructed** the **ZDI maps** from the simulations
- The reconstruction of the radial and azimuthal field structure is often successful

# Thank you!

e-mail:  
ljl (at) st-andrews.ac.uk

paper:  
Lehmann et al, 2017,  
MNRAS, 466L, 24L

or as arxiv link:  
[https://arxiv.org/abs/  
1610.08314](https://arxiv.org/abs/1610.08314)



SDO, Nasa