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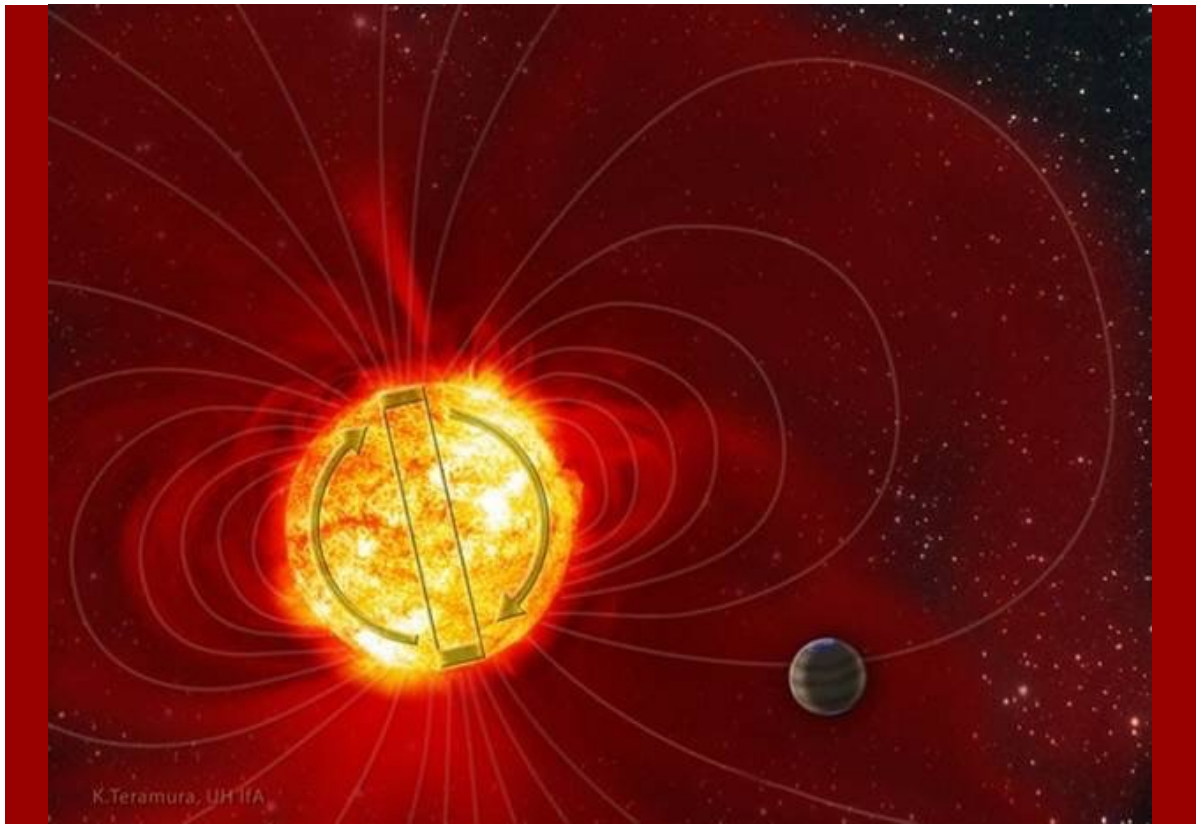


The Magnetic Fields of Planet-Hosting Stars

Matthew Mengel
BCool Workshop 2016, Vienna

Image Credit: Karen Teramura/University of Hawaii Institute for Astronomy

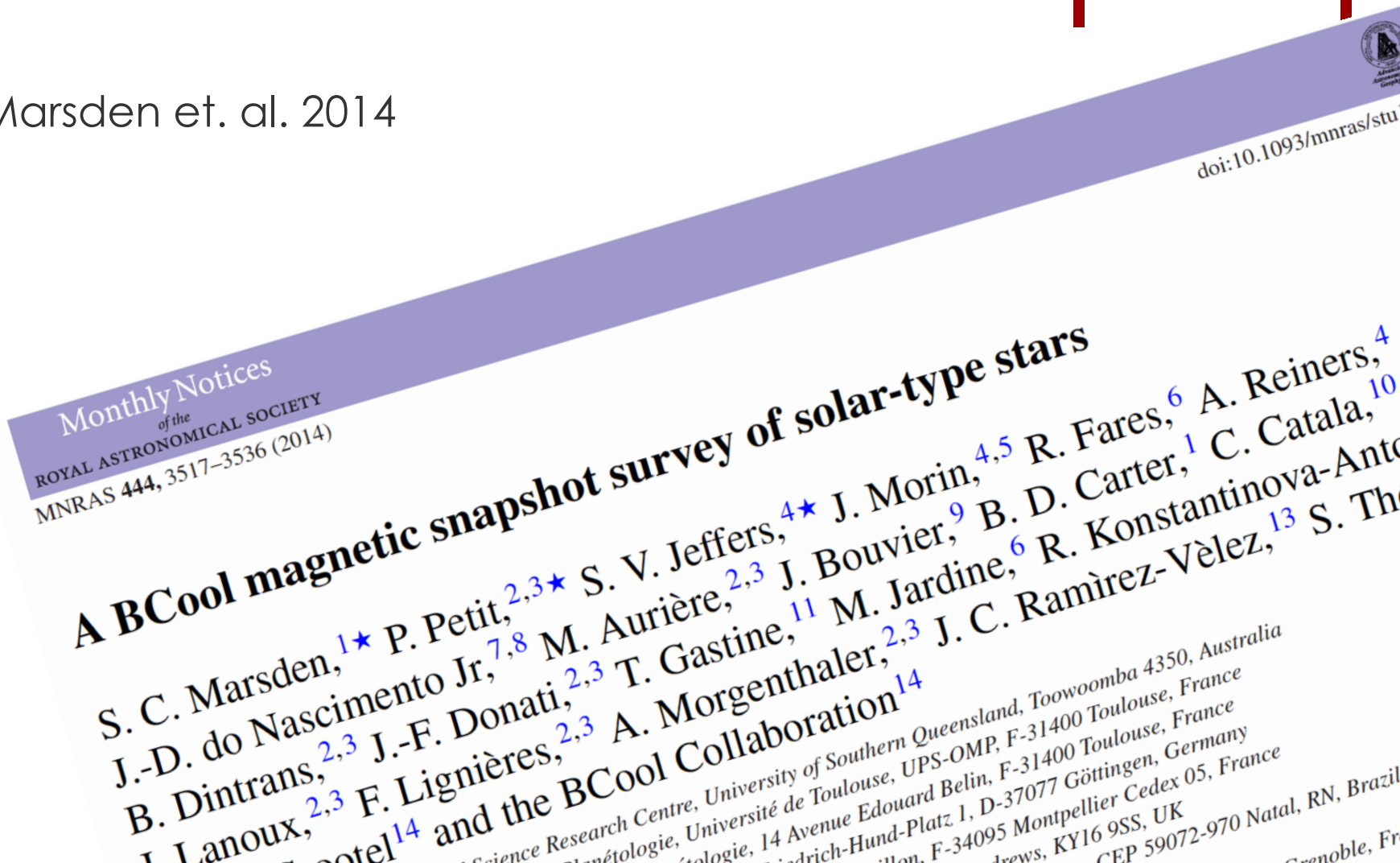
Me…

- PhD Student, University of Southern Queensland
- Supervisors Stephen Marsden, Brad Carter, Rim Fares
- Magnetic fields of planet hosting stars
- Tau Boo, Tau Boo, Tau Boo…..

- All figures/pictures by the author unless different image credit shown.

The BCool Survey

- Marsden et. al. 2014



Monthly Notices of the ROYAL ASTRONOMICAL SOCIETY
MNRAS 444, 3517–3536 (2014)
doi:10.1093/mnras/stu

A BCool magnetic snapshot survey of solar-type stars

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Planet Hosting Stars Survey

- 19 Stars
- Target list chosen:
  - Planet hosting stars
  - Approximate BCool criteria:
    - $5100K < T_{eff} < 6300K$
    - $M_{\star} < 1.5\ M_{\odot}$
    - Visible at TBL ($V < 9$; decl. $> -10^{o}$)
- Paper in Preparation now

Image credit: By Pascal Petit - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=3154064

Planet Hosting Stars Survey

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- Measured longitudinal magnetic field, B_ℓ

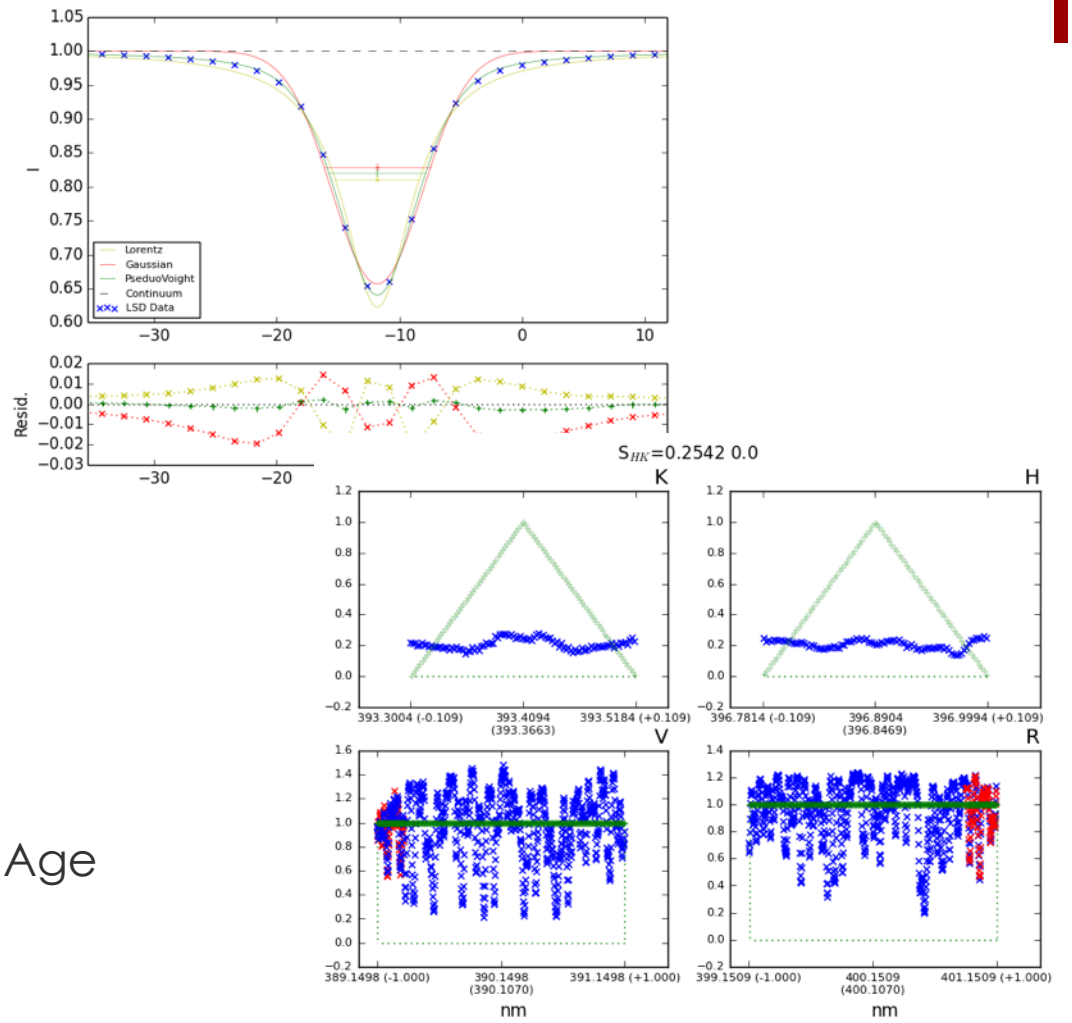
$$B_\ell = -2.14 \times 10^{11} \frac{\int vV(v)dv}{\lambda_0 g_0 c \int [I_c - I(v)]dv}$$

(Donati et al 1997, Mathys, 1989)

- Determined if magnetic detection (FAP < 10^{-5} for definite)

Planet Hosting Stars Survey

- Measured radial velocity
- Stellar activity proxies
  - Ca II H &K (S-Index)
  - Ca II IRT
  - Hα
- Derived:
  - log(R'_{HK})
  - log(P_{rot}/τ), Chromospheric Age



HR Diagram

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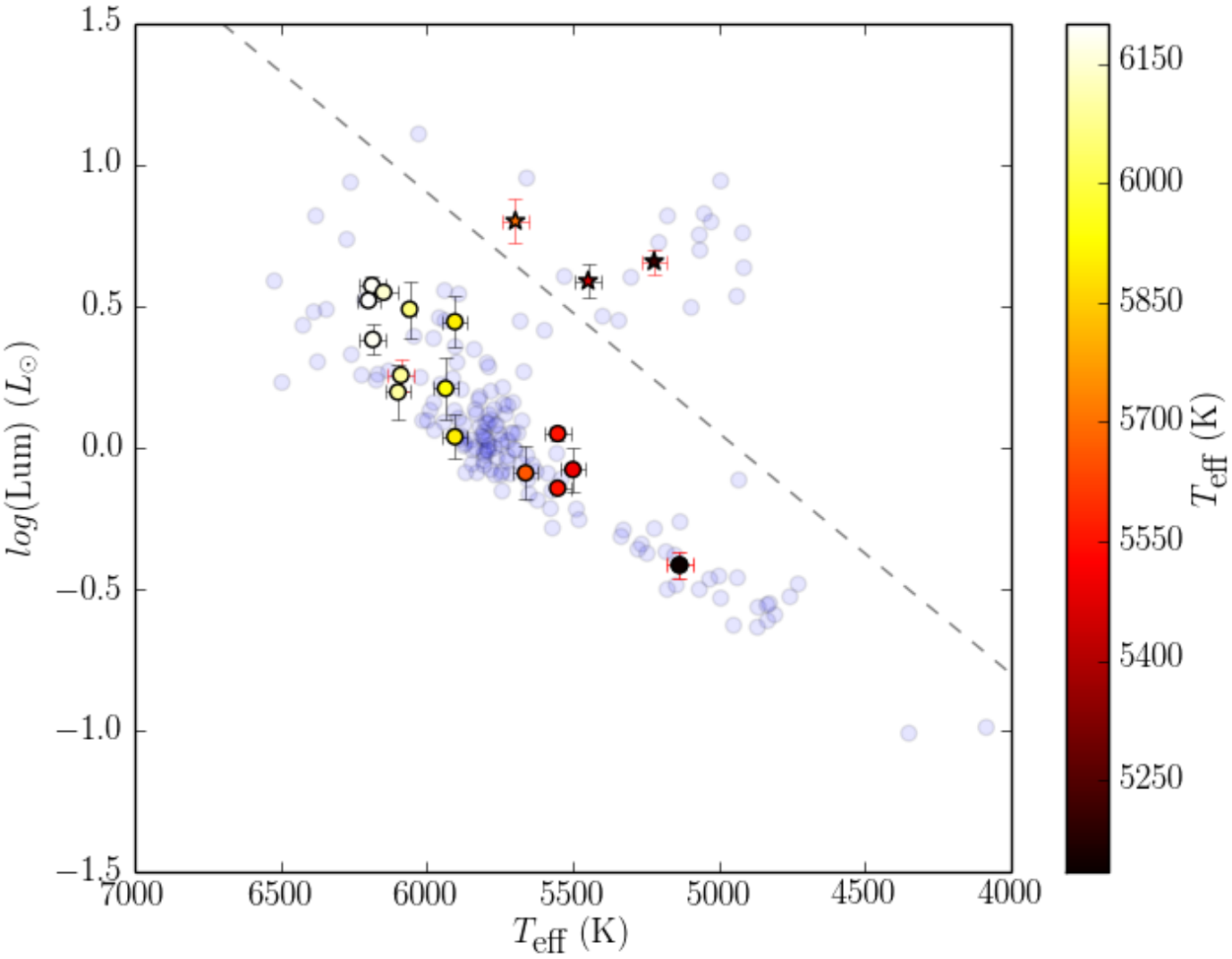

log(*v* sin *i*) vs T_{eff}

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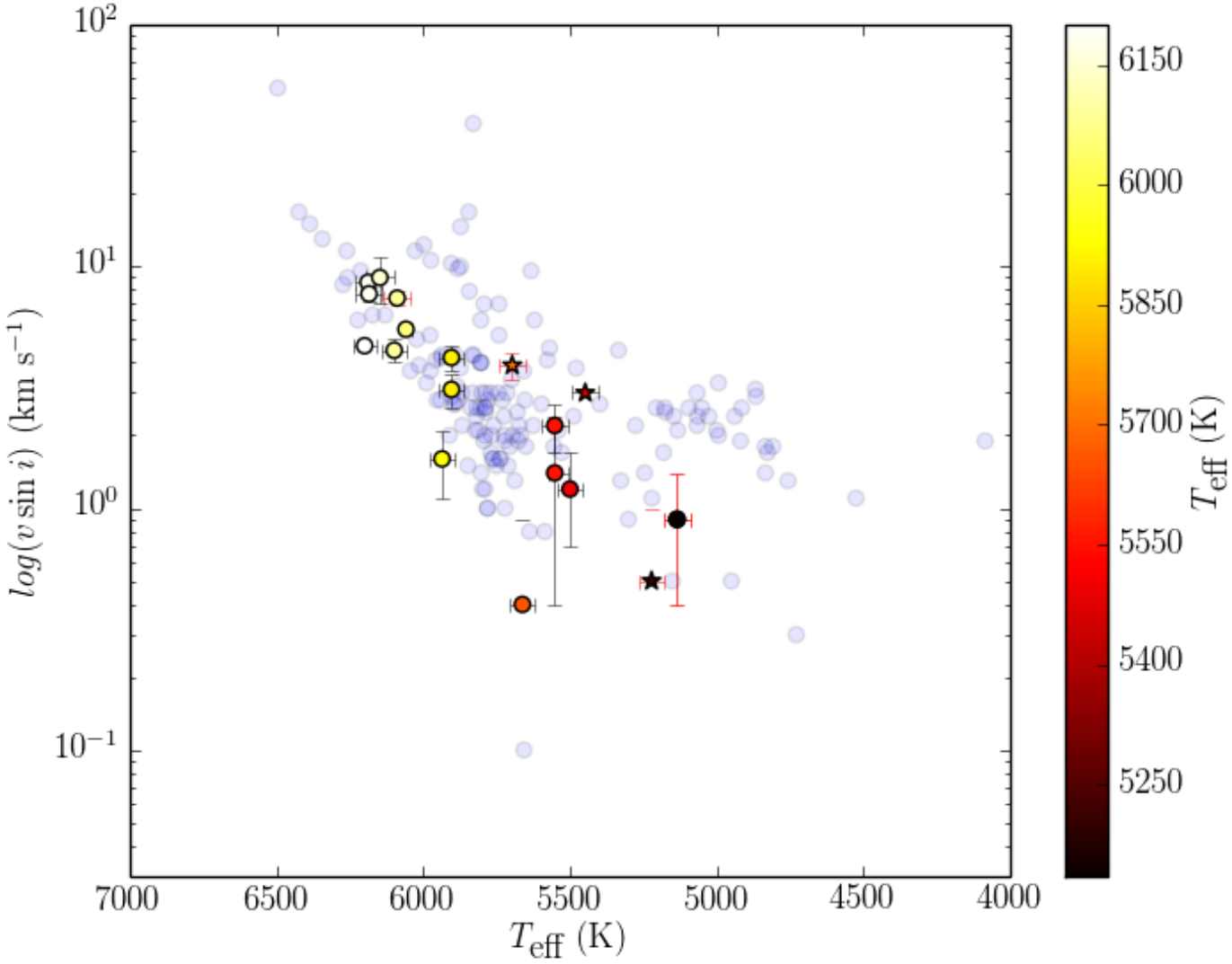

log(|B$_\ell$|) vs T$_{eff}$

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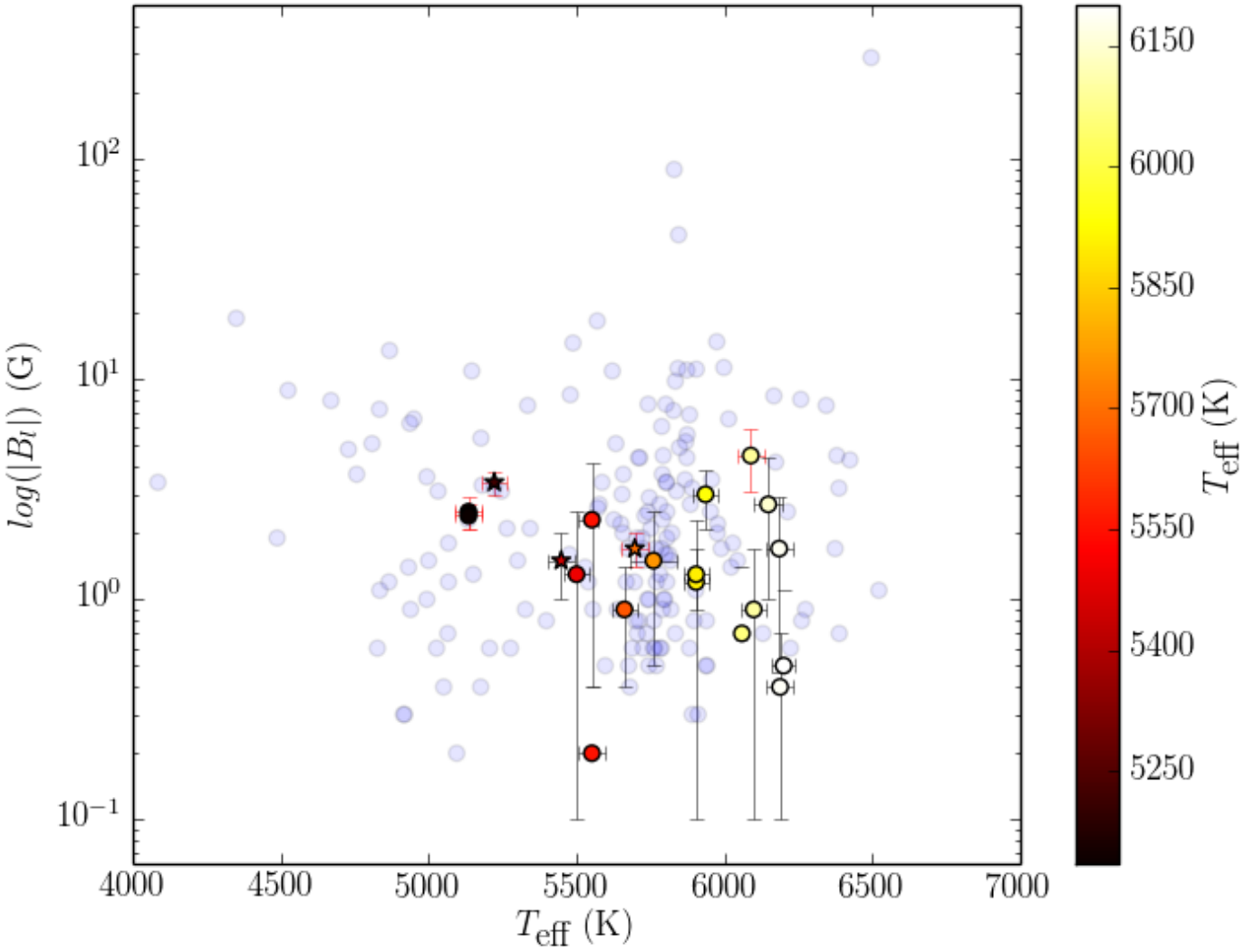

log(| B_ℓ |) vs log(R'_{HK})

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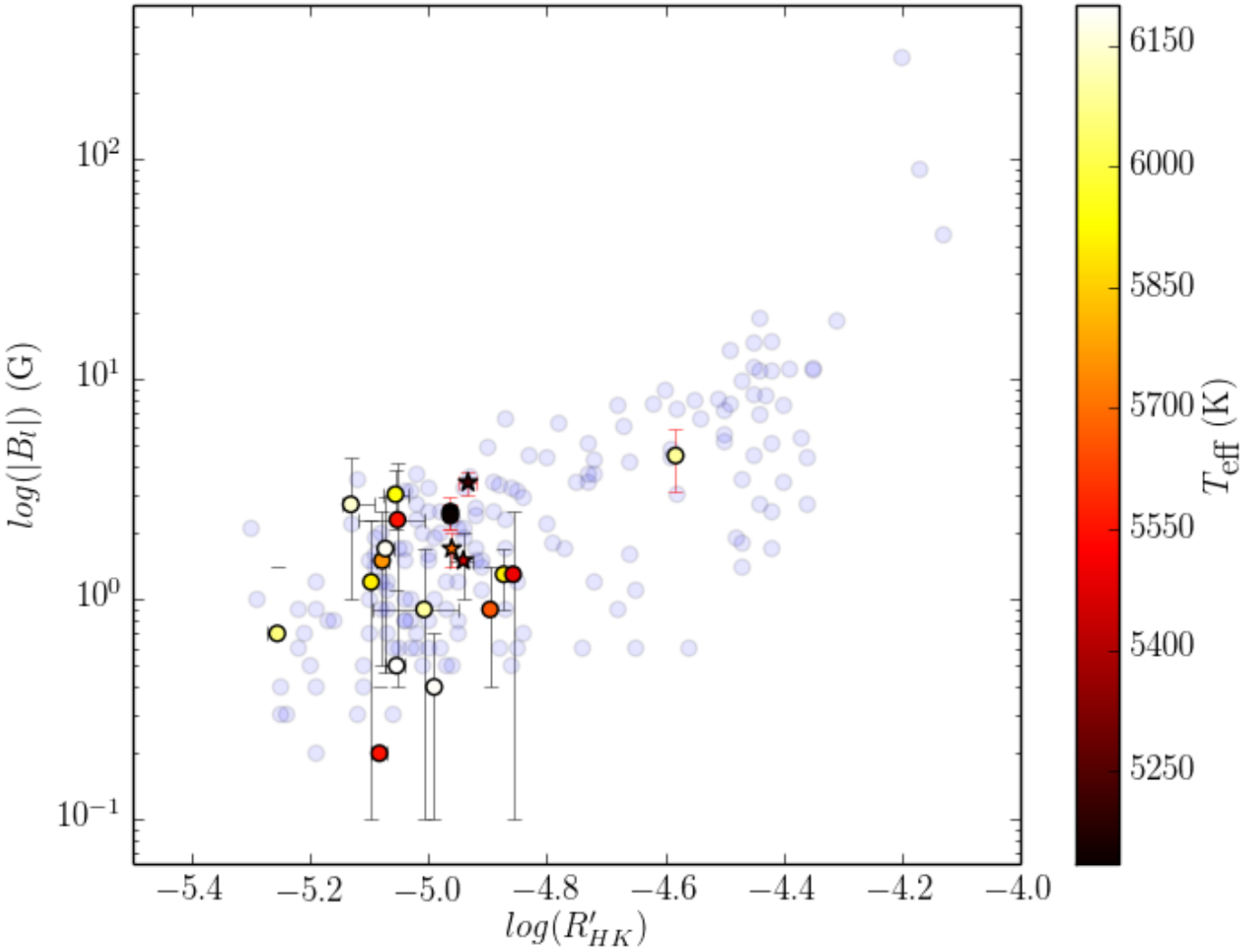

log(| B$_\ell$ |) vs log(v sin i)

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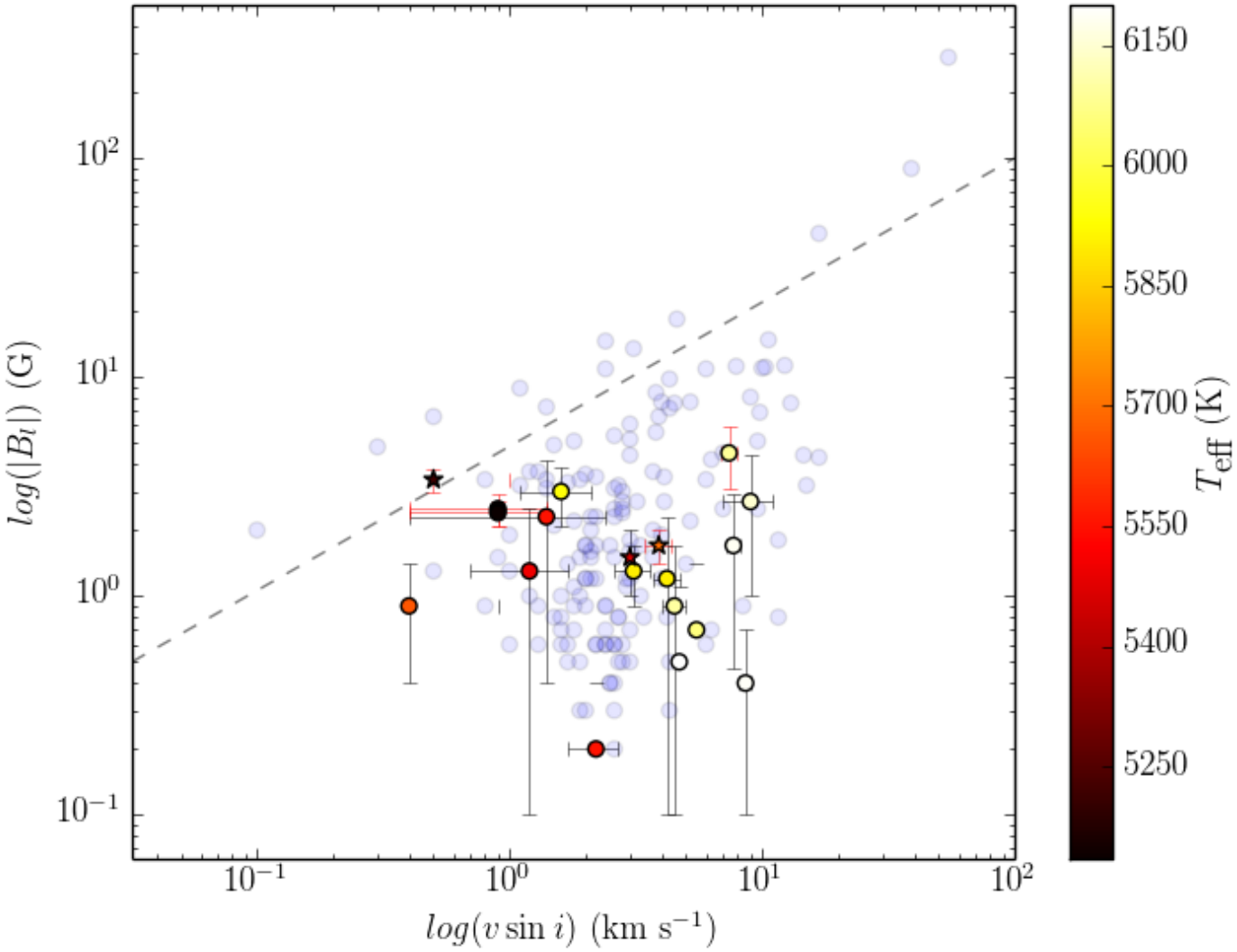

log(|B$_\ell$|) vs Age/Chromospheric Age

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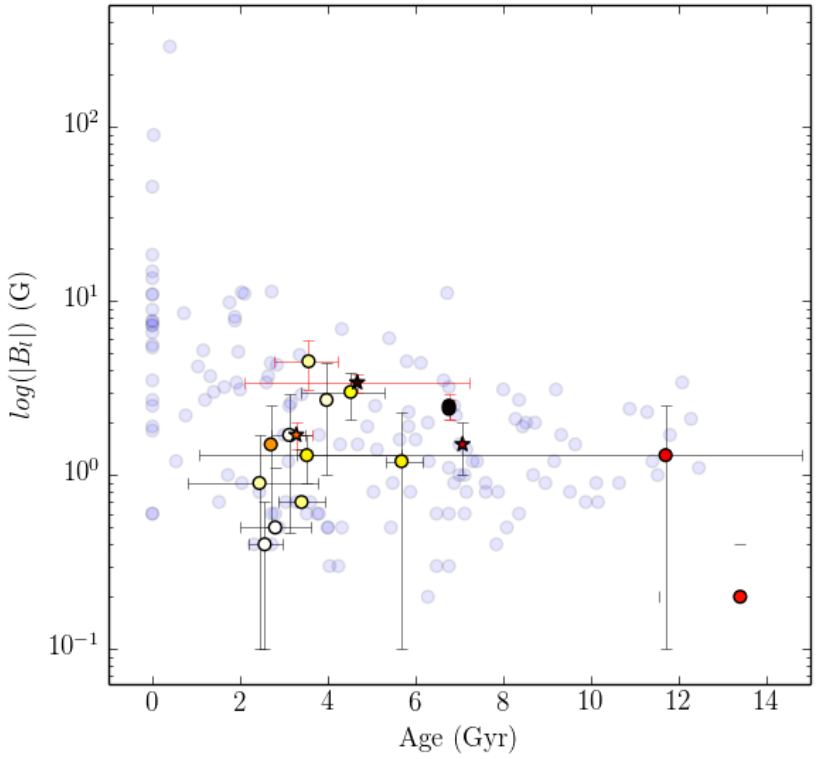
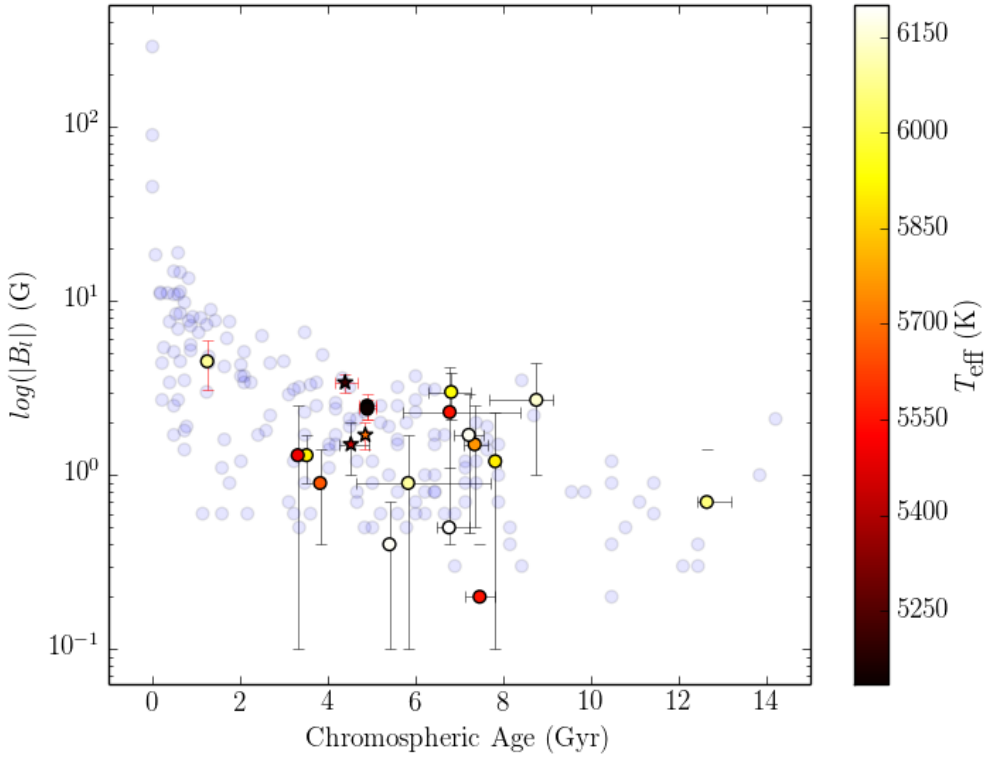
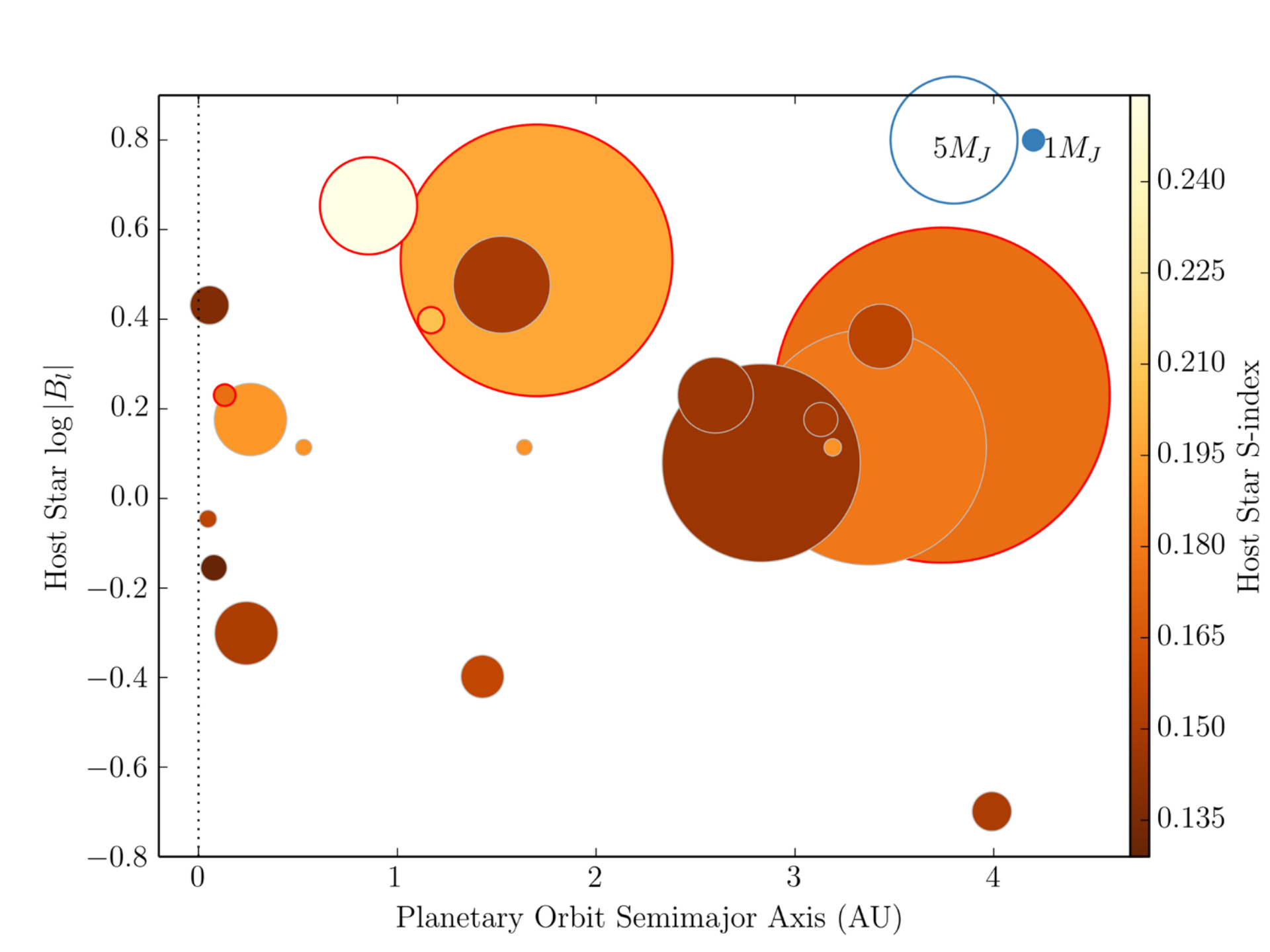
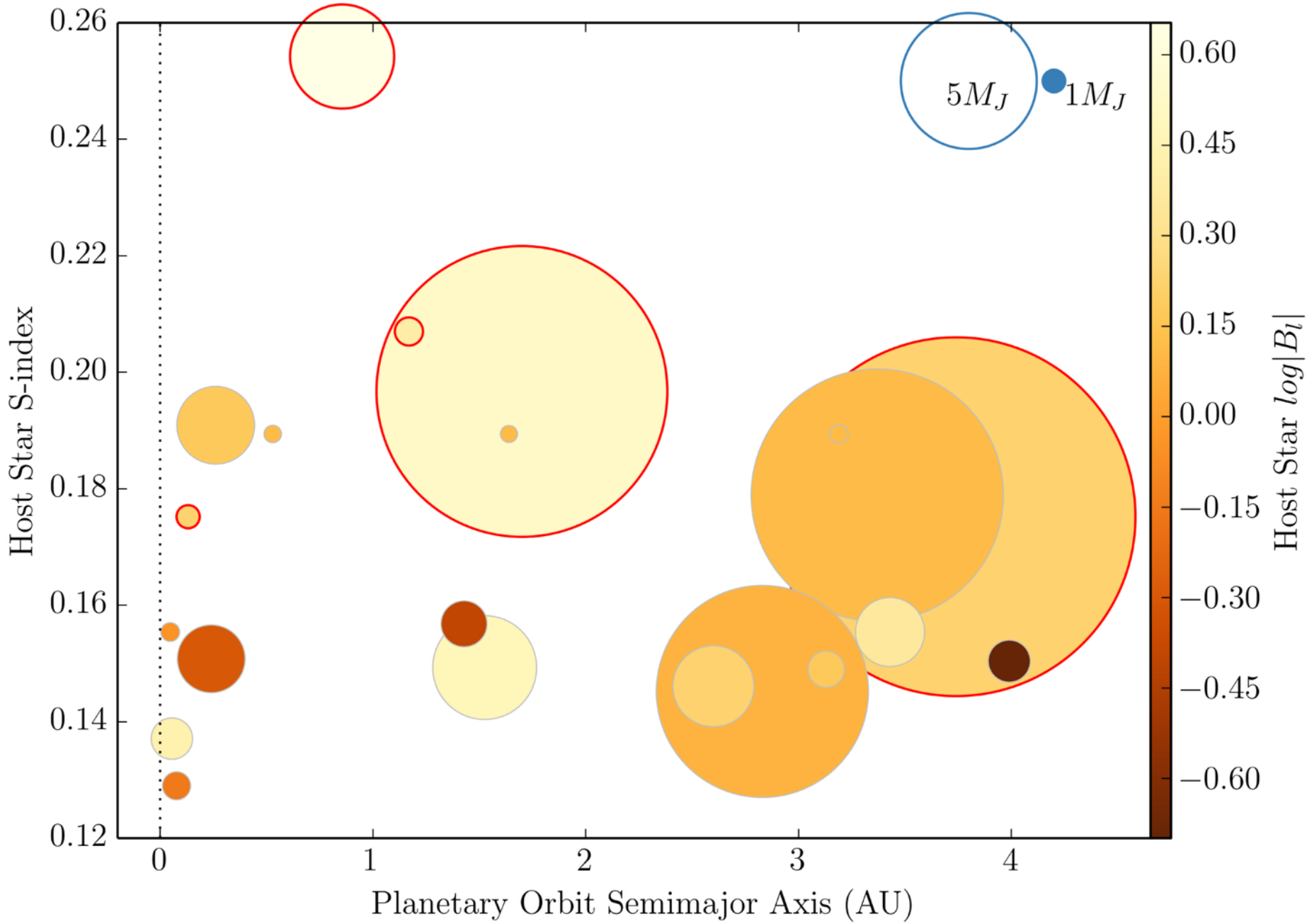





$5M_J$
$1M_J$
Host Star log $|B_l|$
Planetary Orbit Semimajor Axis (AU)
Host Star S-index
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
−0.8
0
1
2
3
4
0.240
0.225
0.210
0.195
0.180
0.165
0.150
0.135


0.26
0.24
0.22
0.20
0.18
0.16
0.14
0.12
Host Star S-index
0
1
2
3
4
Planetary Orbit Semimajor Axis (AU)
$5M_J$
$1M_J$
0.60
0.45
0.30
0.15
0.00
−0.15
−0.30
−0.45
−0.60
Host Star $log|B_l|$

Summary

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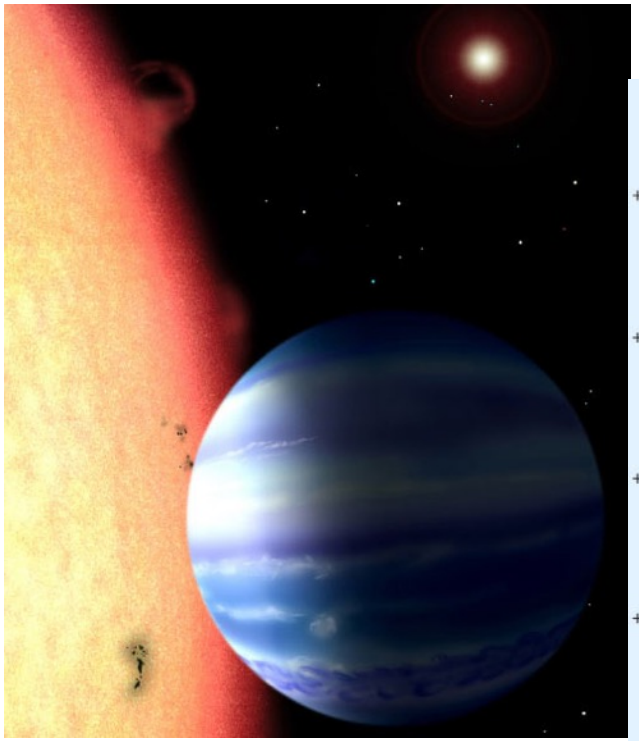
- Planet hosts (especially discovered using RV) usually older, therefore less active - sample bias
  - Lower detection rate than wider BCool survey
  - Same relationships with rotation, age, Rossby number, etc as Marsden et. al. 2014
- No indication of SPI, although most sample stars are not hot Jupiters (and therefore most likely due to tides/magnetic reconnection/whatever). More targets needed - Claire Mouton CFHT
- Mengel, M. W. et. al. (in prep)

(and even more!) τ Boötis



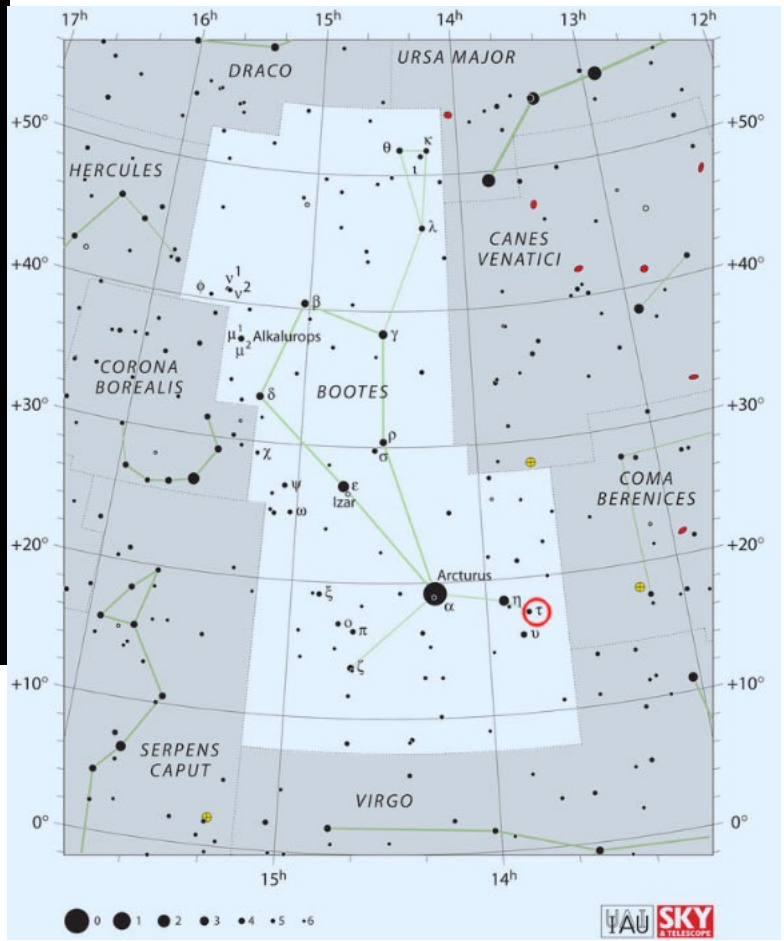


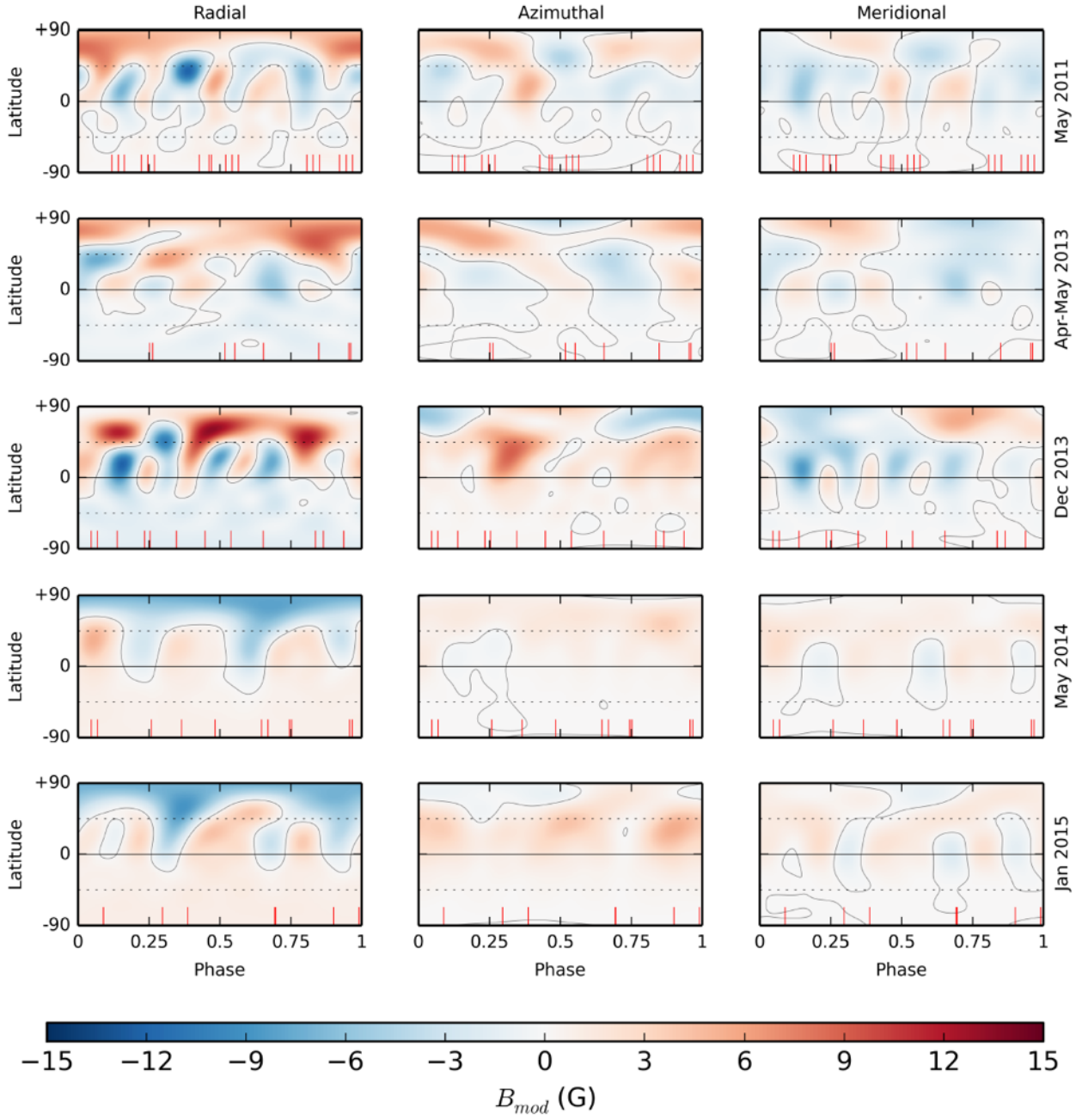
Image credits: (L): David Aguilar / Harvard-Smithsonian Center for Astrophysics; (R): International Astronomical Union / Sky and Telescope Magazine.

τ Boötis

- F7V
- v sin i ~ 15.9 km/s
- Large planet (Mass 6 times Jupiter) at 0.049 AU
  - Orbital period/Rotational period of 3.31d
- Age ~ 1Gyr
- Observed regularly since 2007
- My work on observations since 2011
- Some weak indications of SPI (not entirely convincing)

τBoötis

- Spectropolarimetric observations taken at the Télescope Bernard Lyot at the Observatoire Midi-Pyrenees (2013-2015) using NARVAL
- 2011 observation taken using HARPSpol



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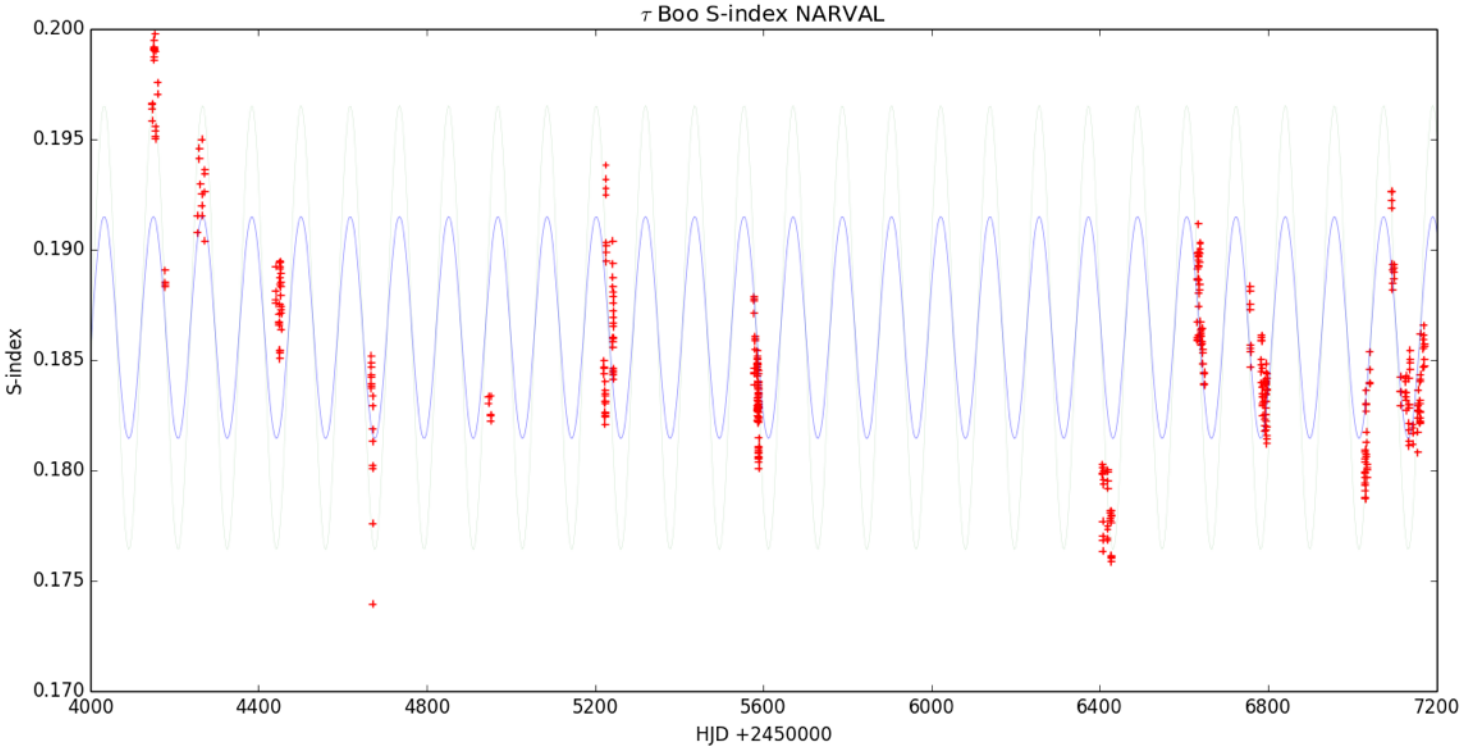
τBoötis

- 2-year cycle of polarity reversals but this would be a reversal per 3 Ca II HK cycles (~117d)



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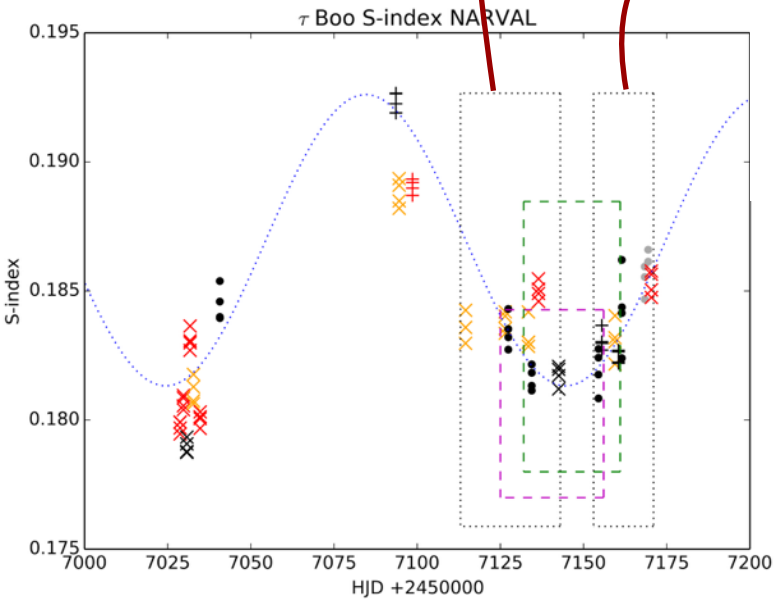
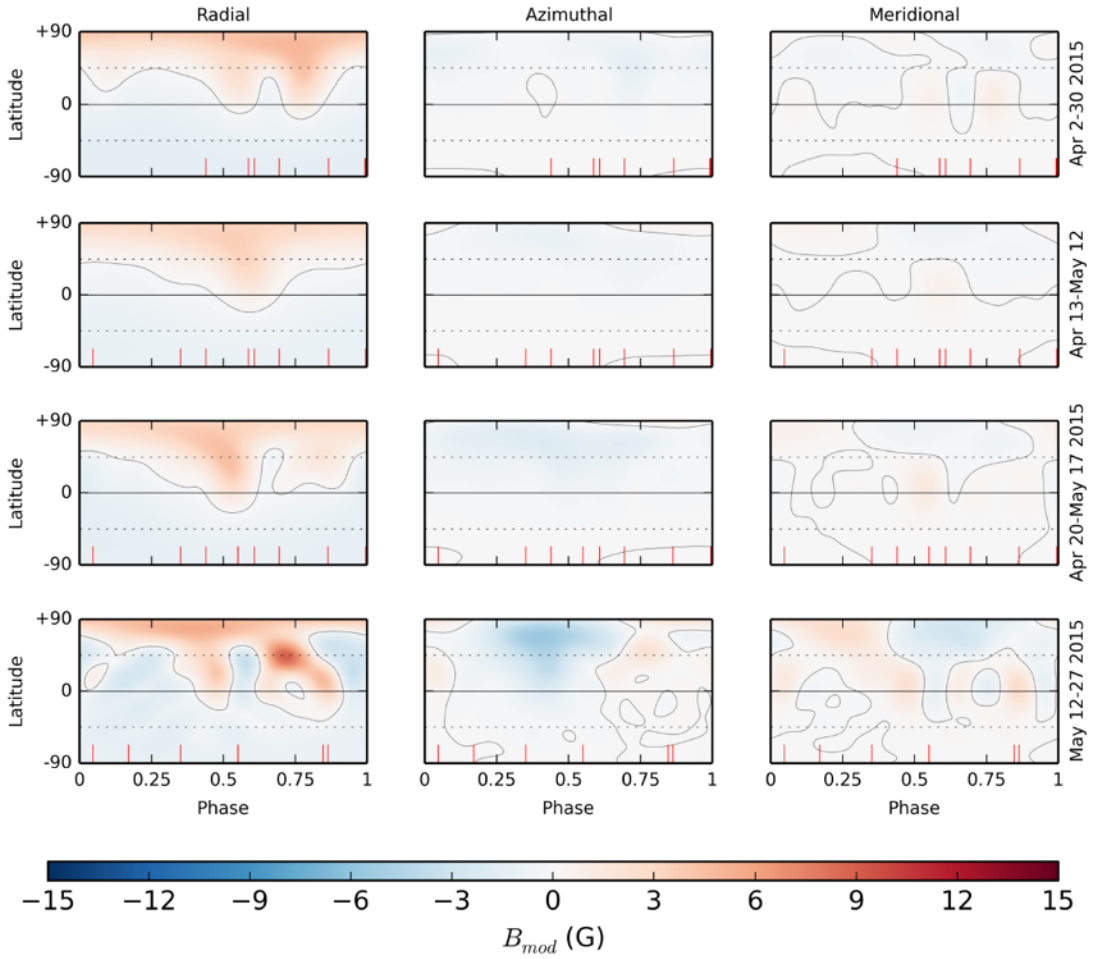
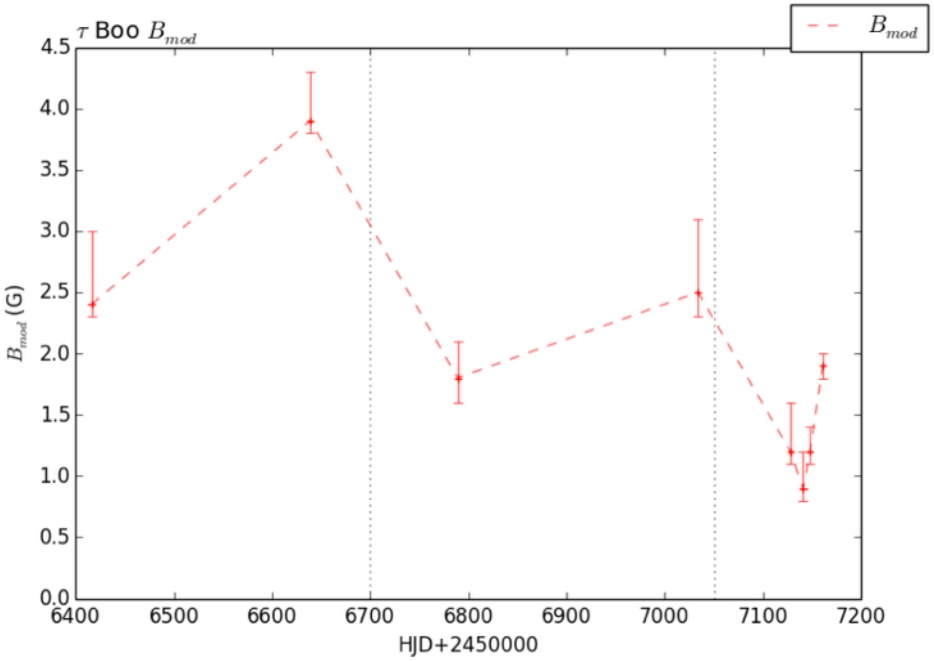
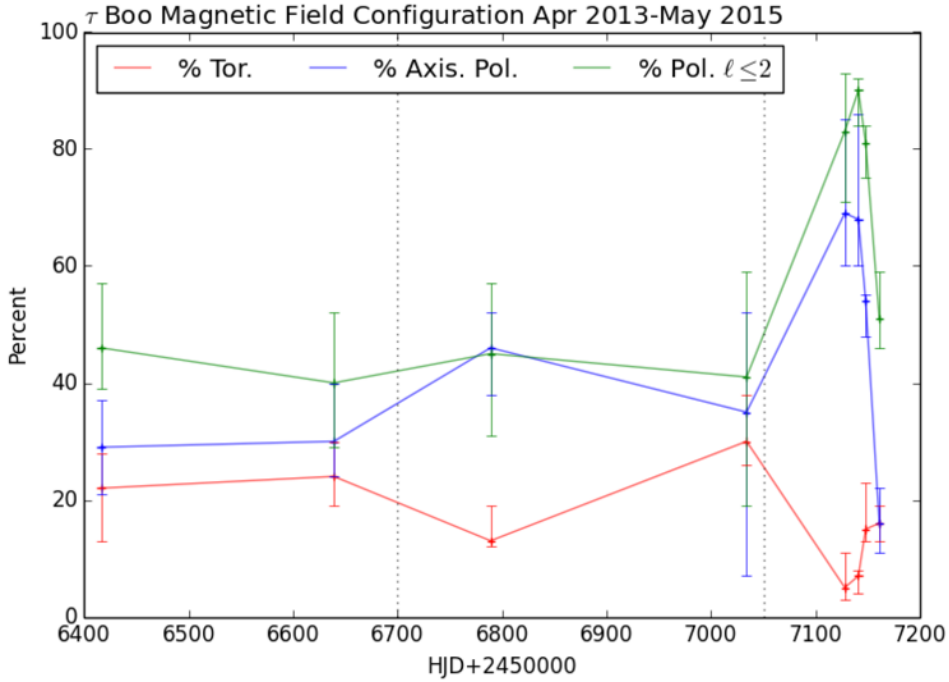




Epoch	B (G)	% toroidal	% axisymm. poloidal	% $\ell \leqslant 2$ in poloidal
2015 02 Apr - 30 Apr	$1.2^{+0.4}_{-0.1}$	5^{+6}_{-2}	69^{+16}_{-9}	83^{+10}_{-12}
2015 13 Apr - 12 May	$0.9^{+0.3}_{-0.1}$	7^{+1}_{-3}	68^{+18}_{-8}	90^{+2}_{-6}
2015 20 Apr - 17 May	$1.2^{+0.2}_{-0.1}$	15^{+8}_{-2}	54^{+1}_{-6}	81^{+3}_{-6}
2015 12 May - 27 May	$1.9^{+0.1}_{-0.1}$	16^{+3}_{-3}	16^{+6}_{-5}	51^{+8}_{-5}

Rapid Evolution after Reversal





Magnetic Cycles of τ Boötis

- 3 cycles of "magnetic energy" per polarity reversal
- MHD simulations (Augustson et al, 2013) suggest this may be correct, in which case we confirm this behaviour
  - The Sun does not behave this way
  - Potentially a different dynamo process?
    - Age/Rotation speed/Spectral Type?
    - Planetary influence?
- Telescope time for 2016 to confirm 3:1 periodicity
- Potential biases based on time of observation?
- Mengel, M. W. et. al. (submitted MNRAS)

Thank you

- Questions

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- t: @mengelm