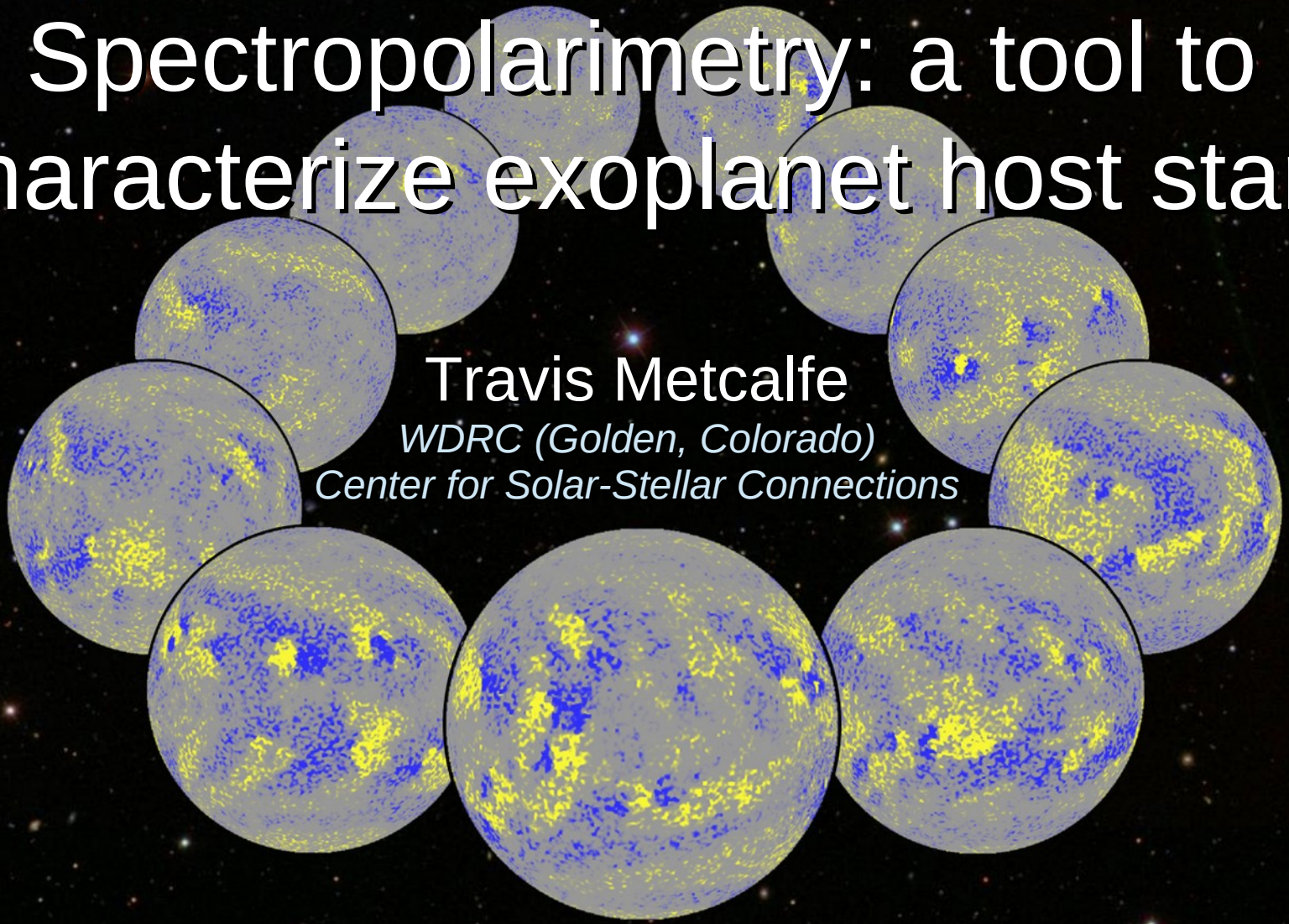
Spectropolarimetry: a tool to characterize exoplanet host stars



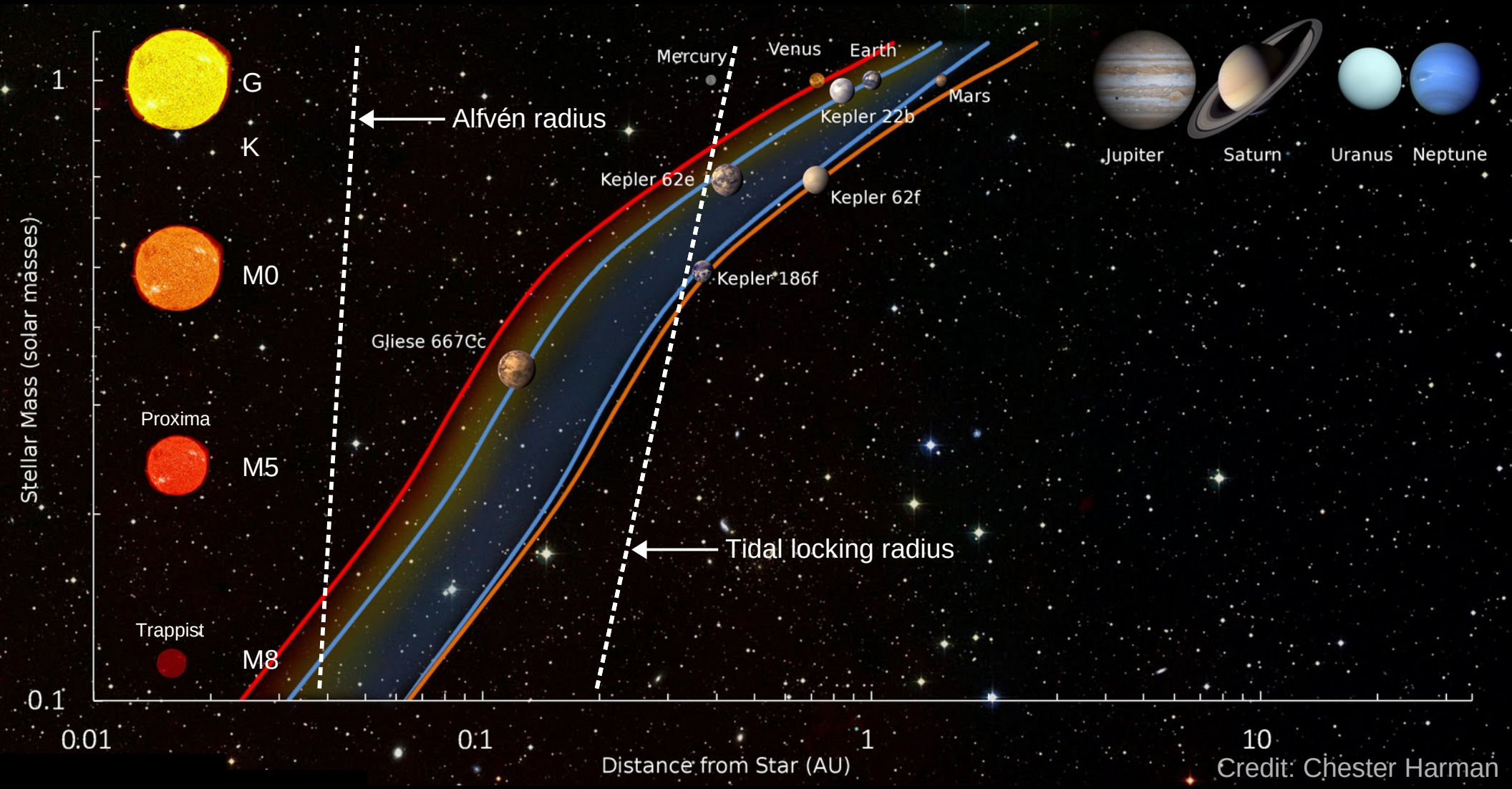
Travis Metcalfe

WDRC (Golden, Colorado)

Center for Solar-Stellar Connections

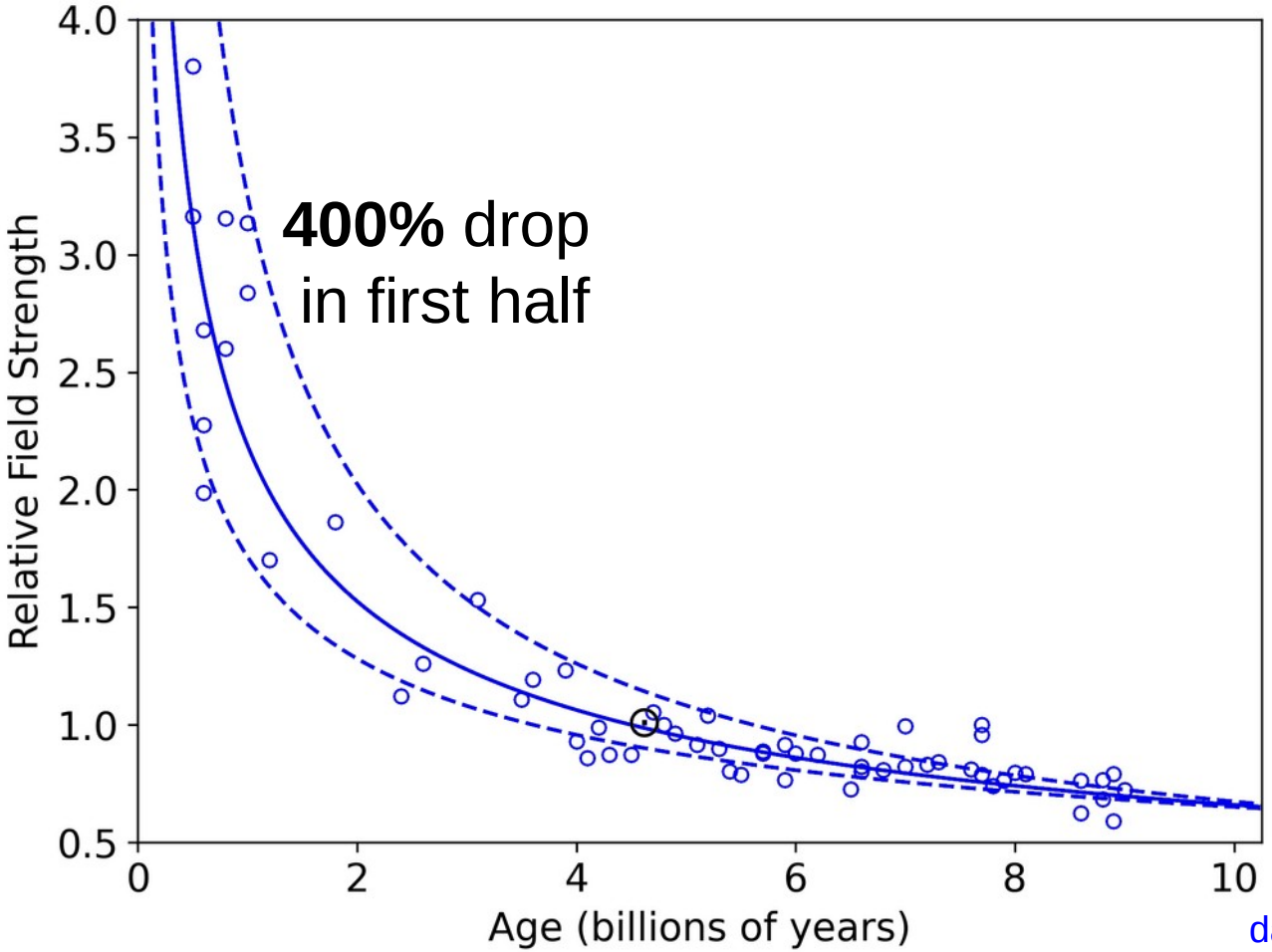
Collaborators: Oleg Kochukhov, Pascal Petit, Klaus Strassmeier & many others

Magnetic fields and tidal locking – reconsidering the “habitable zone”



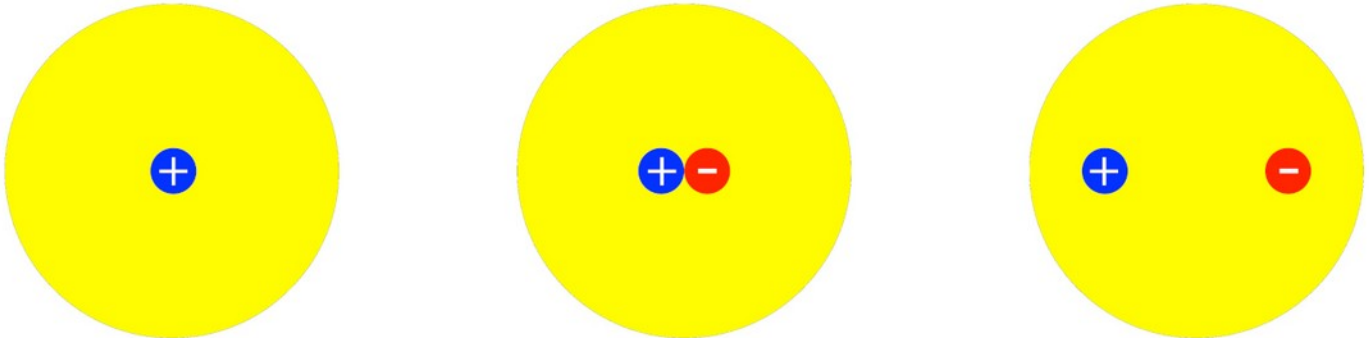
Credit: Chester Harman

Magnetism evolves slowly in old stars

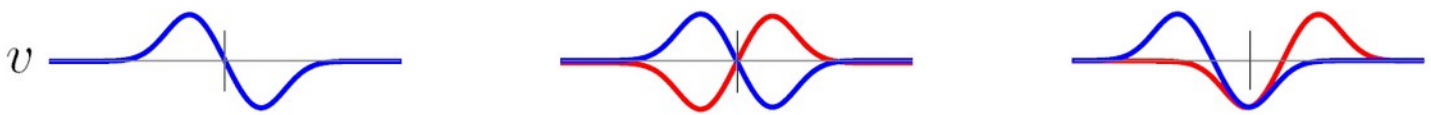


data: Lorenzo-Oliveira+2018

Geometry

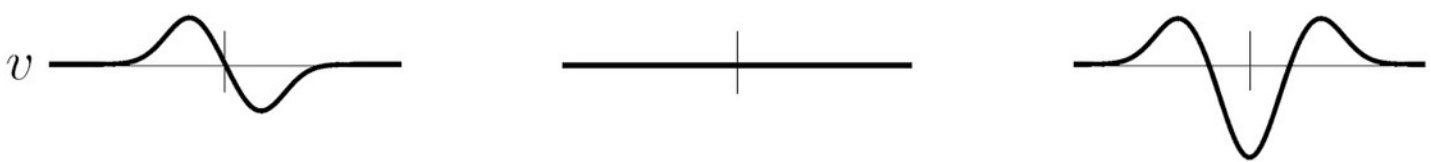


Stokes V signal (components)



Signals doppler shifted due to rotation

Stokes V signal (net)



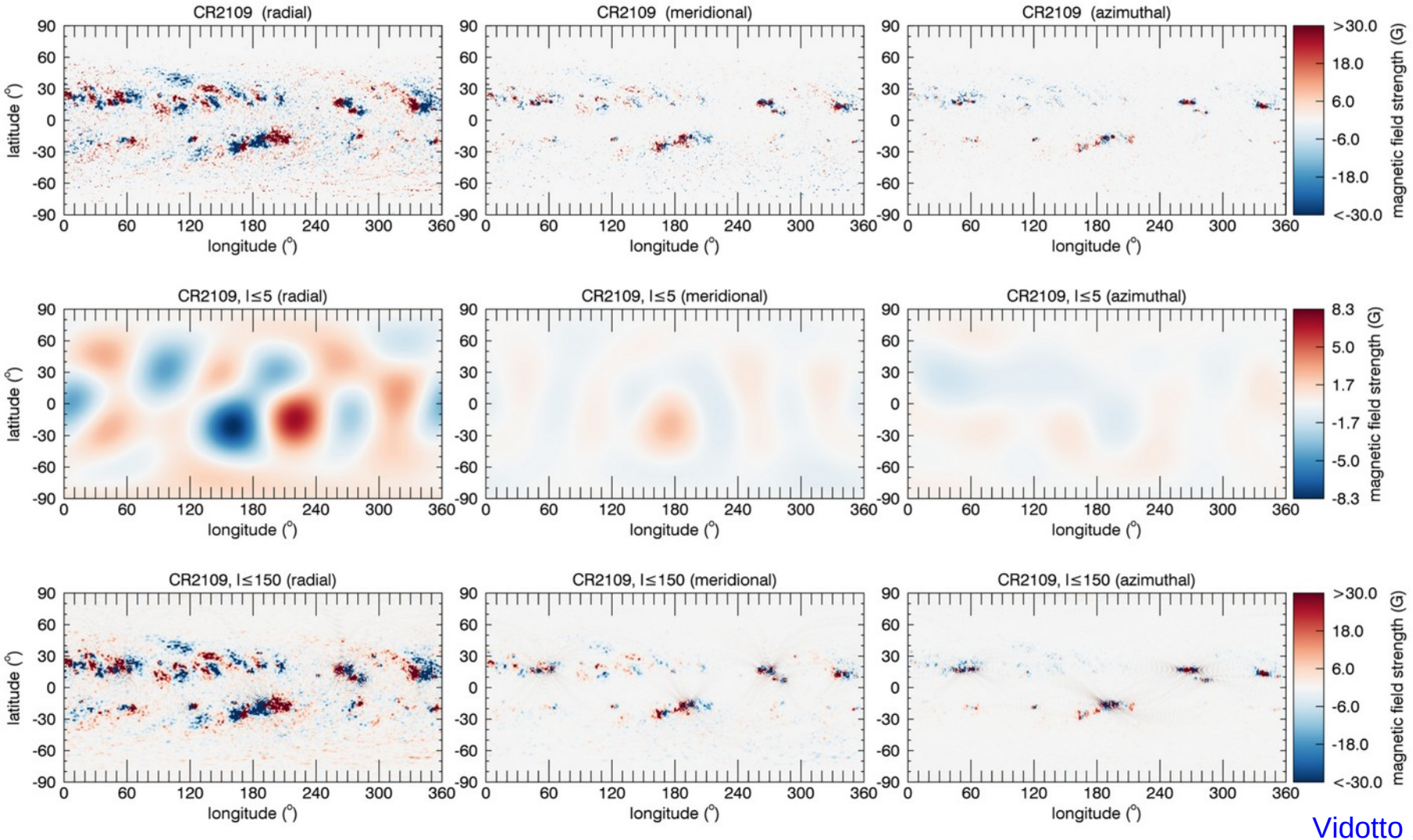
Credit: Victor See

radial meridional (N-S) azimuthal (E-W)

obs

ℓ<5

ℓ<150



Vidotto 2016


Credit: NOAO

2025

The Astrophysical Journal (submitted version)
Typeset using LaTeX **twocolumn** style in AASTeX631

Testing the Rossby Paradigm: Weakened Magnetic Braking in early K-type Stars

Travis S. Metcalfe [1], Pascal Petit [2], Jennifer L. van Saders [3], Thomas R. Ayres [4], Derek Buzasi [5], Oleg Kochukhov [6], Keivan G. Stassun [7], Marc H. Pinsonneault [8], Ilya V. Ilyin [9], Klaus G. Strassmeier [9], Adam J. Finley [10], Rafael A. García [10], Yuxi (Lucy) Lu [8], and Victor See [11]

early K-type

2023

The Astrophysical Journal Letters, 948:L6 (5pp), 2023 May 1 https://doi.org/10.3847/2041-8213/acce38

Constraints on Magnetic Braking from the G8 Dwarf Stars 61 UMa and τ Cet

Travis S. Metcalfe[1], Klaus G. Strassmeier[2], Ilya V. Ilyin[2], Jennifer L. van Saders[3], Thomas R. Ayres[4], Adam J. Finley[5], Oleg Kochukhov[6], Pascal Petit[7], Victor See[8], Keivan G. Stassun[9], Sandra V. Jeffers[10], Stephen C. Marsden[11], Julien Morin[12], and Aline A. Vidotto[13]

late G-type

2022

The Astrophysical Journal Letters, 933:L17 (6pp), 2022 July 1 https://doi.org/10.3847/2041-8213/ac794d

The Origin of Weakened Magnetic Braking in Old Solar Analogs

Travis S. Metcalfe[1], Adam J. Finley[2], Oleg Kochukhov[3], Victor See[4], Thomas R. Ayres[5], Keivan G. Stassun[6], Jennifer L. van Saders[7], Catherine A. Clark[8,9], Diego Godoy-Rivera[10,11,12], Ilya V. Ilyin[13], Marc H. Pinsonneault[10], Klaus G. Strassmeier[13], and Pascal Petit[14]

solar analogs

2021

The Astrophysical Journal, 921:122 (10pp), 2021 November 10 https://doi.org/10.3847/1538-4357/ac1f19

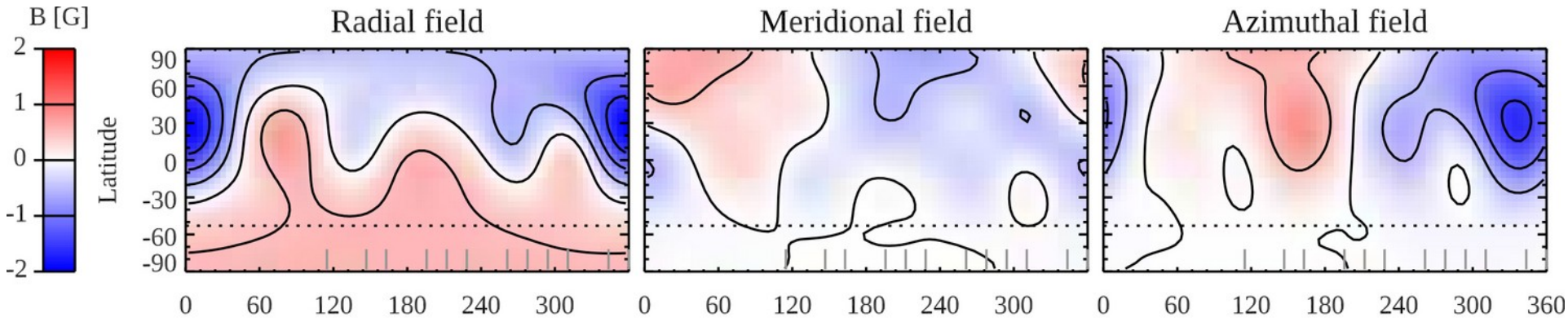
Magnetic and Rotational Evolution of ρ CrB from Asteroseismology with TESS

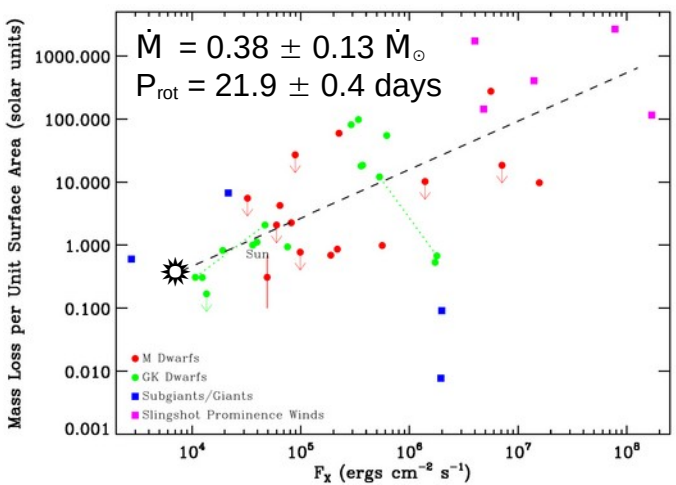
Travis S. Metcalfe[1,2], Jennifer L. van Saders[3], Sarbani Basu[4], Derek Buzasi[5], Jeremy J. Drake[6], Ricky Egeland[7], Daniel Huber[3], Steven H. Saar[6], Keivan G. Stassun[8], Warrick H. Ball[9,10], Tiago L. Campante[11,12], Adam J. Finley[13], Oleg Kochukhov[14], Savita Mathur[15,16], Timo Reinhold[17], Victor See[18], Sallie Baliunas[6], and Willie Soon[6]

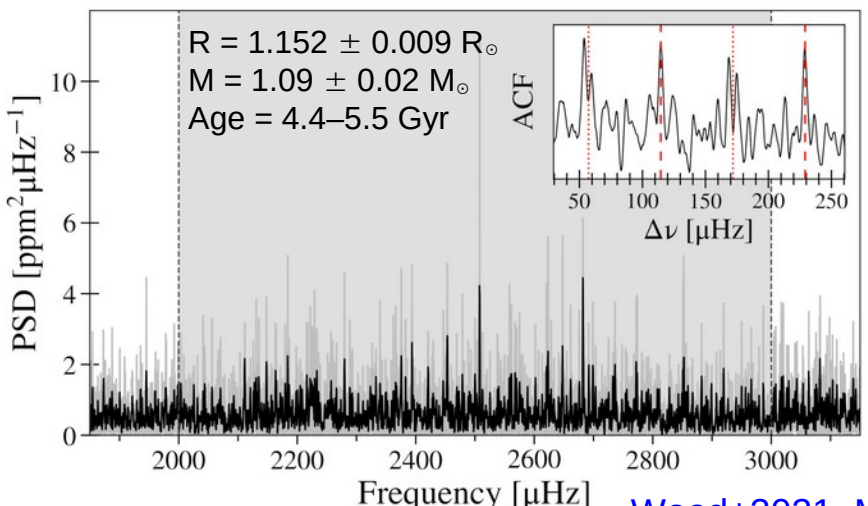
late F-type

Credit: NOAO

51 Peg: (B_ℓ, $\dot{M}$, P_{rot}, R, M)

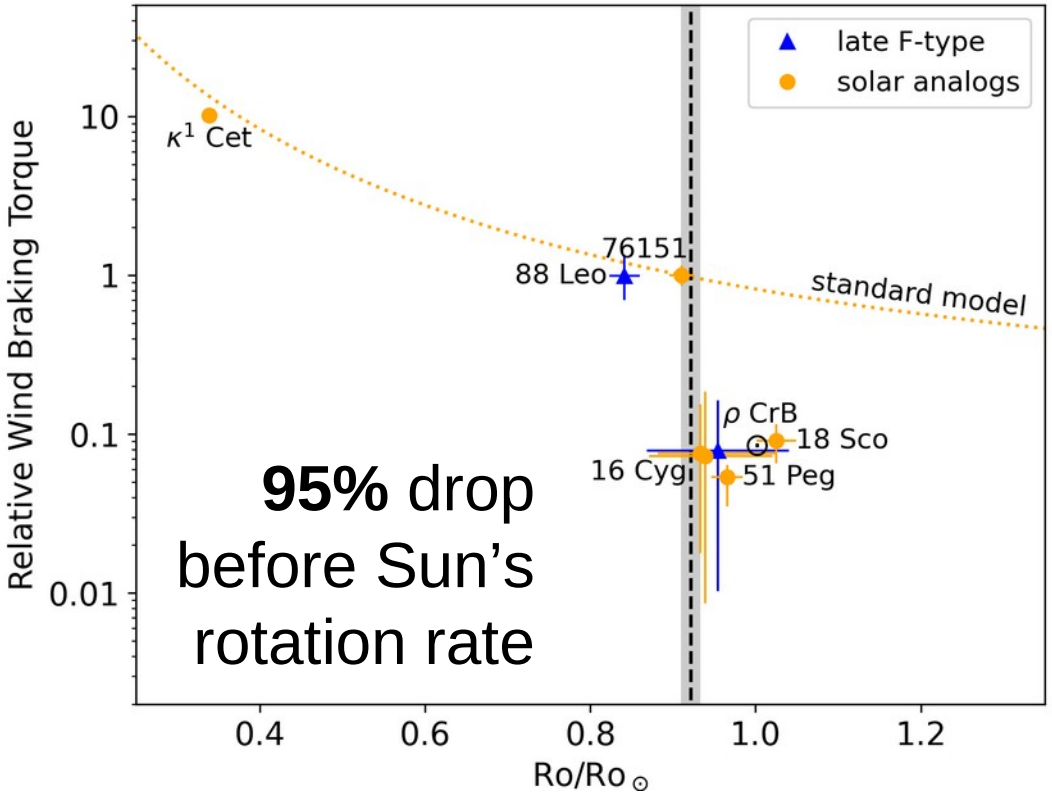


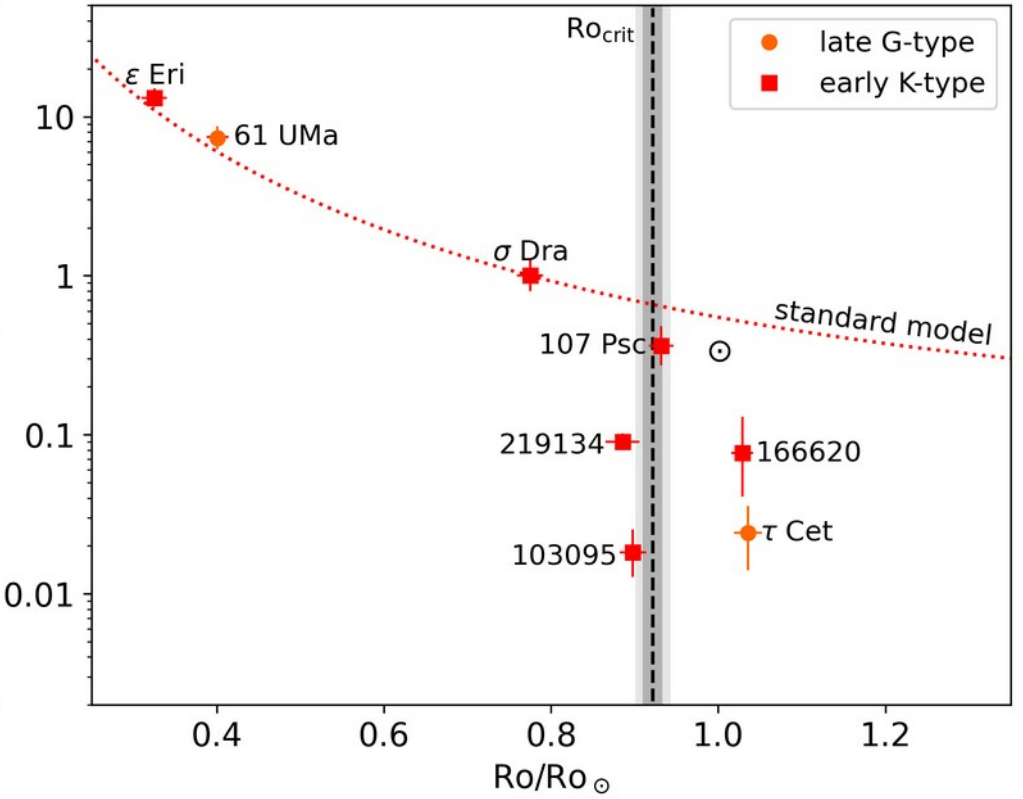




Wood+2021, Metcalfe+2024a

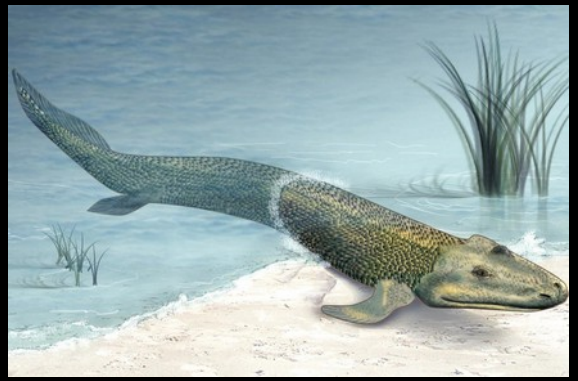
Direct estimates of wind braking torque





Metcalfe+2021, 2022, 2023a, 2024a, 2025

WMB in Sun ~ land-based life on Earth



~400 million years ago

Credit: NASA

Summary of conclusions

- At the onset of WMB, rotation and activity decouple as magnetic fields become weaker and more complex
- WMB begins before stars reach the Rossby number of the Sun, empirically near $Ro_{crit} \sim 0.92 \pm 0.01\ Ro_{\odot}$
- The wind braking torque of the exoplanet host stars ρ CrB, 51 Peg, and τ Cet are all in the WMB regime
- Older stars may provide a more stable environment for the development of technological civilizations