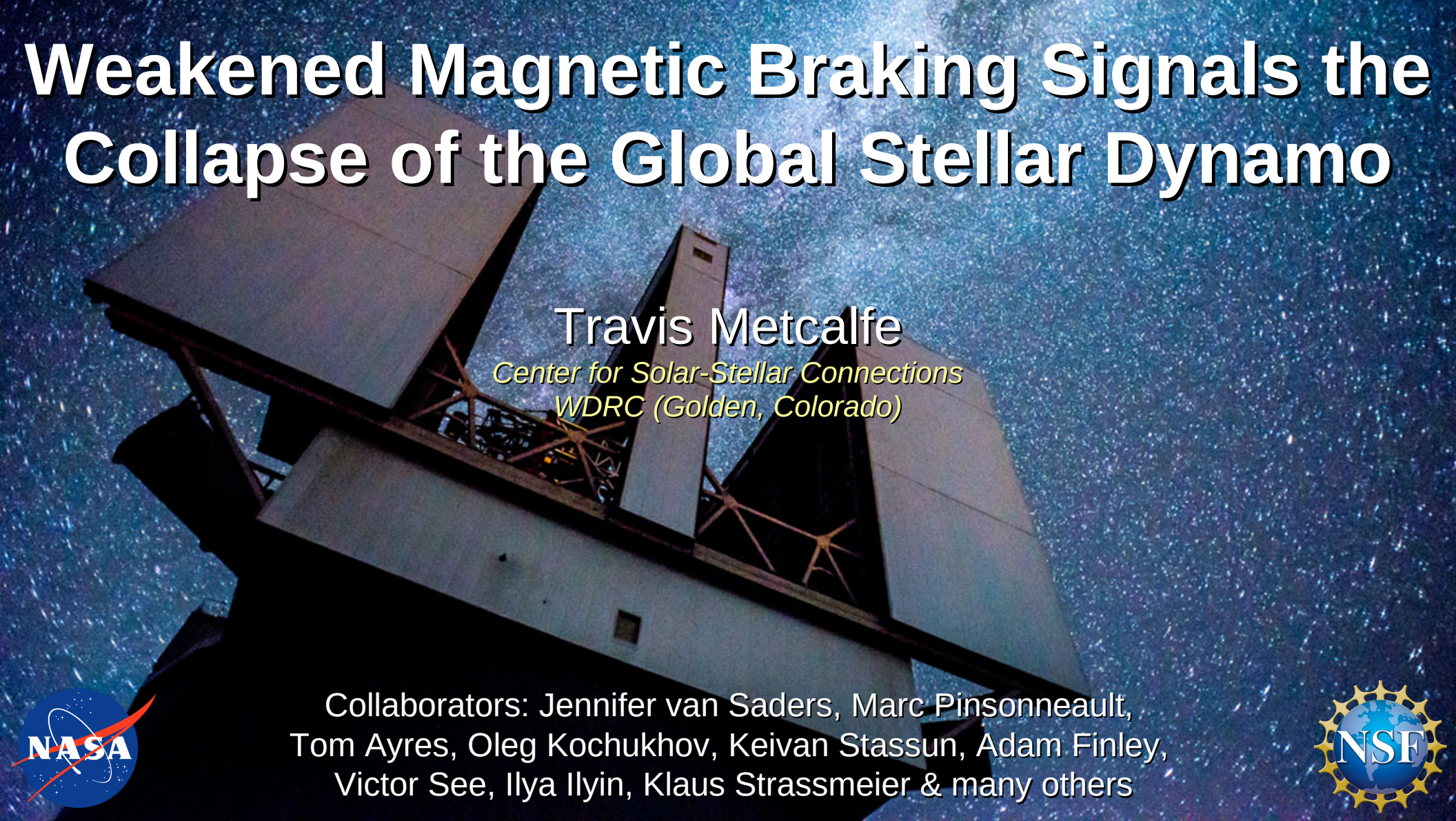
Weakened Magnetic Braking Signals the Collapse of the Global Stellar Dynamo



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2025

The Astrophysical Journal, 986:120 (13pp), 2025 June 20
https://doi.org/10.3847/1538-4357/add40a

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], Daniel Huber[3,11], Yuxi (Lucy) Lu[8], and Victor See[12]

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

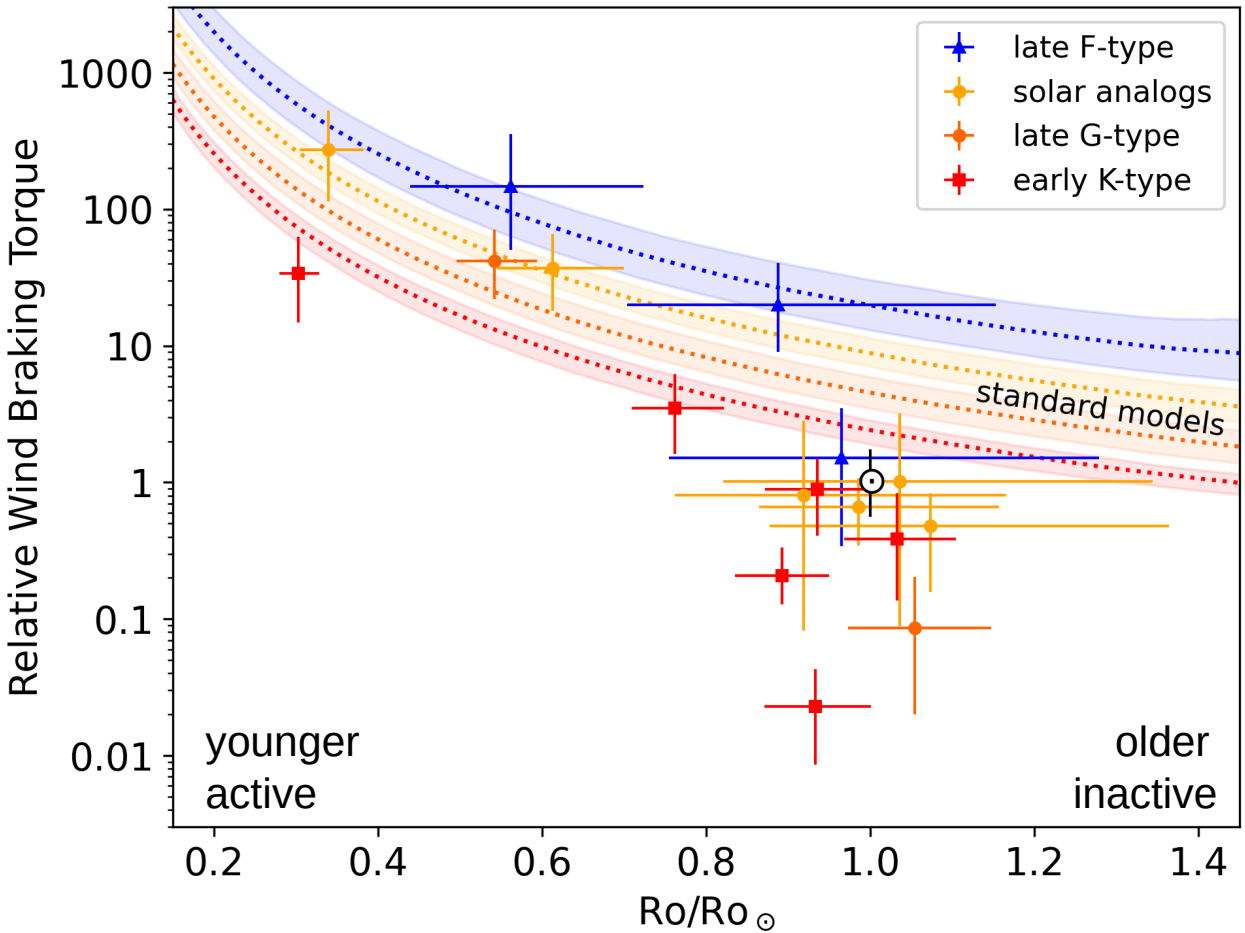
The Astrophysical Journal, 921:122 (10pp), 2021 November 10
https://doi.org/10.3847/1538-4357/ac1f19

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]

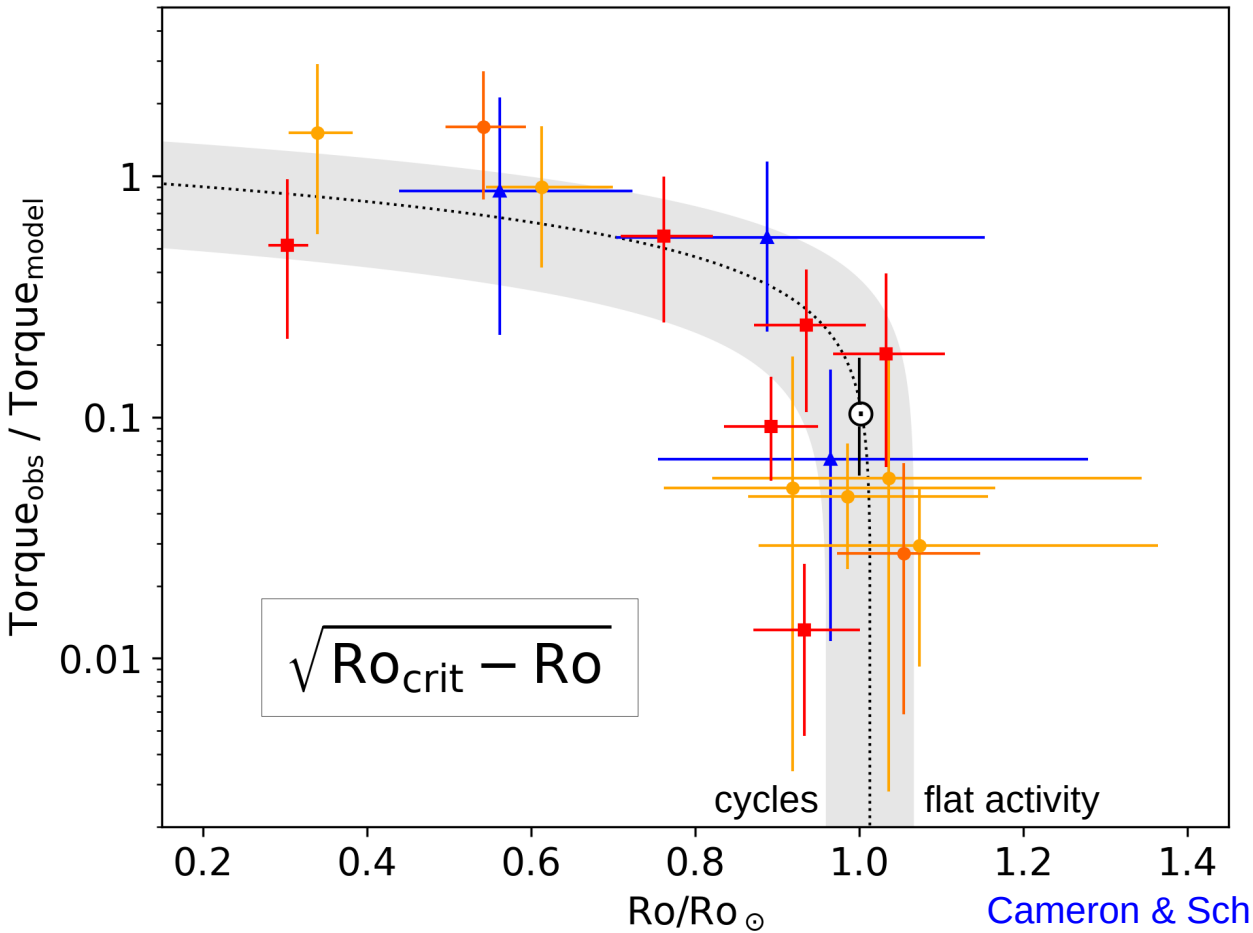
late F-type

Onset of weakened magnetic braking



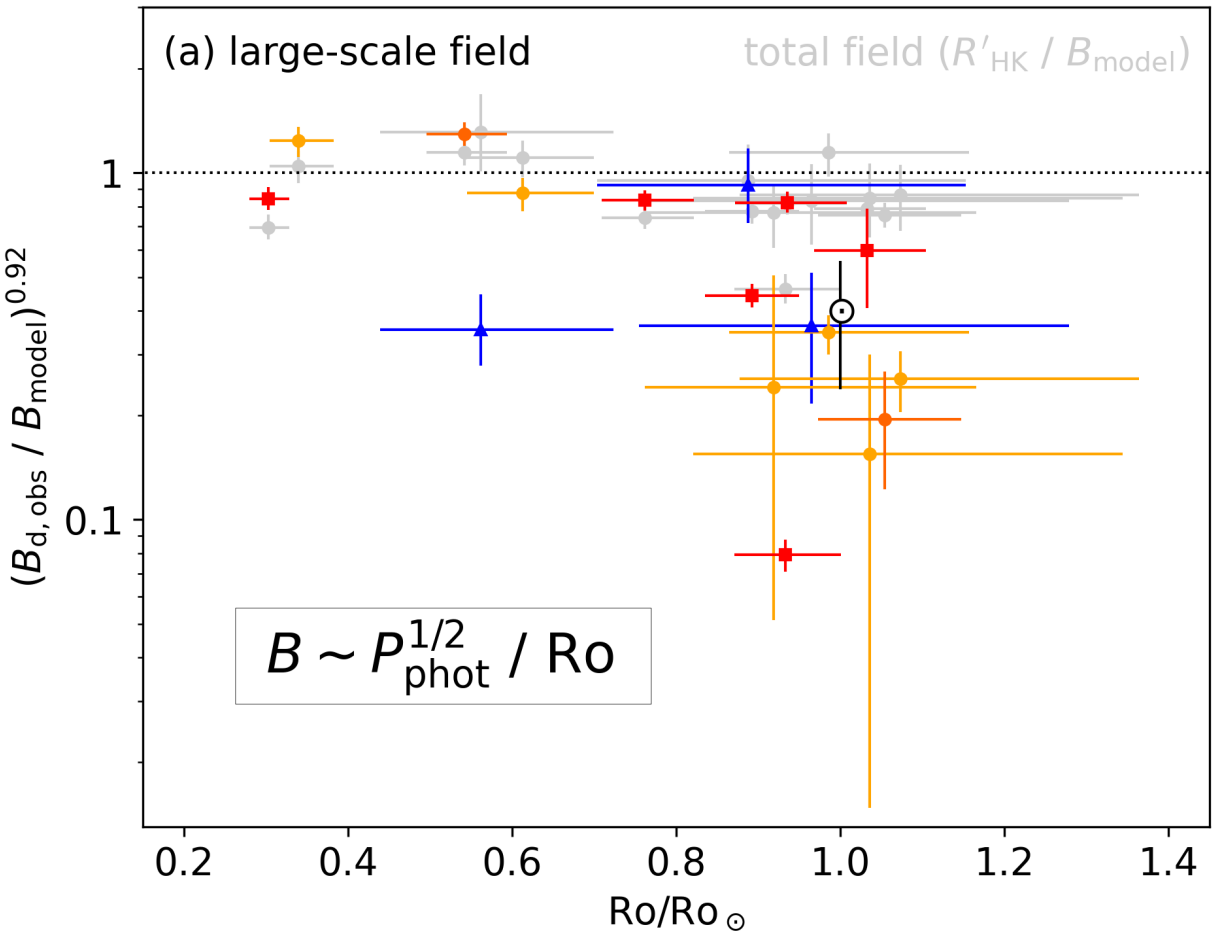
Metcalfe+2025b

Collapse of the global stellar dynamo



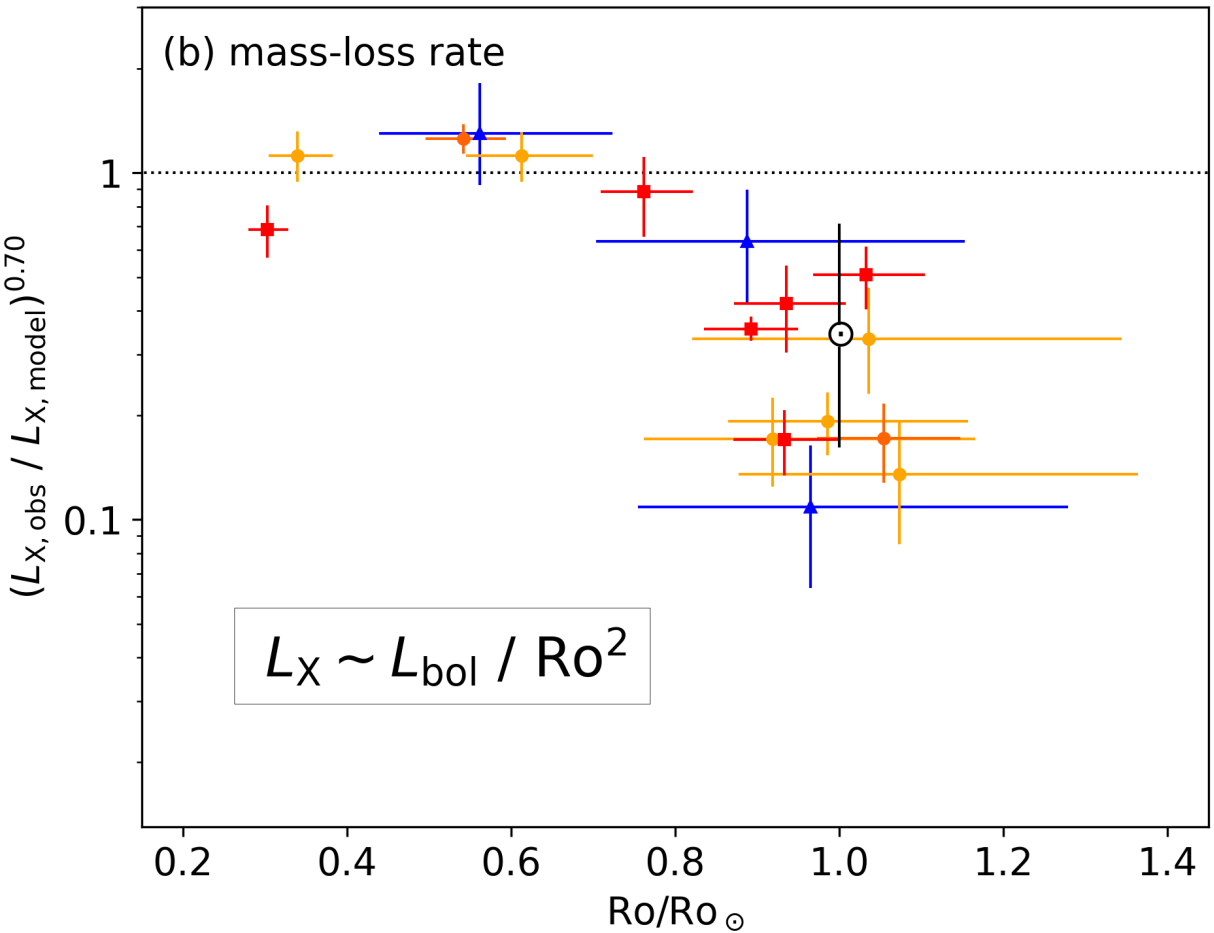
Cameron & Schüssler 2017, Metcalfe+2025b

Disrupted large-scale magnetic field



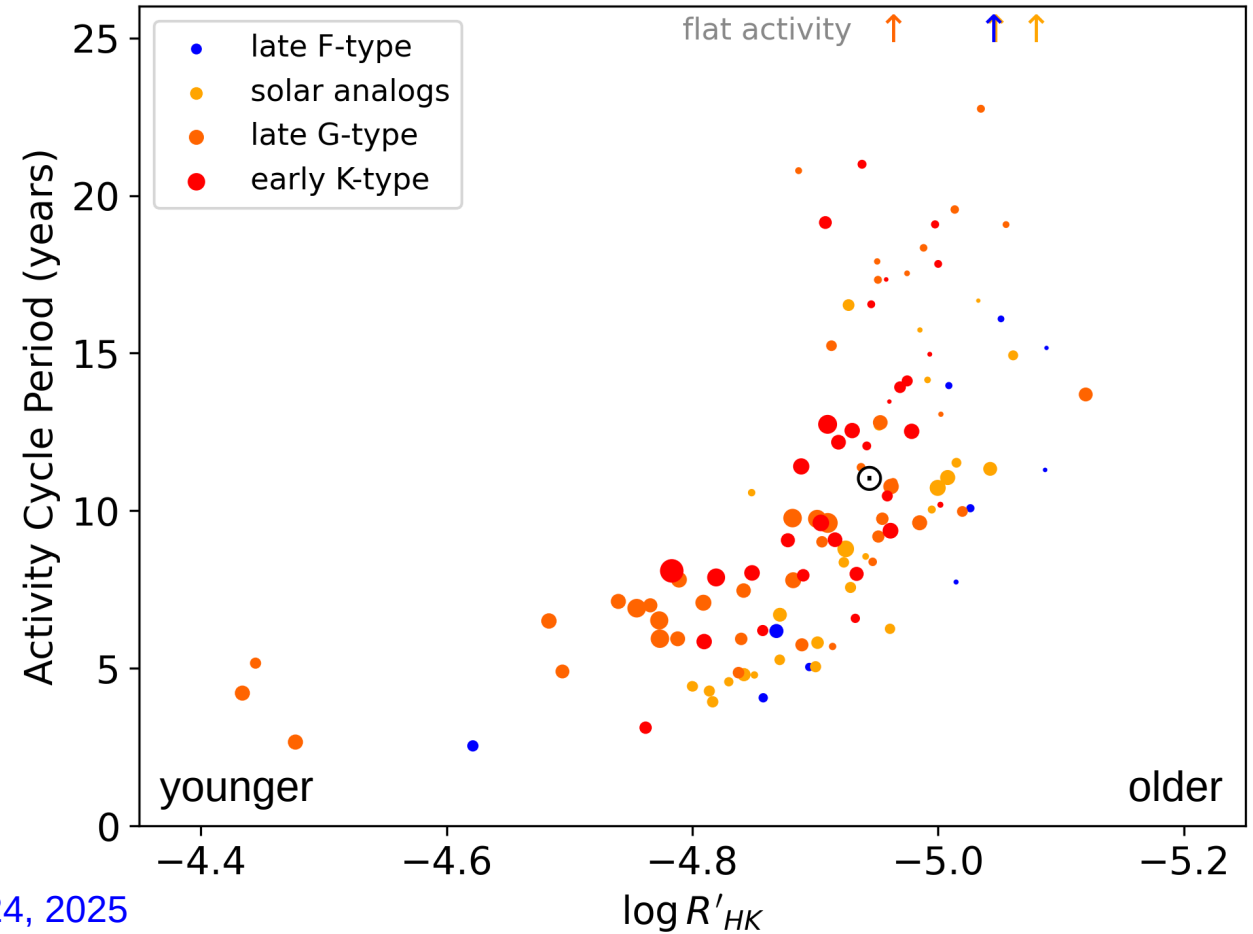
Finley+2018, Metcalfe+2025b

Reduced coronal heating & mass-loss



Judge+2003, Metcalfe+2025b

Activity cycles grow longer and weaker



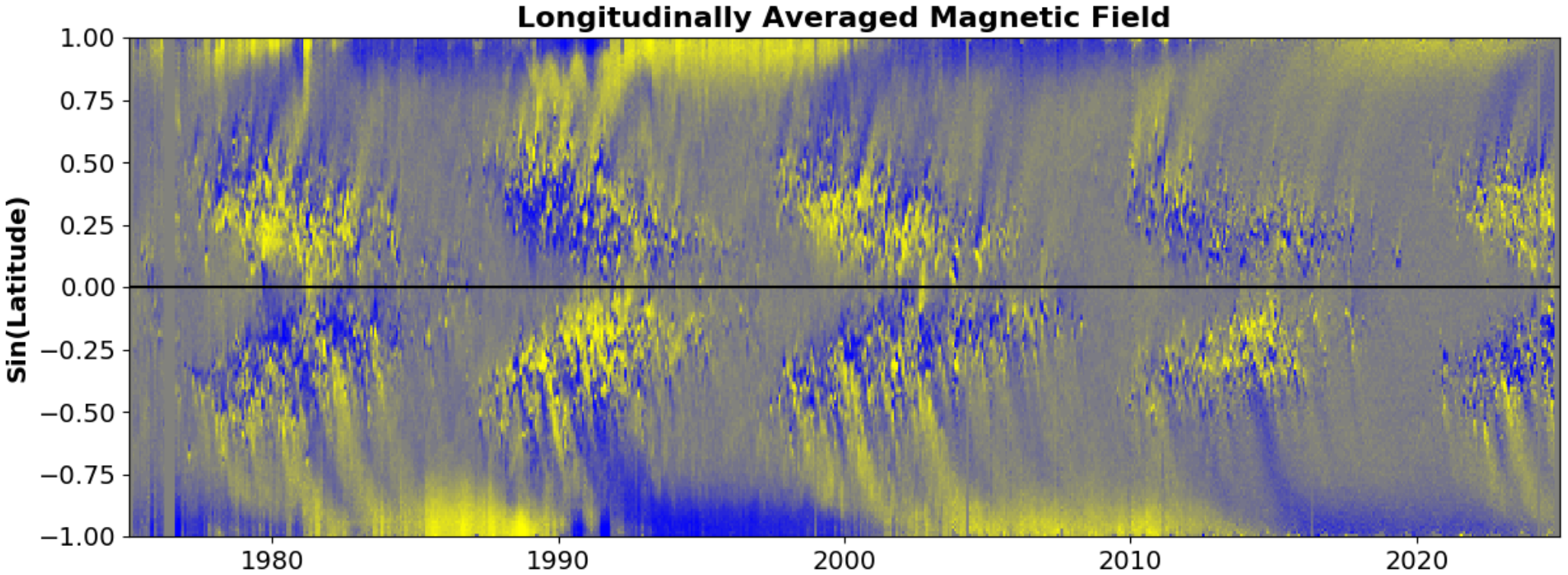
data: Isaacson+2024, 2025

Metcalfe & van Saders 2017

Summary of conclusions

- Approaching a critical Ro just above the solar value, magnetic field starts to lose large-scale organization
- Global dynamo collapses at the critical Ro, which separates cycling stars from those with flat activity
- Disrupted large-scale field and reduced mass-loss combine to produce weakened magnetic braking
- At constant rotation period, magnetic cycles grow longer & weaker on stellar evolutionary timescales

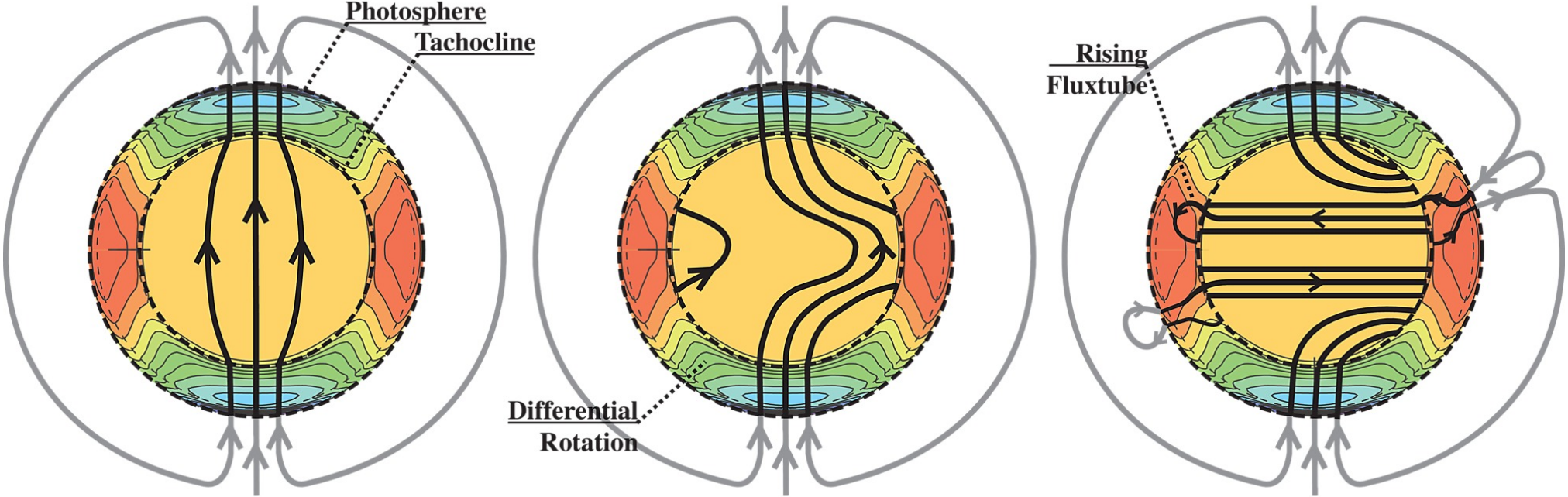
Slow rotation weakens large-scale field



Coriolis force ⇒ Joy's law tilt, differential rotation, meridional circulation

Credit: SolarCycleScience.com

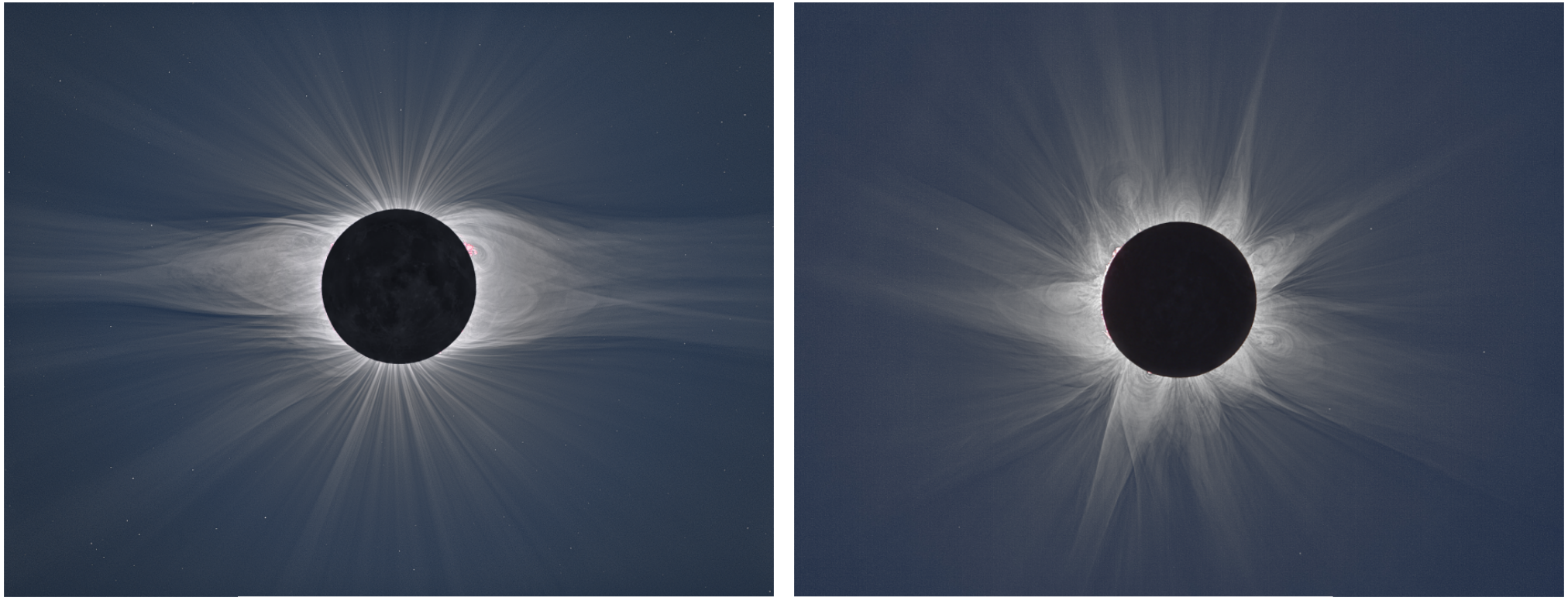
Slow rotation reduces flux emergence



Ω-effect: weaker differential rotation acting on weaker large-scale field

Higgins 2012

Complex field throttles mass-loss



Stellar wind escapes along open magnetic field lines

Credit: Miloslav Druckmüller

Garraffo+2015, Shoda+2023