

Stellar Evidence of a Collapsing Solar Dynamo

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Victor See, Ilya Ilyin, Klaus Strassmeier & many others



Sufficiently slow rotation



Disrupts large-scale field



Collapse of global dynamo

Sufficiently slow rotation



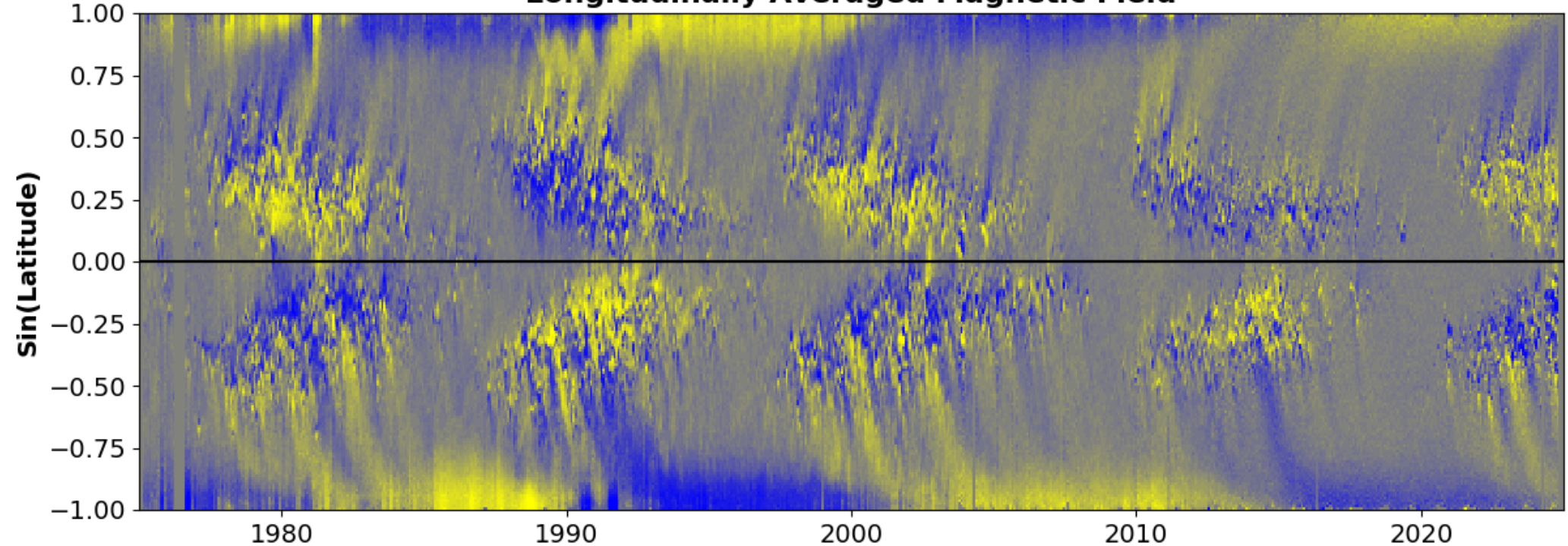
Disrupts large-scale field



Collapse of global dynamo

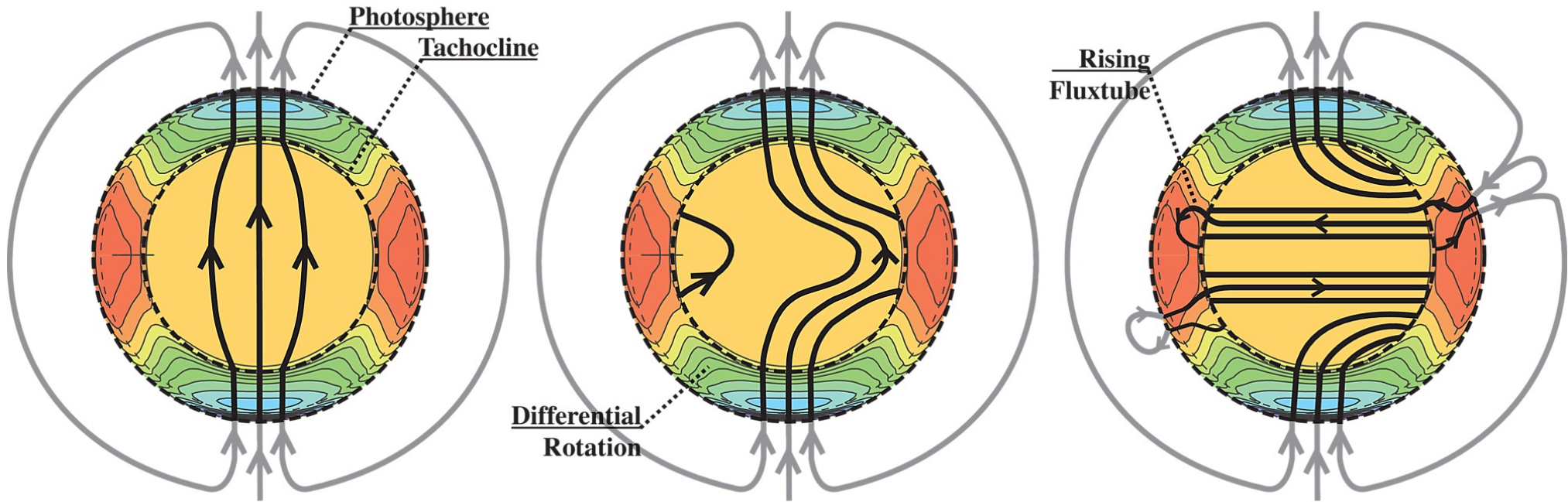
Slow rotation weakens large-scale field

Longitudinally Averaged Magnetic Field



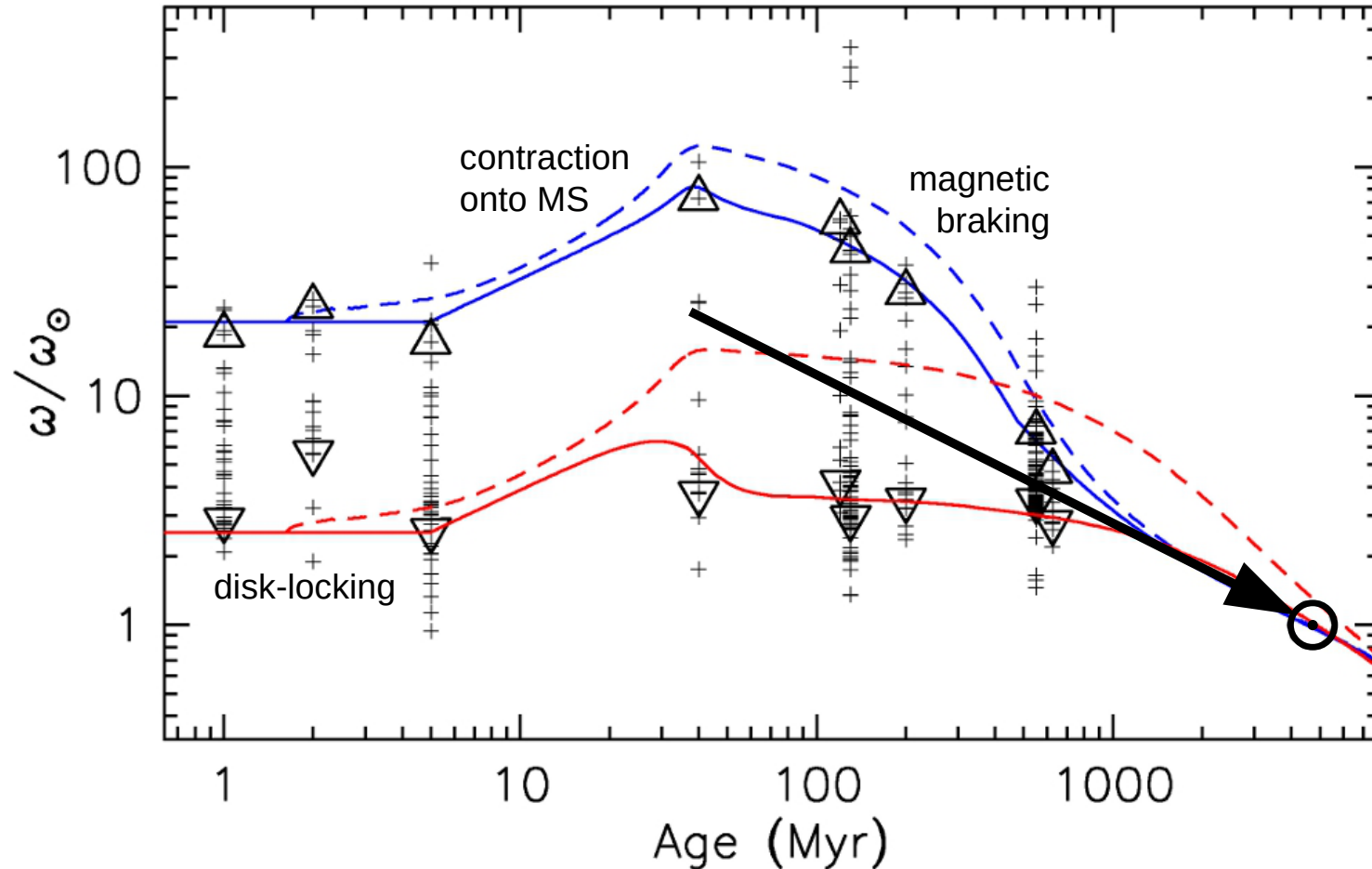
Coriolis force \Rightarrow Joy's law tilt, differential rotation, meridional circulation

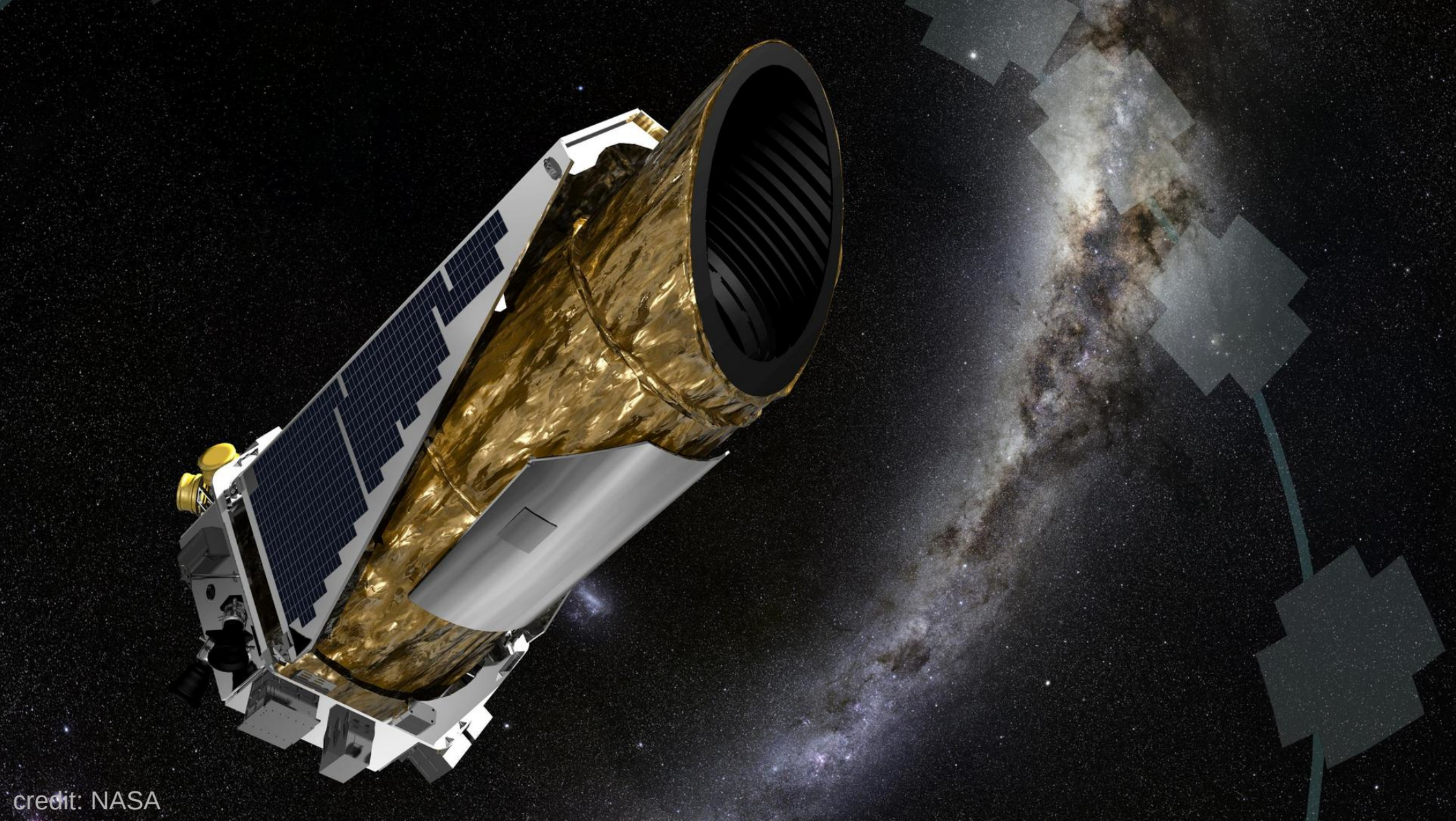
Slow rotation reduces flux emergence



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

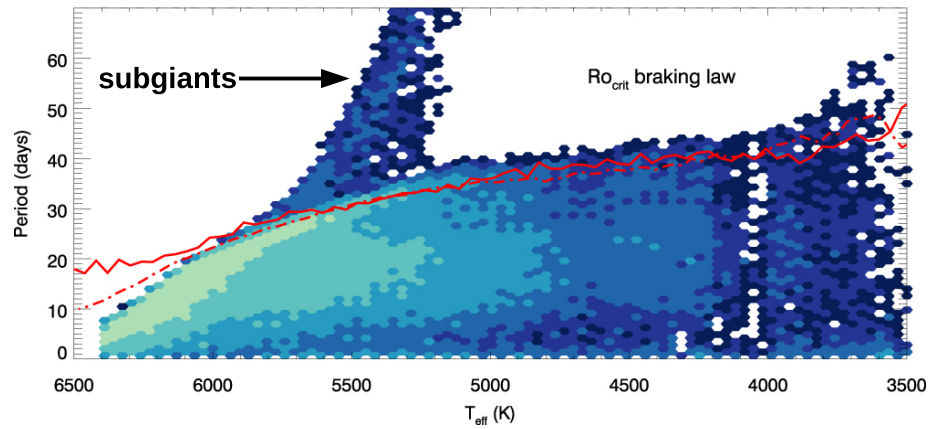
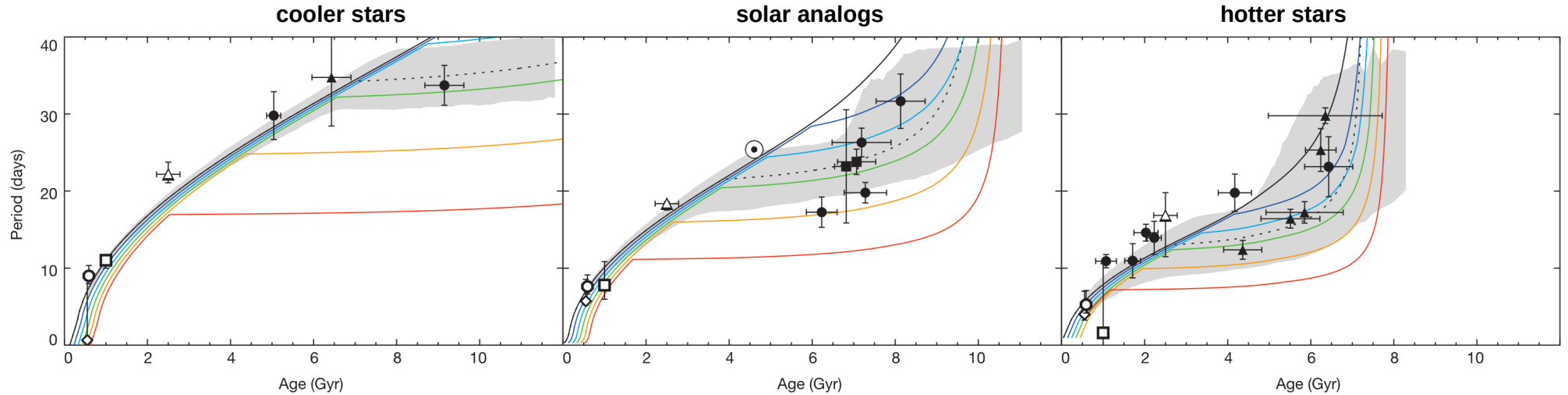
Standard model of rotational evolution



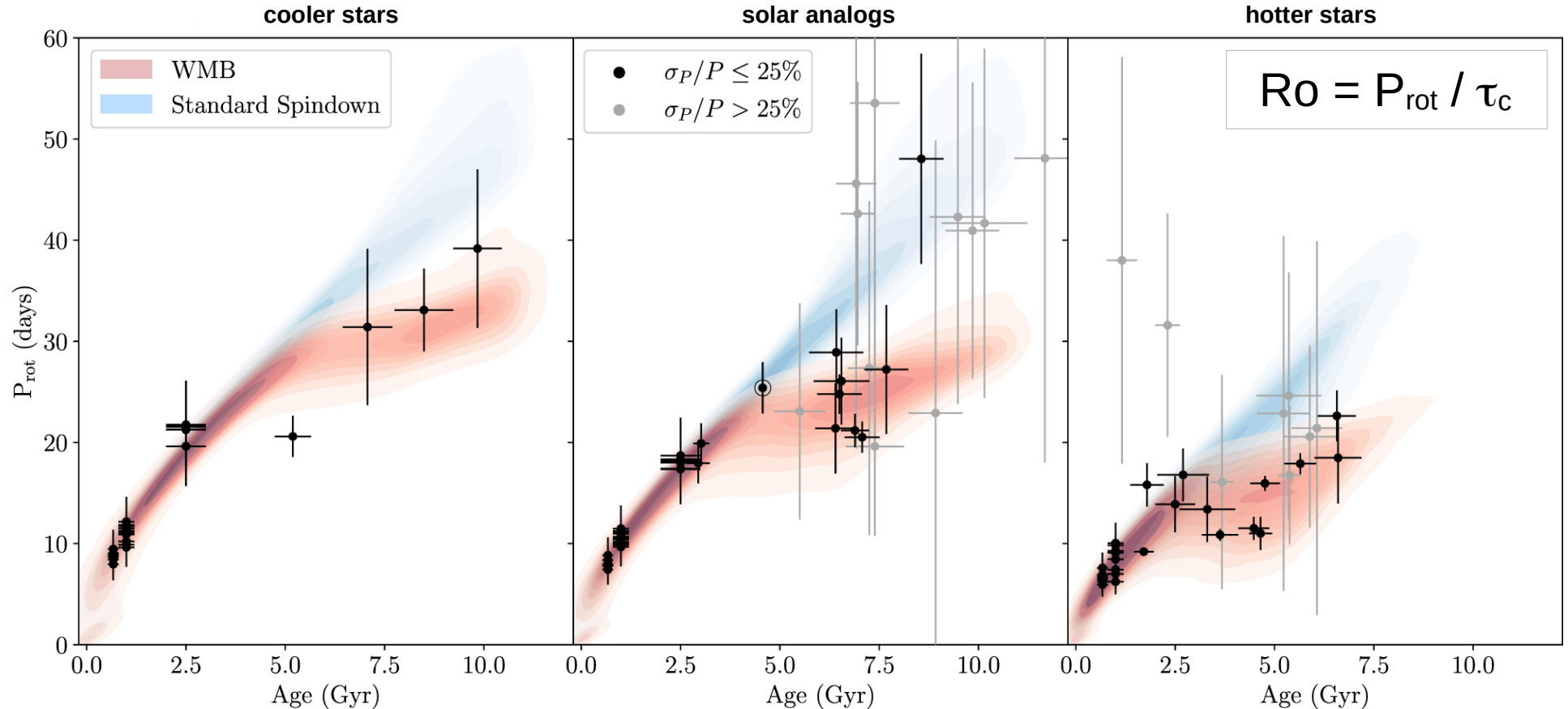


credit: NASA

Rotation of old stars suggests WMB



Rotation of old stars suggests WMB



Sufficiently slow rotation

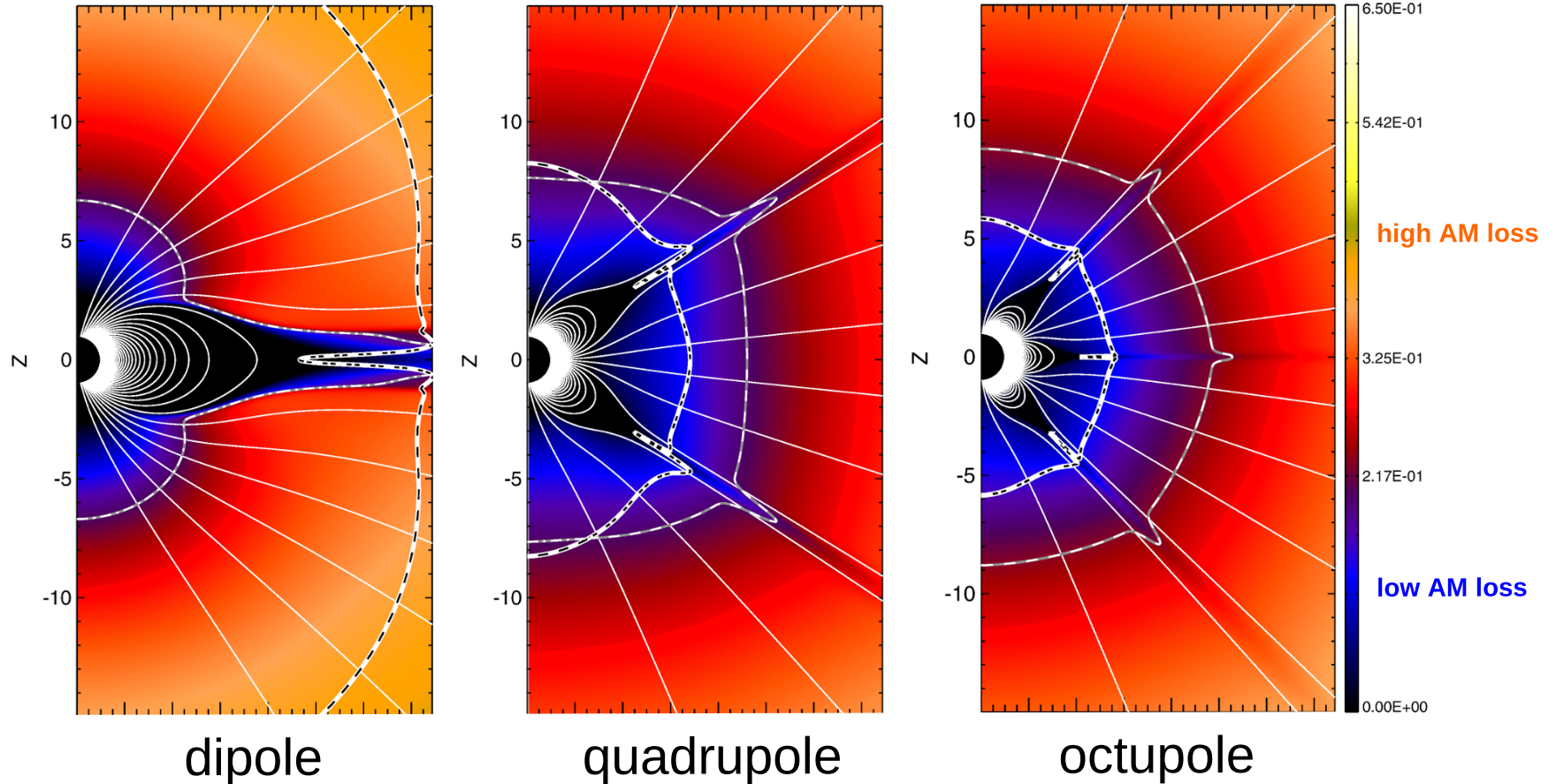


Disrupts large-scale field



Collapse of global dynamo

Large-scale field dominates AM loss

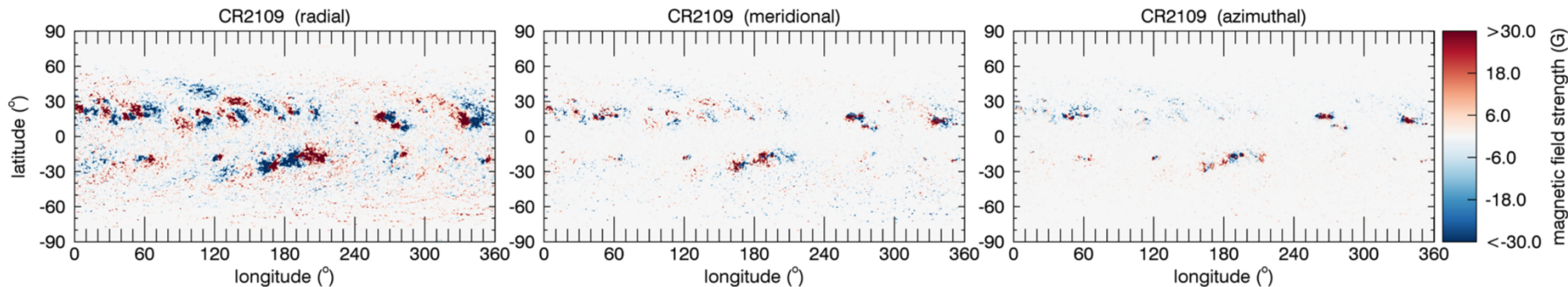


radial

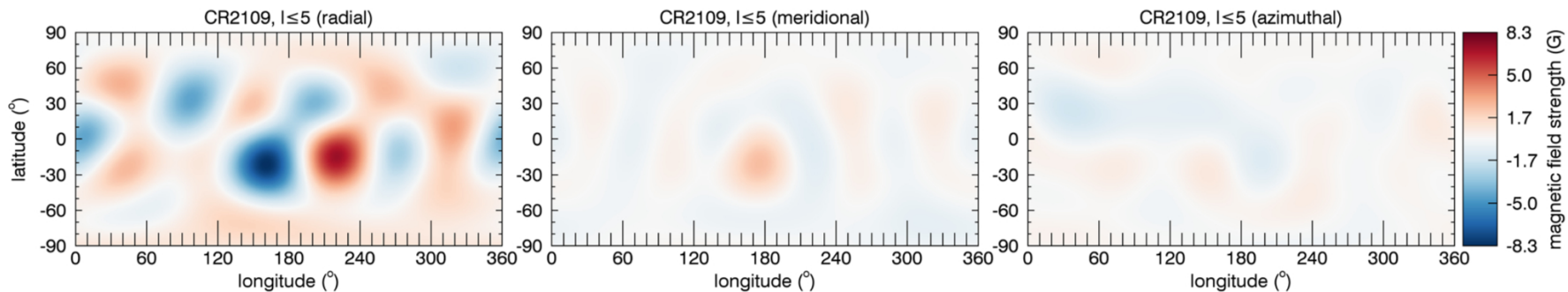
meridional (N-S)

azimuthal (E-W)

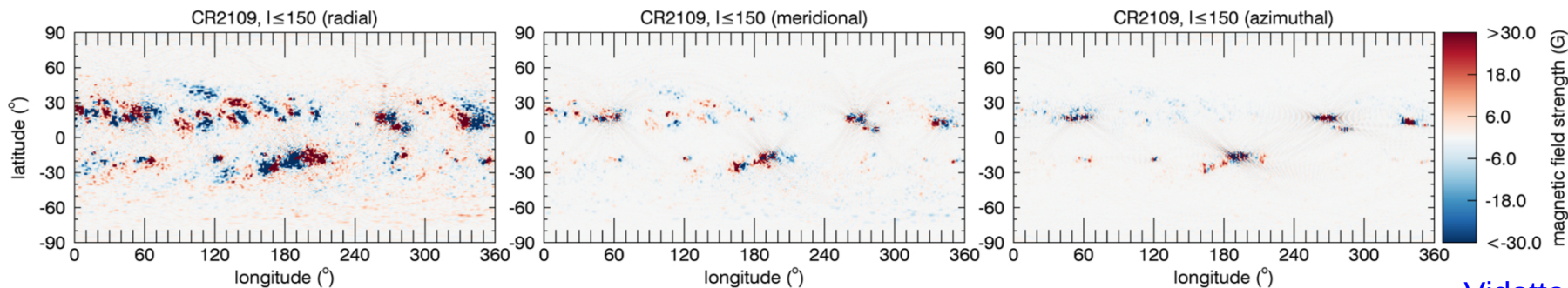
obs



$l < 5$



$l < 150$





credit: Ryan Ketterer

2021

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Magnetic and Rotational Evolution of ρ CrB from Asteroseismology with TESS

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2022

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OPEN ACCESS

The Origin of Weakened Magnetic Braking in Old Solar Analogs

Travis S. Metcalfe¹, Adam J. Finley², Oleg Kochukhov³, Victor See⁴, Thomas R. Ayres⁵, Keivan G. Stassun⁶, Jennifer L. van Saders⁷, Catherine A. Clark^{8,9}, Diego Godoy-Rivera^{10,11,12}, Ilya V. Ilyin¹³, Marc H. Pinsonneault¹⁰, Klaus G. Strassmeier¹³, and Pascal Petit¹⁴

2023

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

Travis S. Metcalfe¹, Klaus G. Strassmeier², Ilya V. Ilyin², Jennifer L. van Saders³, Thomas R. Ayres⁴, Adam J. Finley⁵, Oleg Kochukhov⁶, Pascal Petit⁷, Victor See⁸, Keivan G. Stassun⁹, Sandra V. Jeffers¹⁰, Stephen C. Marsden¹¹, Julien Morin¹², and Aline A. Vidotto¹³

2025

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

Travis S. Metcalfe¹, Pascal Petit², Jennifer L. van Saders³, Thomas R. Ayres⁴, Derek Buzasi⁵, Oleg Kochukhov⁶, Keivan G. Stassun⁷, Marc H. Pinsonneault⁸, Ilya V. Ilyin⁹, Klaus G. Strassmeier⁹, Adam J. Finley¹⁰, Rafael A. García¹⁰, Daniel Huber^{3,11}, Yuxi (Lucy) Lu⁸, and Victor See¹²

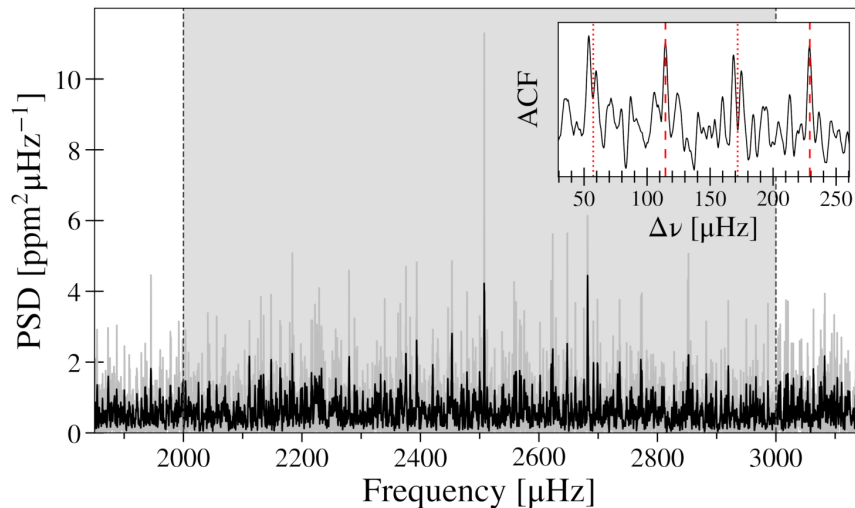
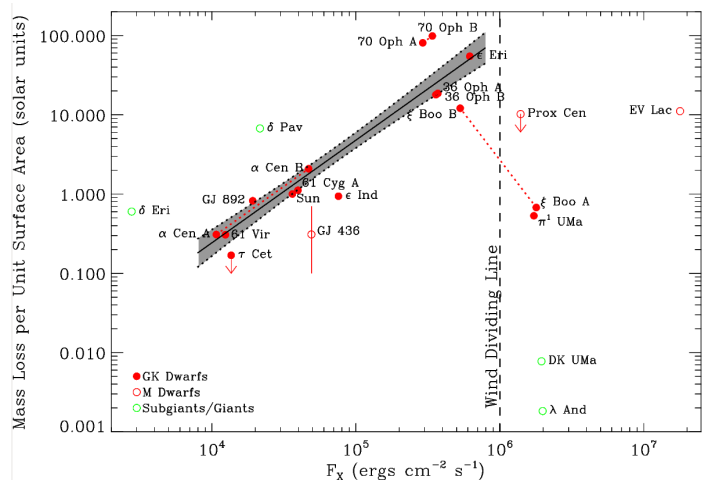
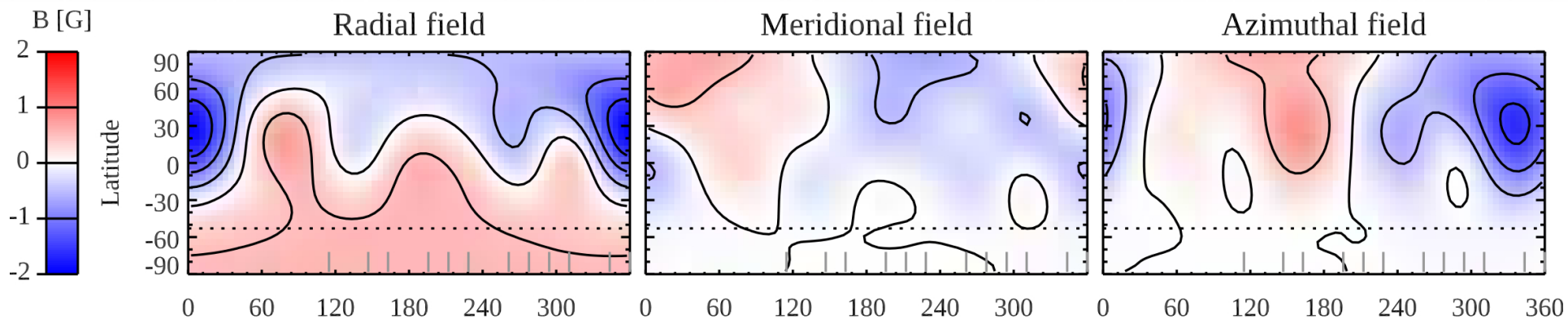
late
F-type

solar
analogs

late
G-type

early
K-type

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



Sufficiently slow rotation



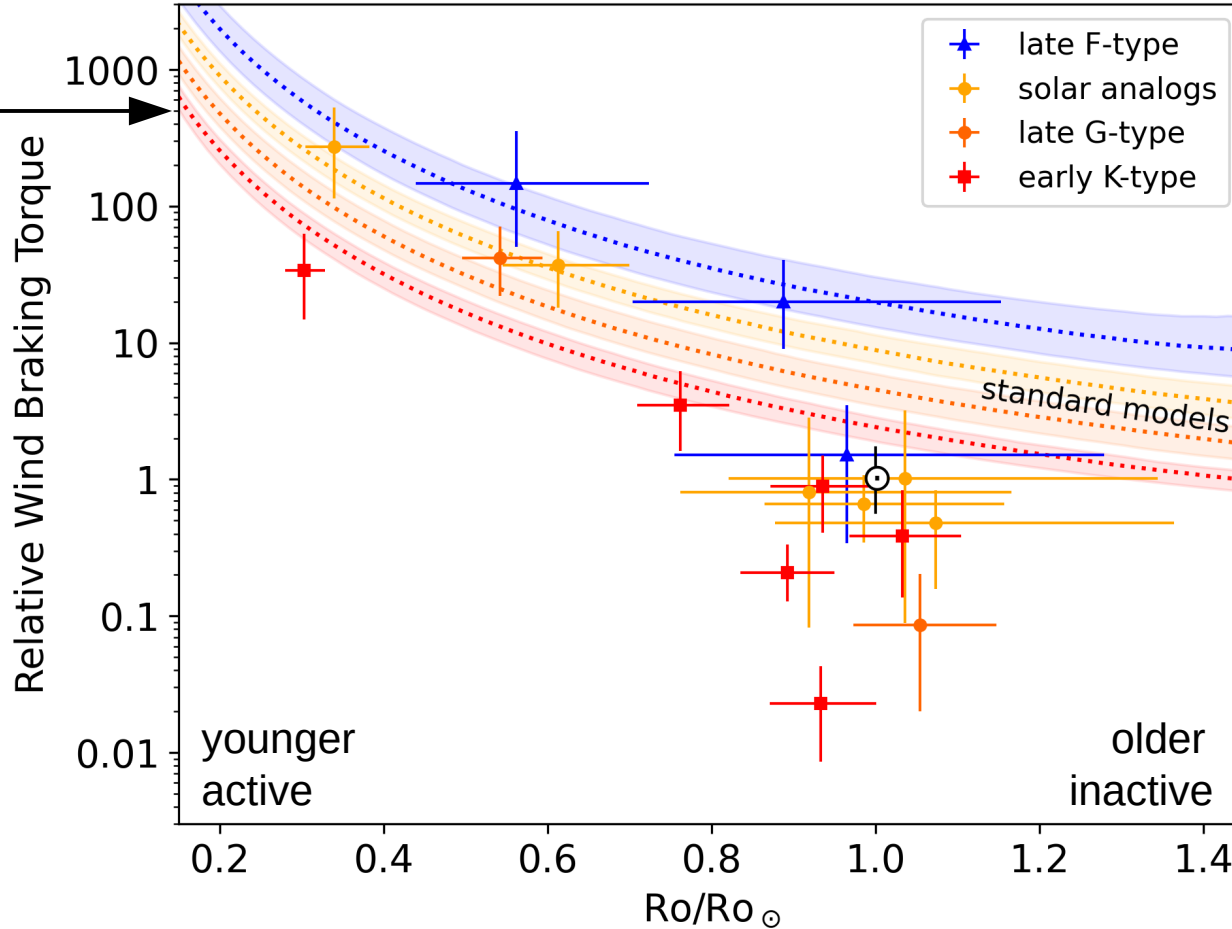
Disrupts large-scale field



Collapse of global dynamo

Weakened magnetic braking at $Ro \sim Ro_{\odot}$

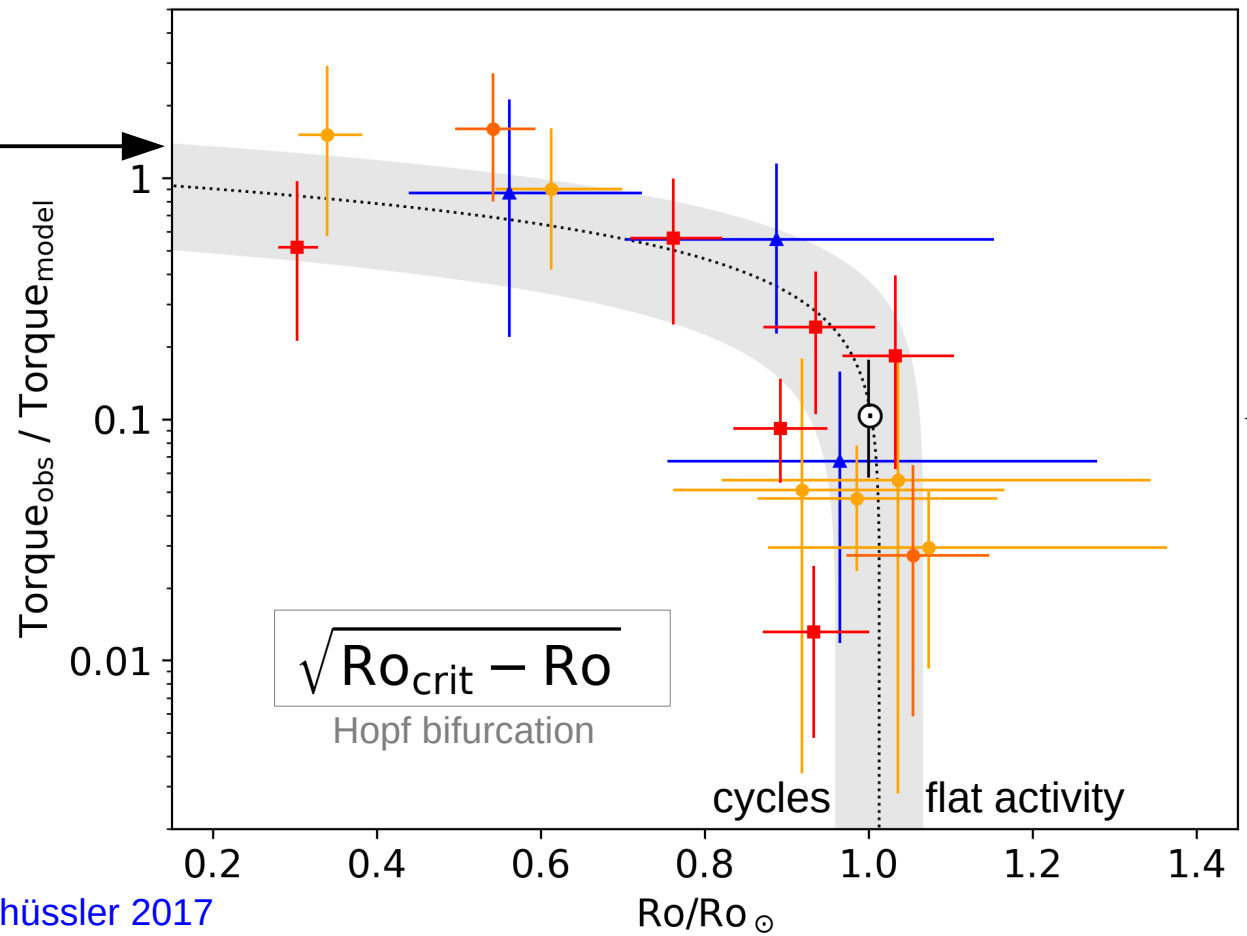
Skumanich
spin-down



Weakened
braking

Efficiency of global dynamo collapses

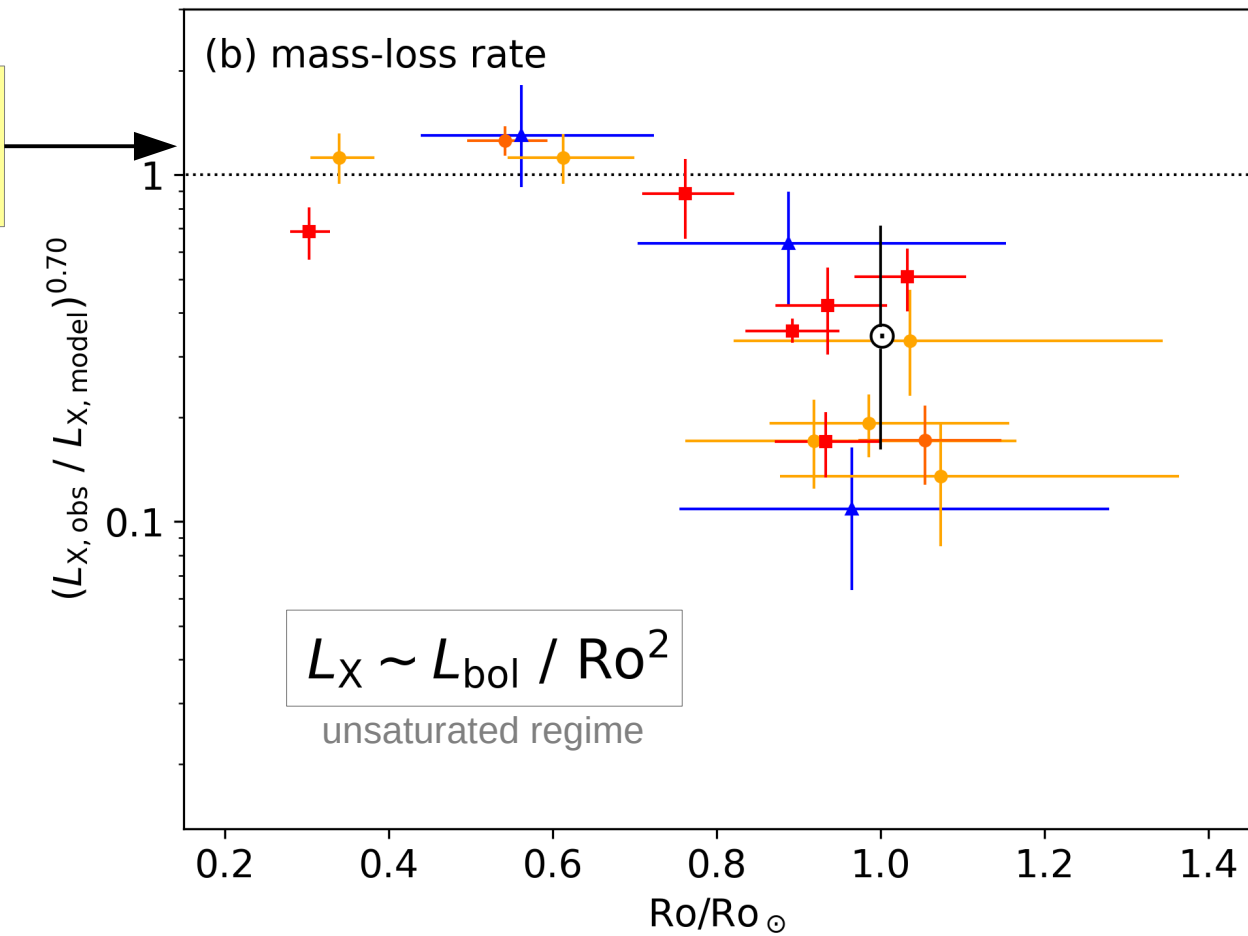
Skumanich
spin-down



Weakened
braking

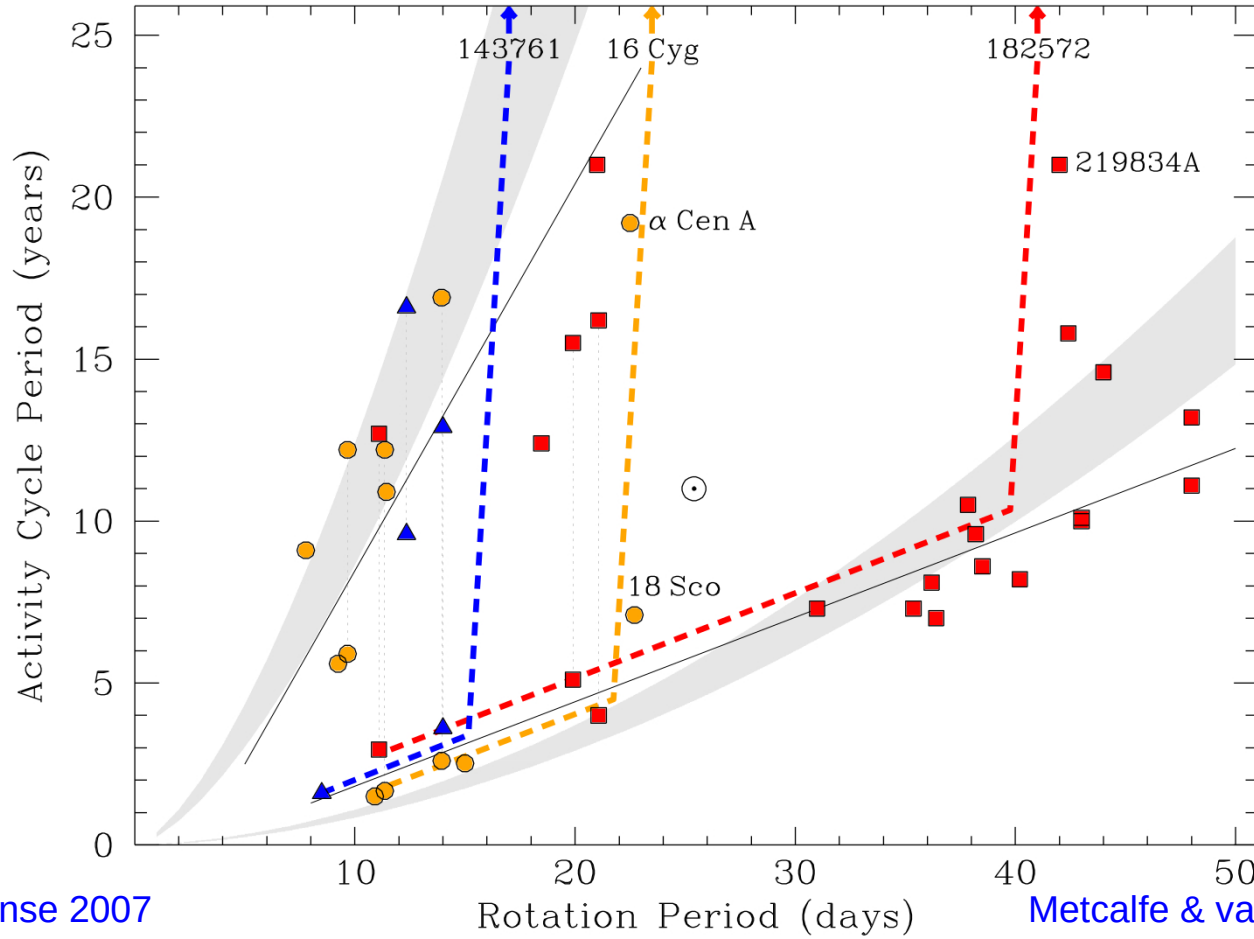
Reduced coronal heating & mass-loss

Skumanich
spin-down

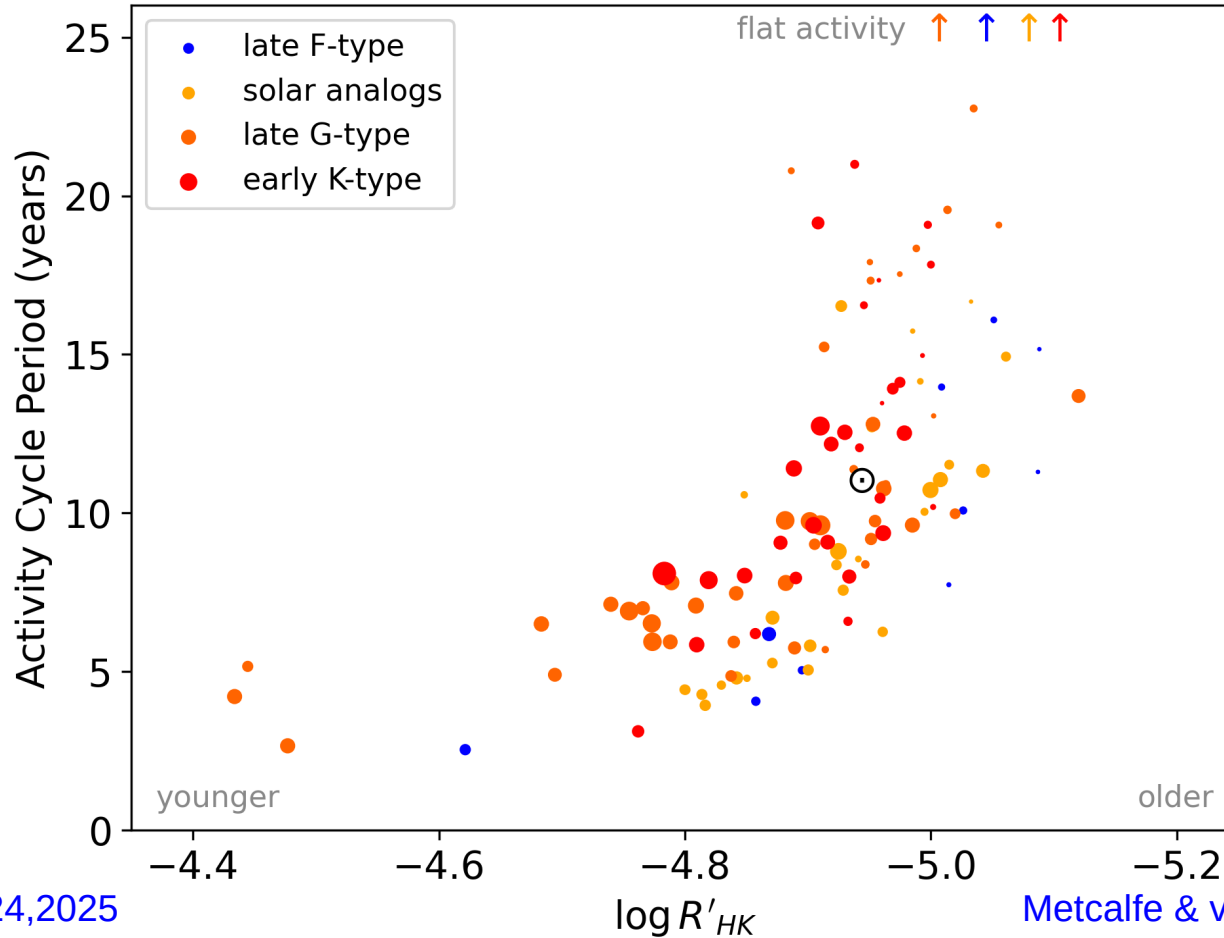


Weakened
braking

Activity cycles grow longer and weaker



Activity cycles grow longer and weaker



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

