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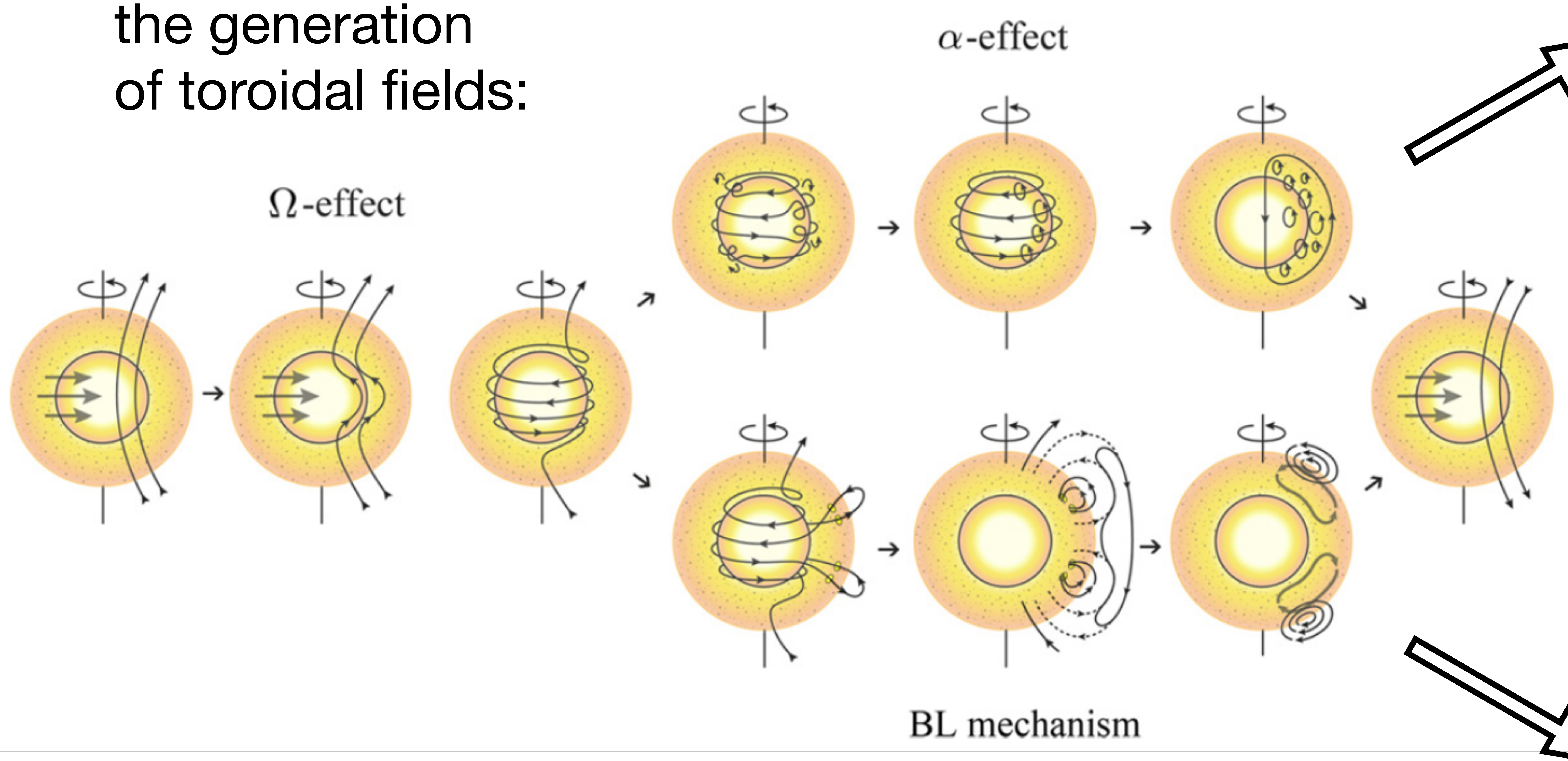
Common dynamo scaling in slowly rotating young and evolved stars

Jyri J. Lehtinen[1,2] ✉, Federico Spada[1], Maarit J. Käpylä[1,2], Nigul Olspert[1] and Petri J. Käpylä[2,3]

the generation of poloidal fields:

the generation of toroidal fields:

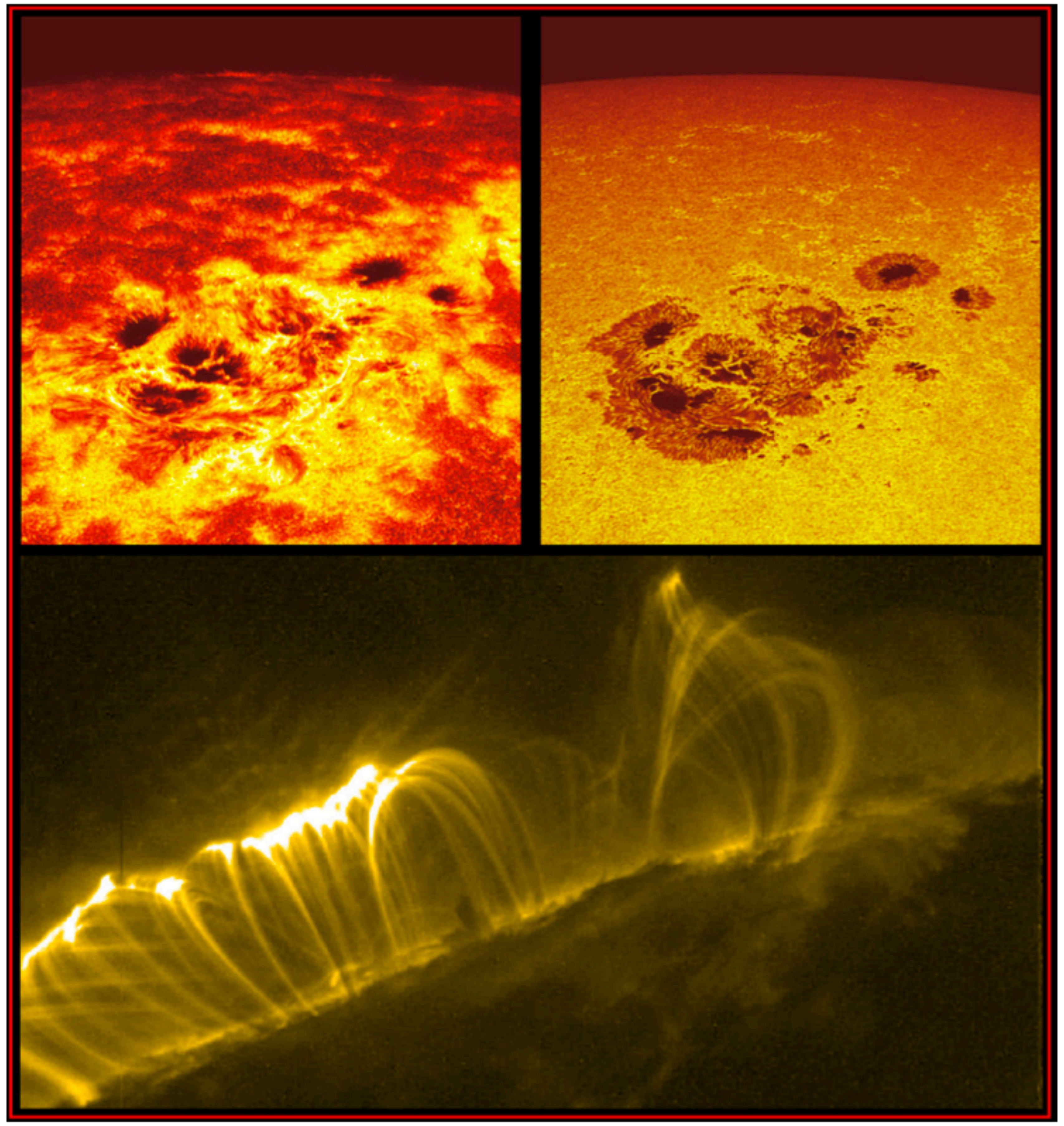


Sanchez et al. 2014

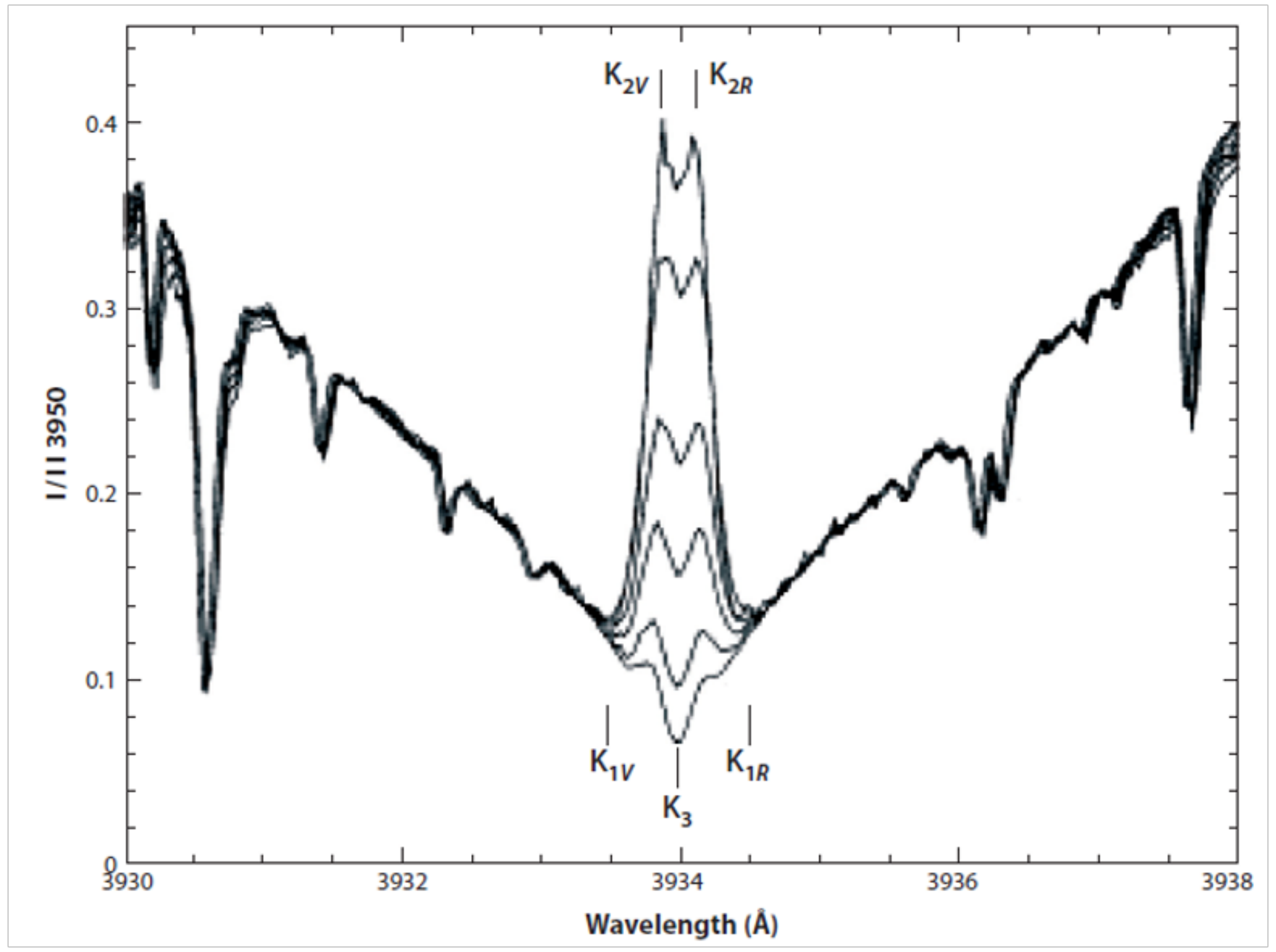
Toroidal fields get dragged by hot rotationally convective cells and become small loops.

The rising flux tubes get twisted by rotation and move polewards by meridional flow.

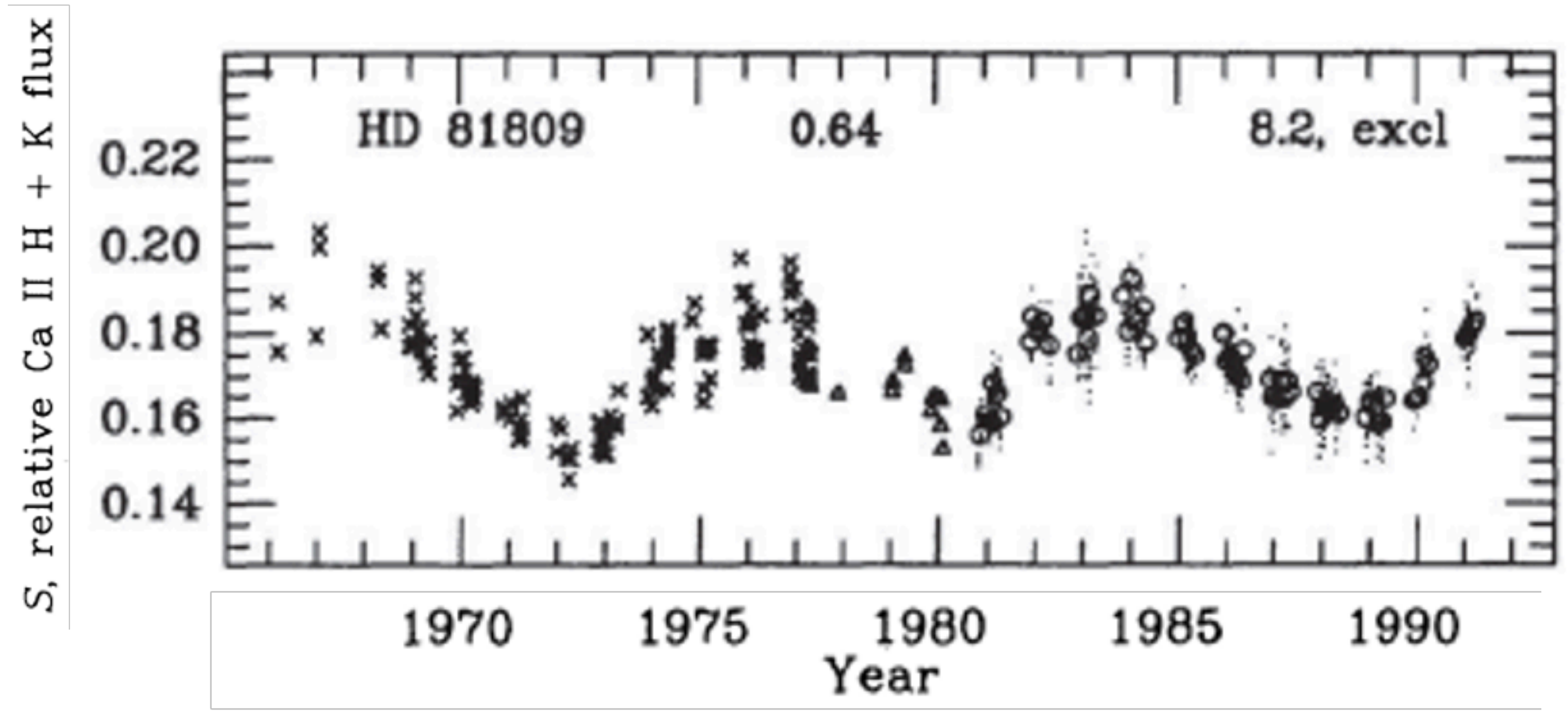
Whether the turbulence is key to stellar dynamos?



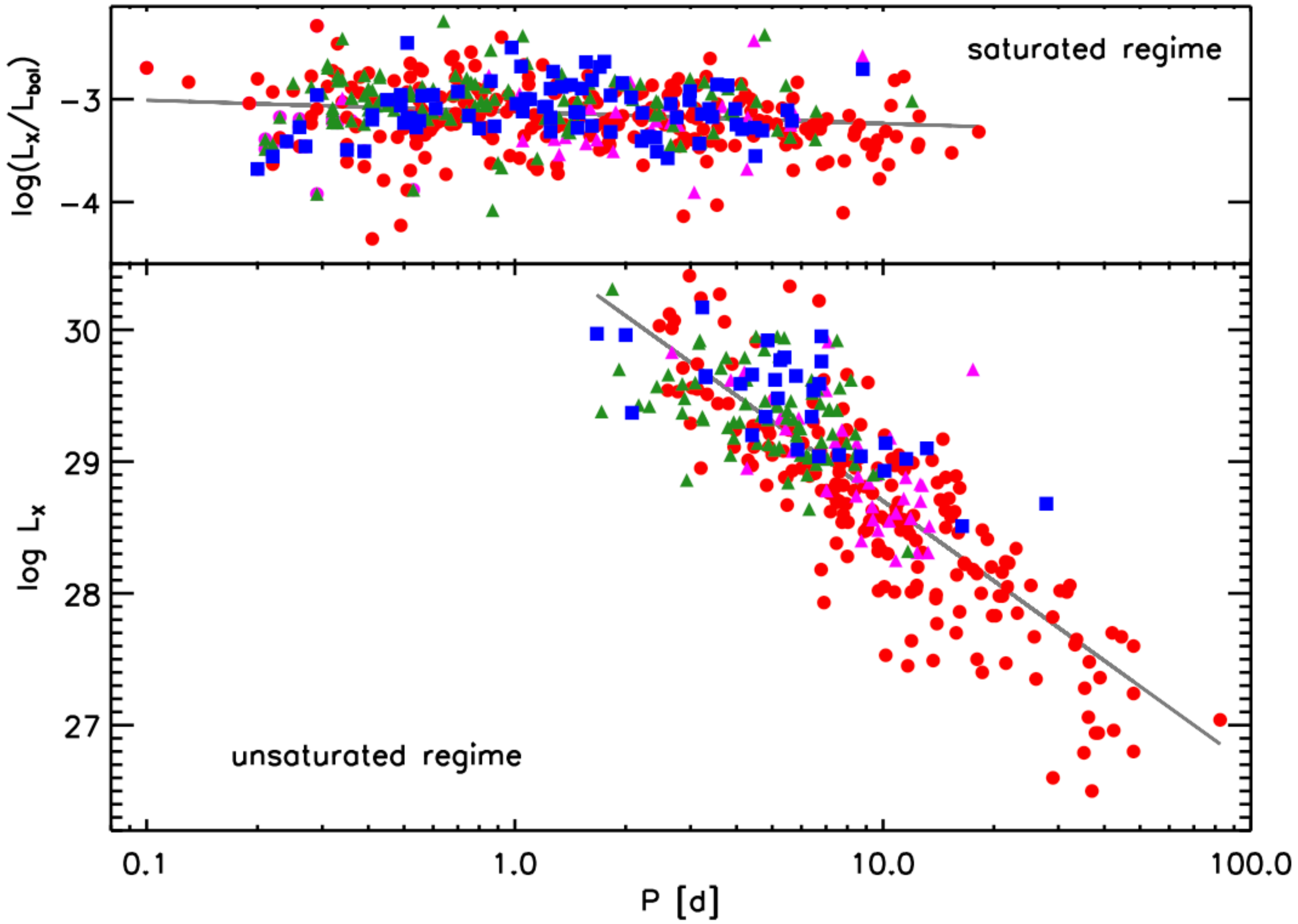
Hall et al. 2008

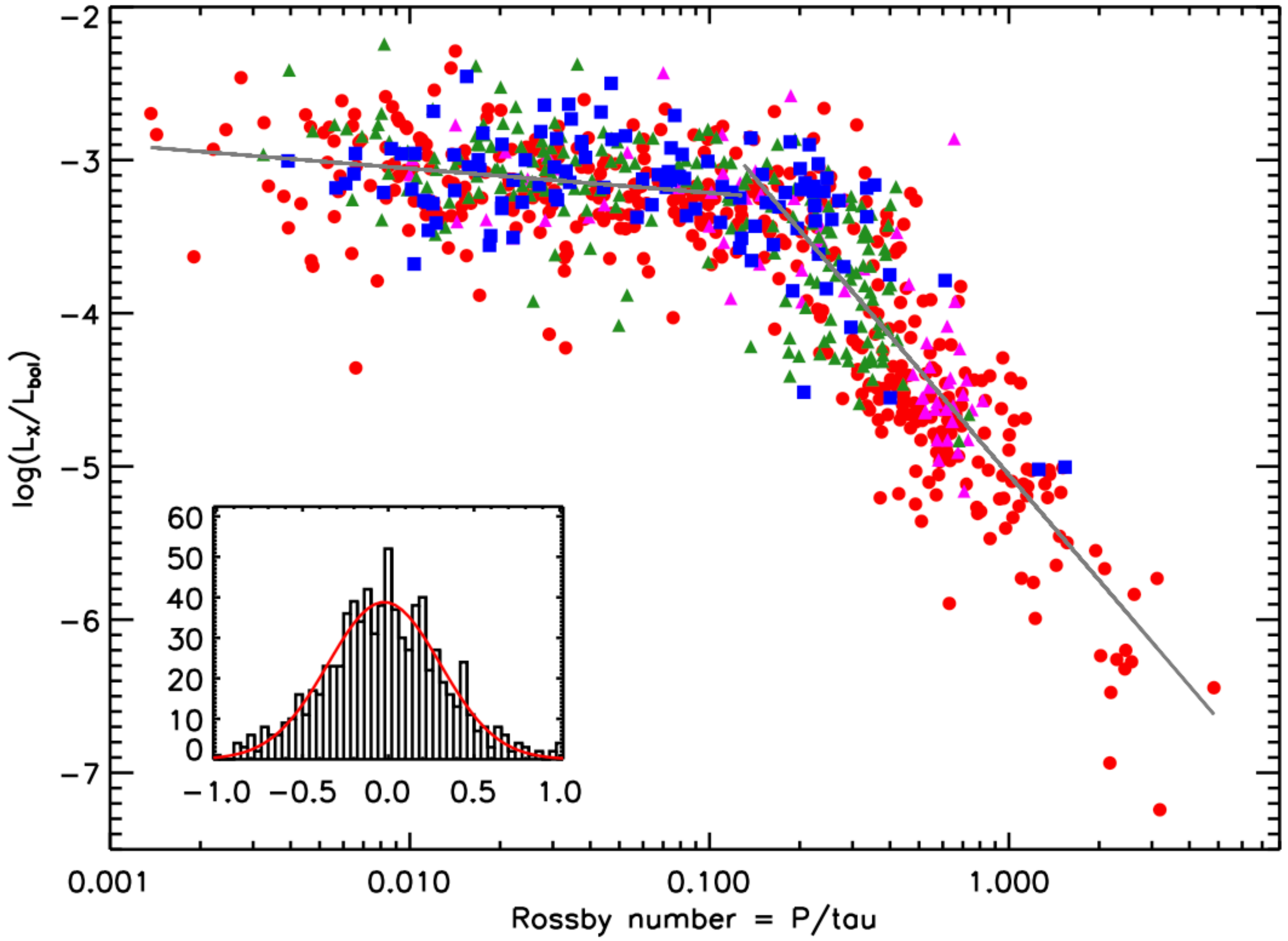


Pasquini et al. 1992



Baliunas et al. 1995





Reiners et al. 2014

$$\mathrm{Ro} = \frac{P_{\mathrm{rot}}}{\tau} \qquad \tau = \frac{d_{\mathrm{CZ}}}{\bar{v}_{\mathrm{T}}}$$

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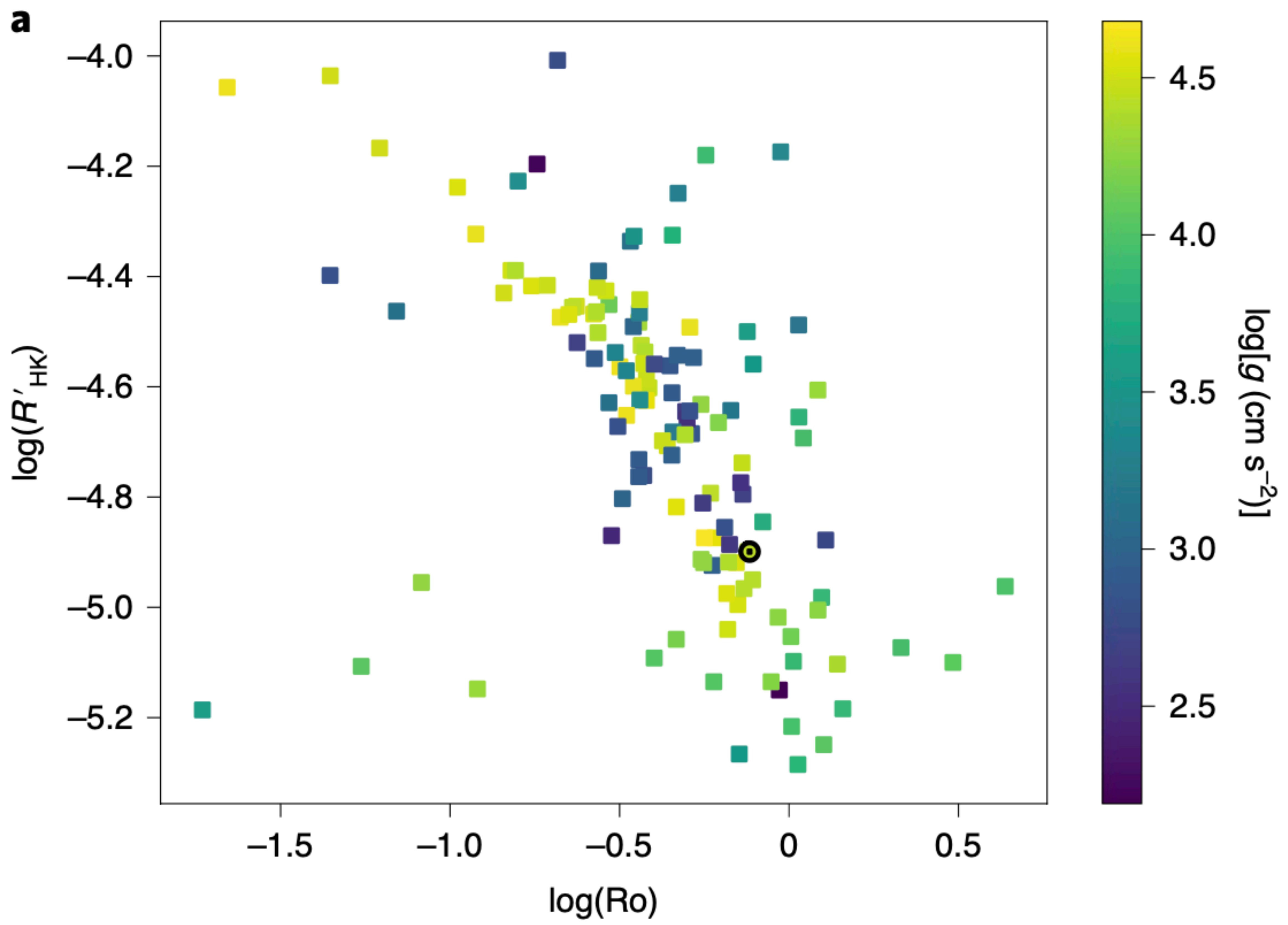
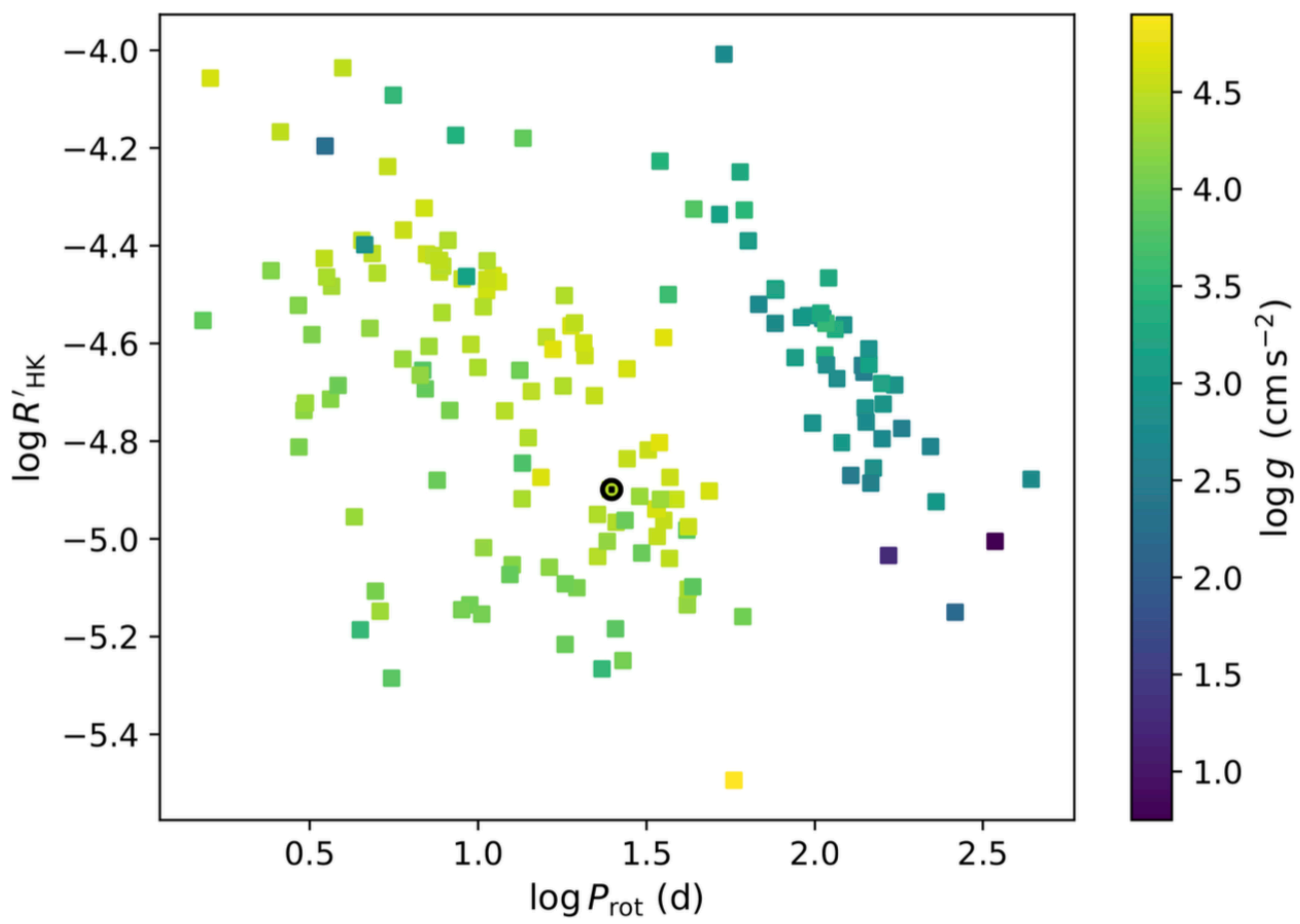
Abstract

One interpretation of the activity and magnetism of late-type stars is that these both intensify with decreasing Rossby number up to a saturation level[1,2,3], suggesting that stellar dynamos depend on both rotation and convective turbulence[4]. Some studies have claimed, however, that rotation alone suffices to parametrize this scaling adequately[5,6]. Here, we tackle the question of the relevance of turbulence to stellar dynamos by including evolved, post-main-sequence stars in the analysis of the rotation–activity relation. These stars rotate very slowly compared with main-sequence stars, but exhibit similar activity levels[7]. We show that the two evolutionary stages fall together in the rotation–activity diagram and form a single sequence in the unsaturated regime in relation only to Rossby numbers derived from stellar models, confirming earlier preliminary results that relied on a more simplistic parametrization of the convective turn-over time[8,9]. This mirrors recent results of fully convective M dwarfs, which likewise fall on the same rotation–activity sequence as partially convective solar-type stars[10,11]. Our results demonstrate that turbulence plays a crucial role in driving stellar dynamos and suggest that there is a common turbulence-related dynamo mechanism explaining the magnetic activity of all late-type stars.





- Stars on the two evolutionary stages form a single sequence.
- The Rossby-independent parametrizations for the rotation–activity relation break down once evolved stars are considered.

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