Rotation and Spot Activity of Young Solar-Type Stars

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Spot activity study

- Recent study of 21 nearby solar-type stars

  (Lehtinen et al. 2016, A&A, 588, A38)
- 16 – 27 years of nightly photometry from Fairborn
- Spectral types F9 – K4

Differential Rotation

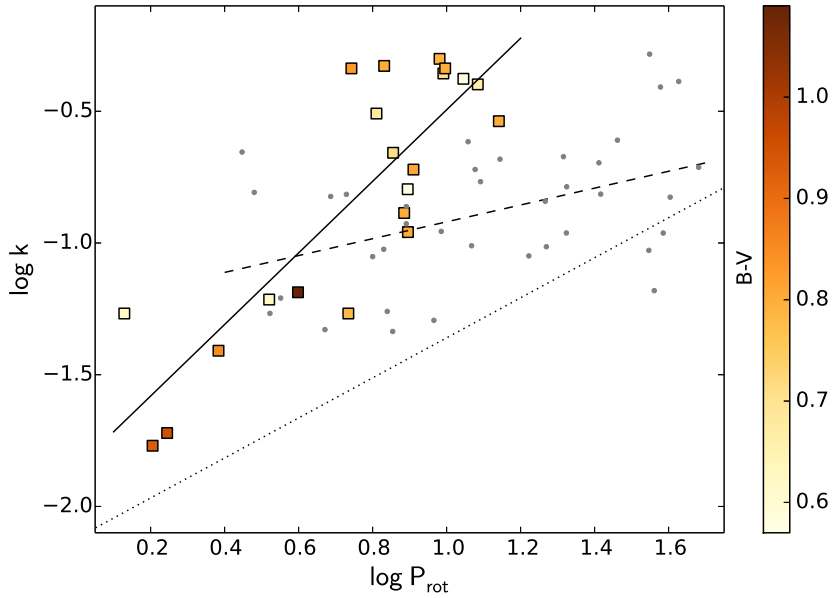
- DR results agree roughly with flat $\Delta\Omega$ vs. Ω dependence.
- No temperature dependence at $4500\,\mathrm{K} < T_{\mathrm{eff}} < 6000\,\mathrm{K}$.

(cf. Küker & Rüdiger 2011, Reinhold et al. 2013)

μ	ν	
0.76	0.24	Henry et al. (1995)
0.3	0.7	Donahue et al. (1996)
0.85	0.15	Barnes et al. (2005)
0.71	0.29	Reinhold & Gizon (2015)
1.36	−0.36	Lehtinen et al. (2016)

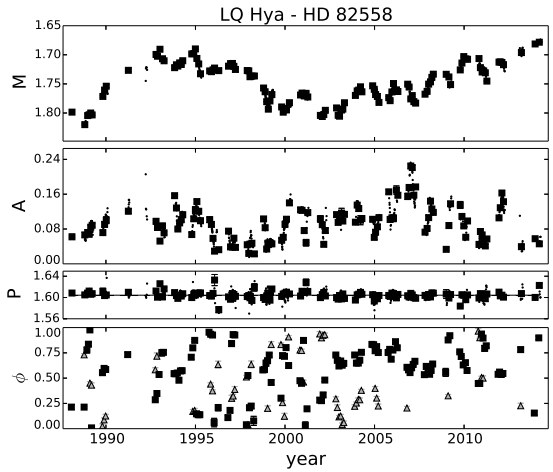
$$k \propto P^{\mu}$$

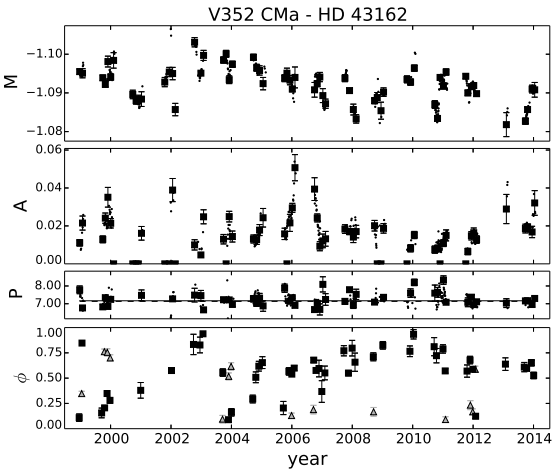
$$\Delta\Omega \propto \Omega^{\nu}$$

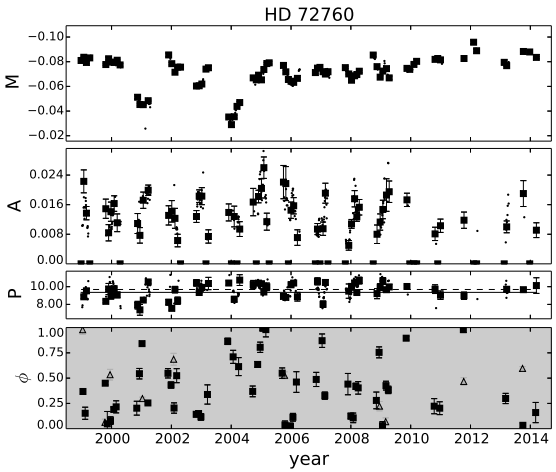


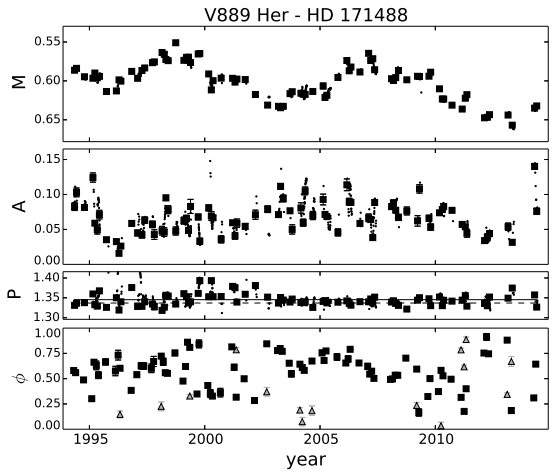
Activity Cycles and Active Longitudes

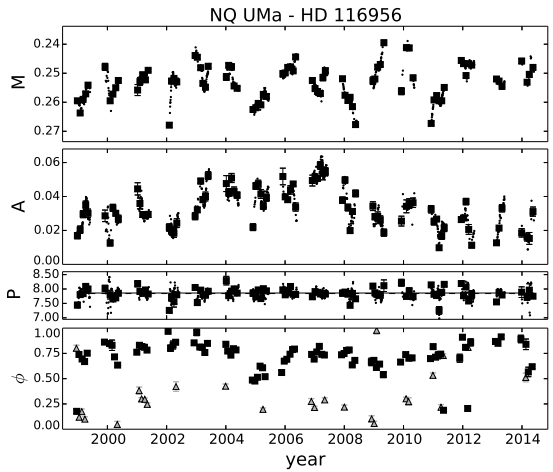
- Activity cycles (M, A) and active longitudes (t_{min}) are both common on the studied stars.

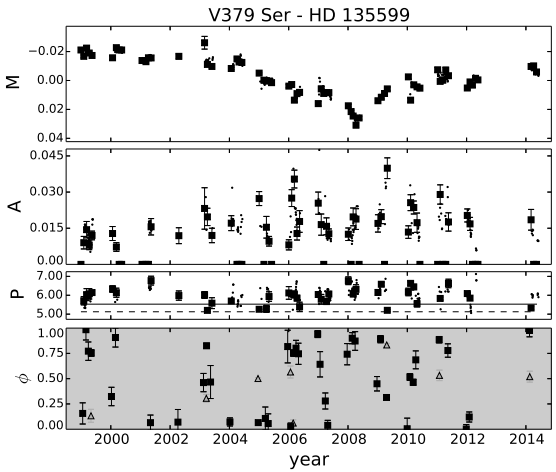






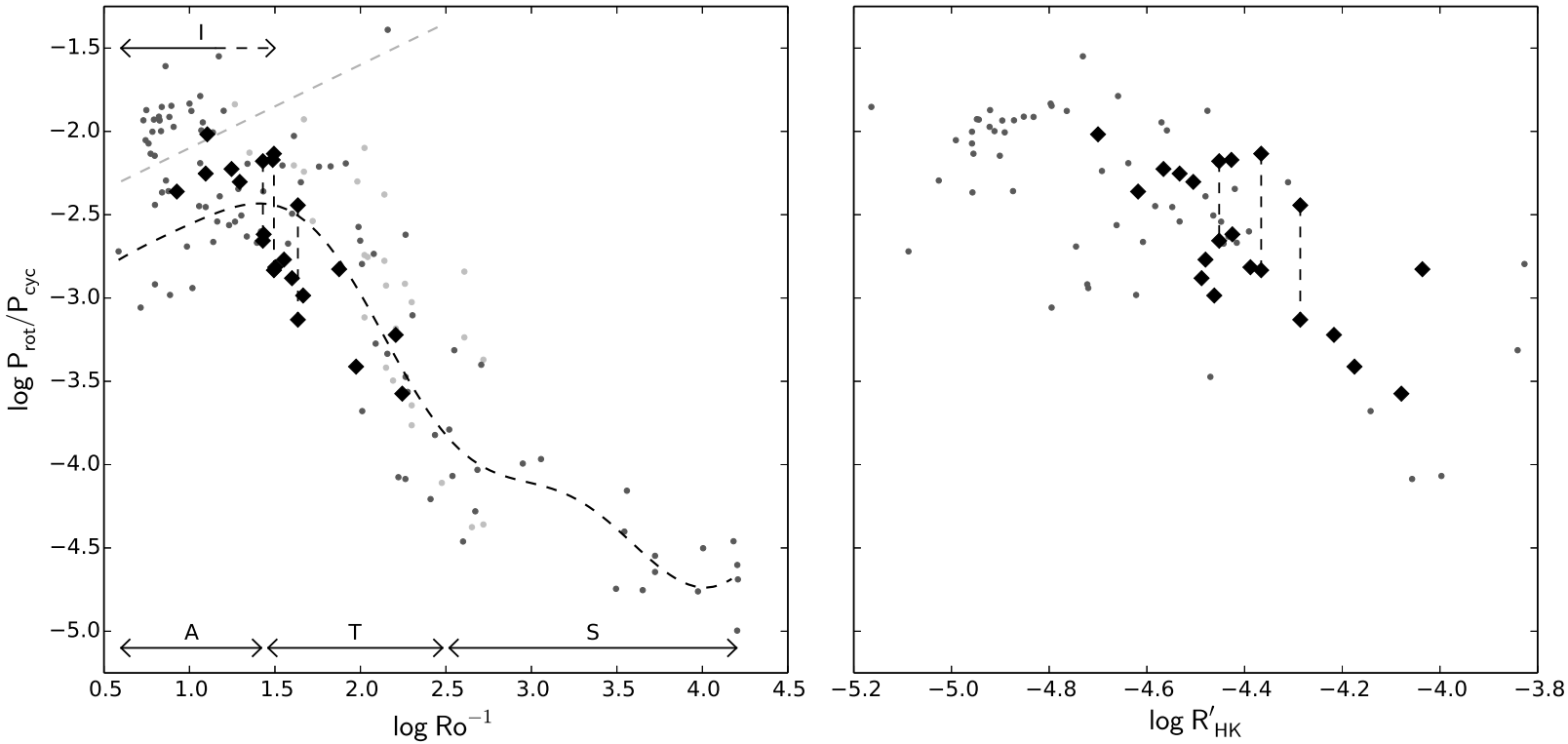






Activity Cycles

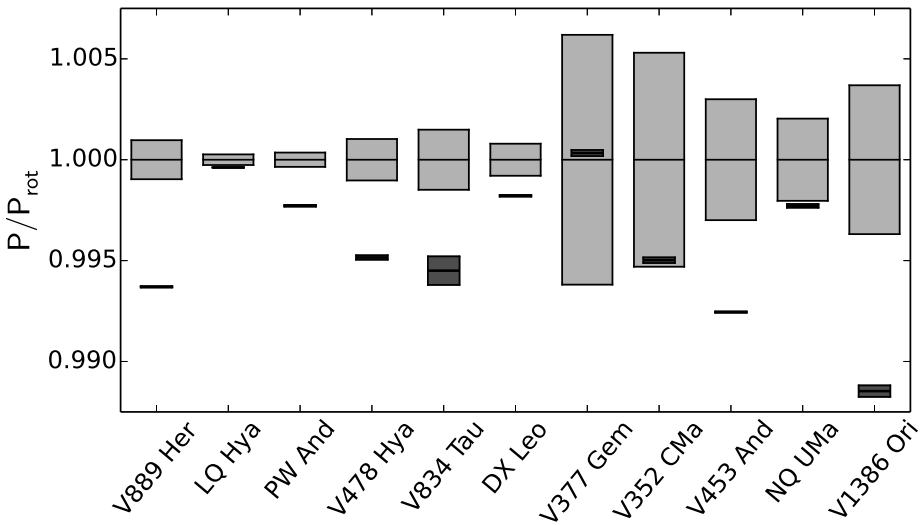
- Cycle lengths fall on a sequence of activity branches against the Rossby number and $\log R'_{\mathrm{HK}}$ (cf. Saar & Brandenburg 1999)
- A new separation into sub-branches is seen with $\frac{P_{\mathrm{cyc,\,long}}}{P_{\mathrm{cyc,\,short}}} \approx 6$.



reference data from Saar & Brandenburg (1999), Oláh et al. (2000, 2009)

Active Longitudes

- Often the active longitudes have significantly shorter rotation periods than the mean spot rotation, $P_{\mathrm{al}} < P_{\mathrm{rot}}$.



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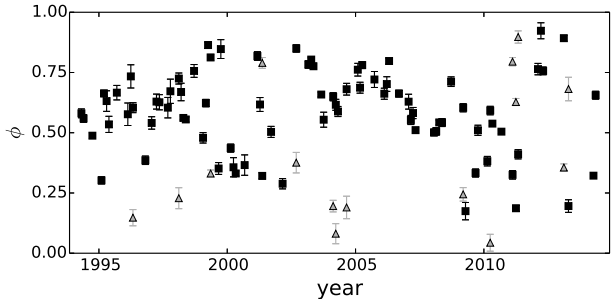
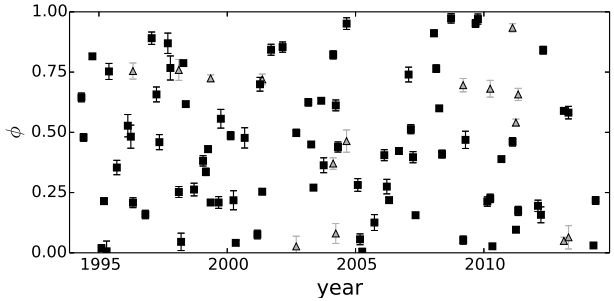


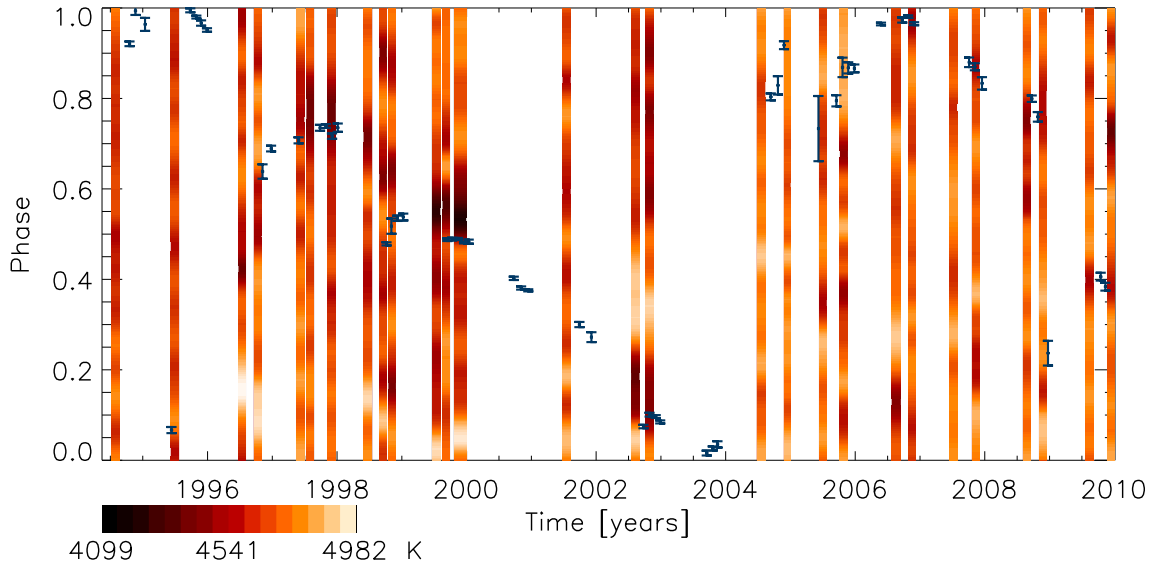
$P_{\mathrm{al}} = 1.33692\,\mathrm{d}$



$P_{\mathrm{rot}} = 1.3454\,\mathrm{d}$

Active Longitudes

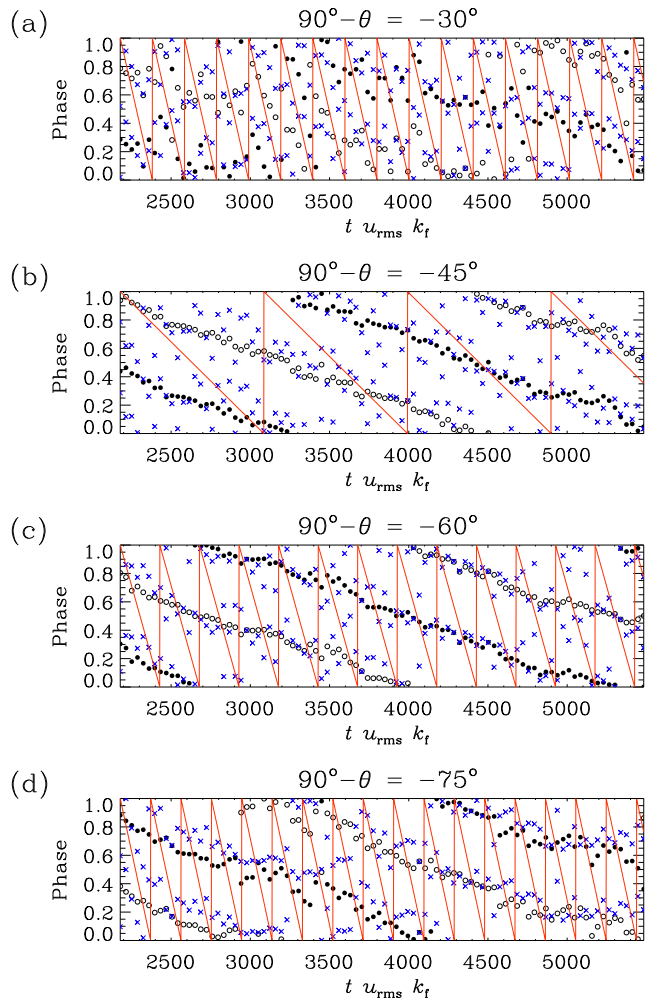
- The period difference $P_{\mathrm{al}} \neq P_{\mathrm{rot}}$ is also observed on RS CVn binaries.



II Peg (Hackman et al. 2011)

Active Longitudes

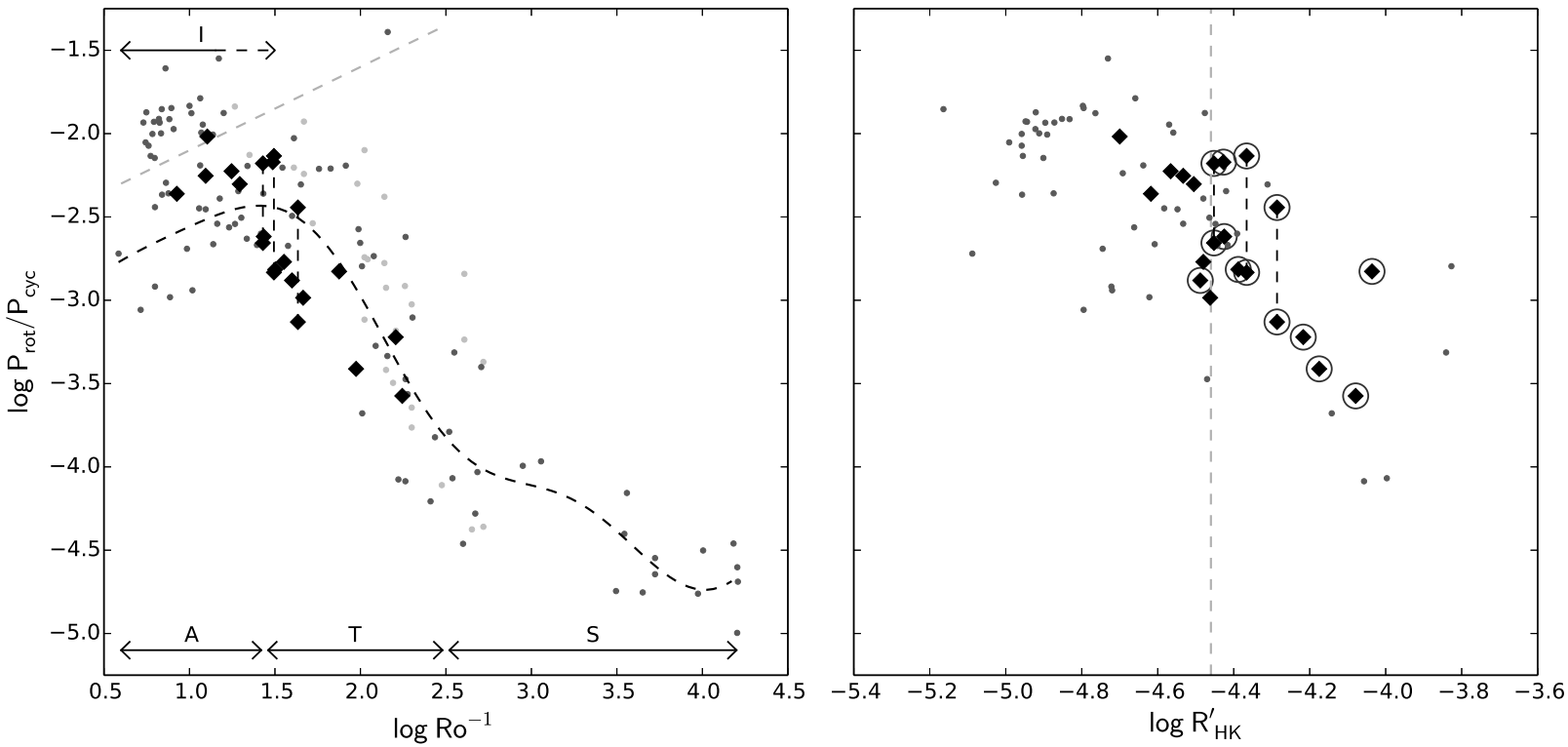
- Persistent active longitude migration may be explained by an azimuthal dynamo wave.
- Or alternatively a deeper anchoring depth plus radial differential rotation.

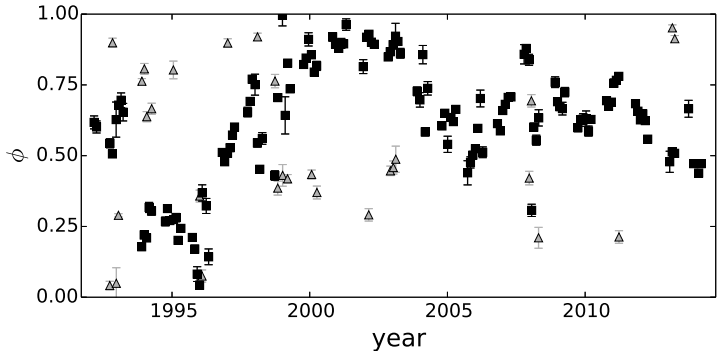


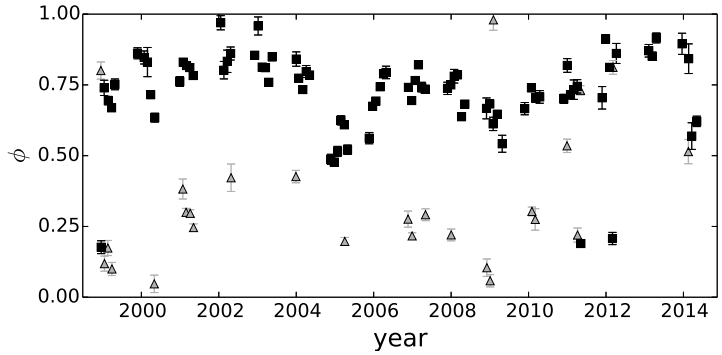
Cole et al. (2014), poster 239

Active Longitudes

- Active longitudes appear limited to stars with roughly $\log R'_{\mathrm{HK}} > -4.46$.
  - A transition between axisymmetric and non-axisymmetric dynamo modes?







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152 – *Rotation and spot activity of young solar-type stars (Lehtinen)*

239 – *Azimuthal dynamo waves in theory and observation (Cole)*