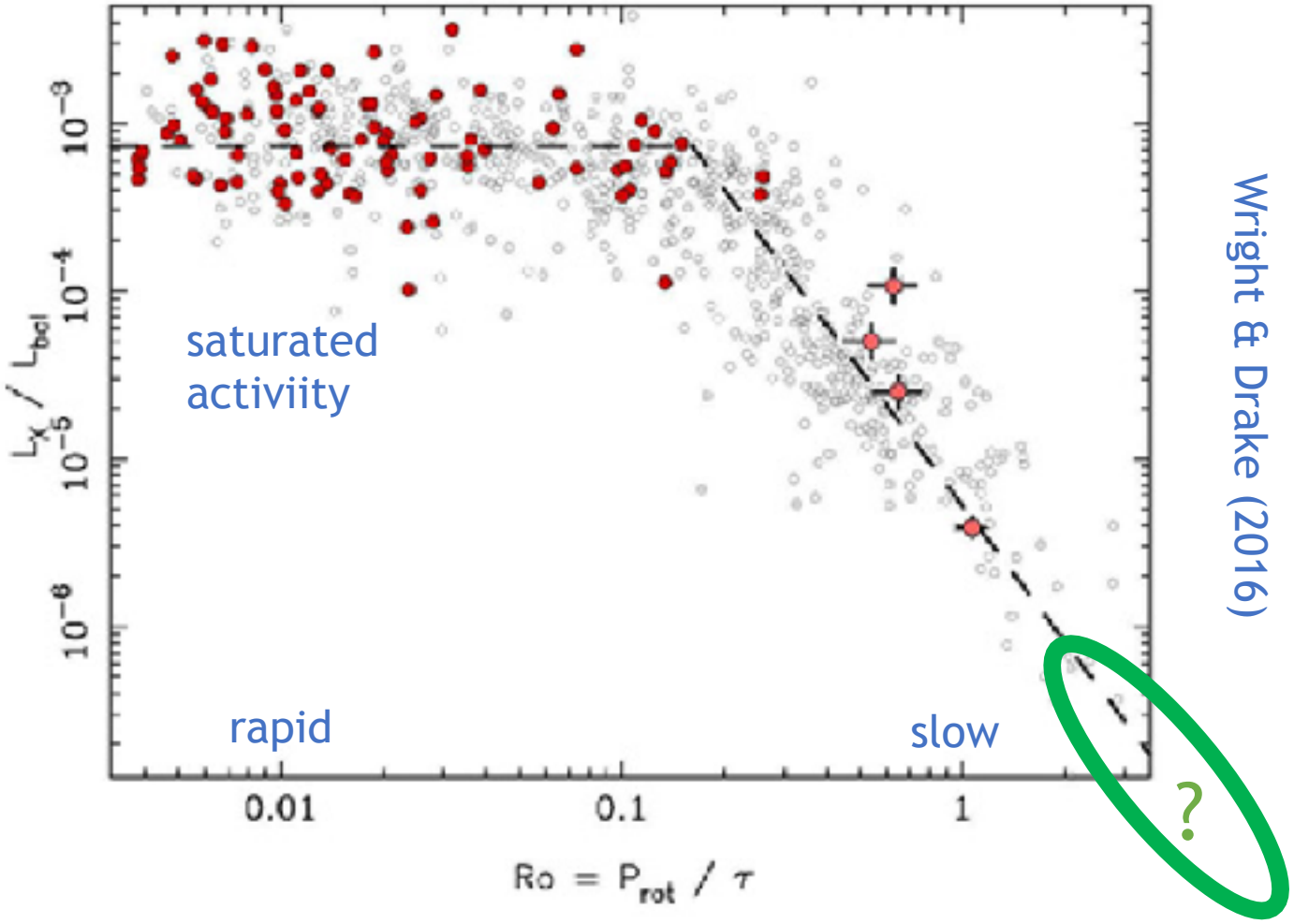
Enhanced stellar activity for slow antisolar differential rotation?

Axel Brandenburg & Mark Giampapa (2018, ApJL 855, L22)

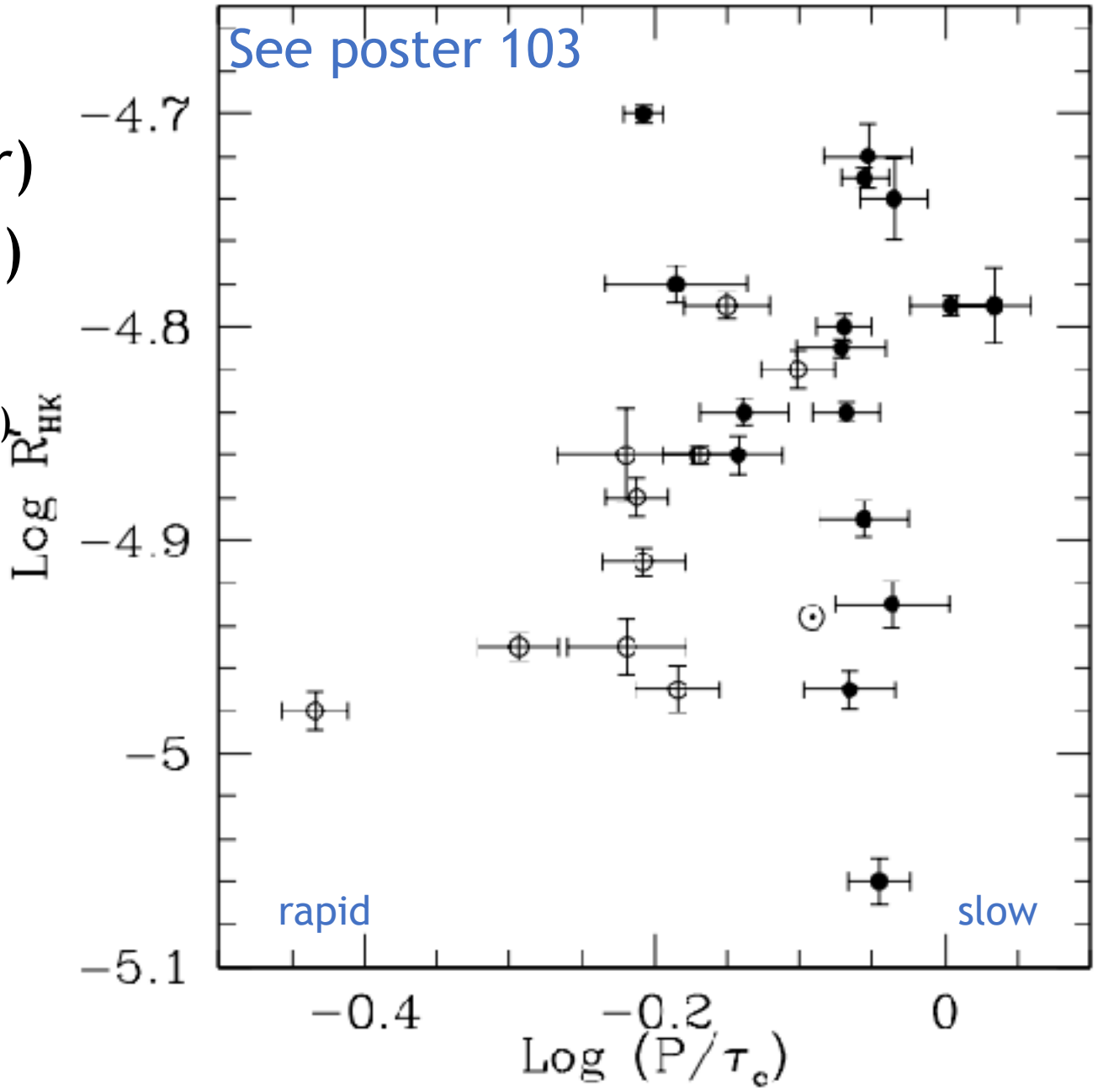
- *Normally*: slow → less active
- Slow: large P_{rot}, large Rossby
- Ro = P_{rot} /$\tau_{turnover}$
  - See, e.g., Wright & Drake (2016)
- What if slower still?
  - No flux at all?
  - Some basal flux level?
  - Or something new??
  - … but: very few stars



Wright & Drake (2016)

Curious findings for M67

- Mark Giampapa (last summer)
- P_{rot} from Kepler K2 (20 stars)
- $\langle R'_{HK} \rangle$ from WIYN 3.5m
  - Kitt Peak (Wisconsin, Indiana, Yale, NSO)
- Increase of activity with P_{rot}
  - Wrong periods?
  - Evolved stars? (τ_c smaller?)
  - See color-magnitude diagram
  - Large-scale dynamo weaker
    - Small-scale dynamo stronger?
  - Stronger differential rotation
    - When differential rotation is antisolar

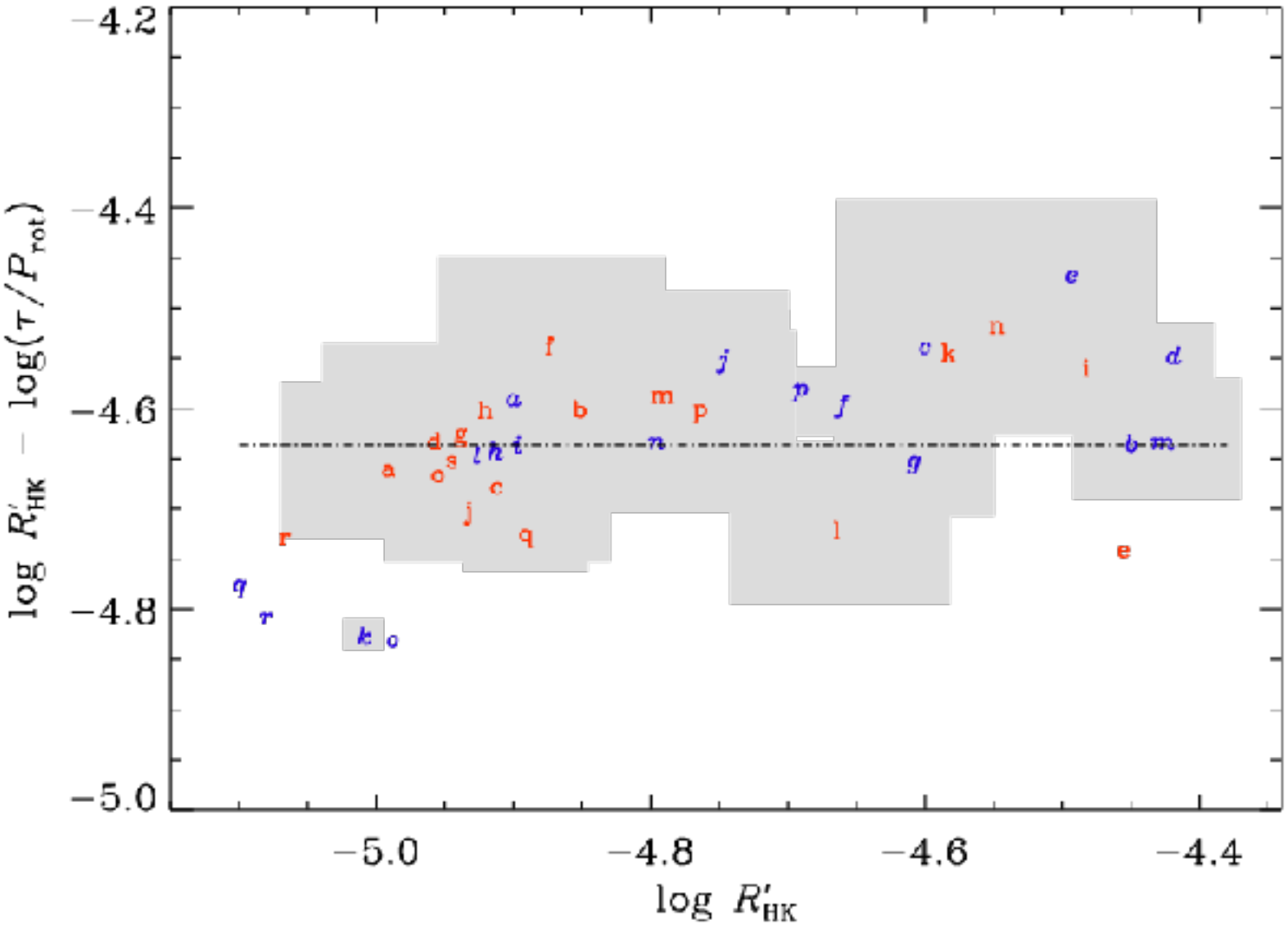


Giampapa, Brandenburg, Cody, ++ 2017 (Nordita preprint #121)

Rotation-Activity residual

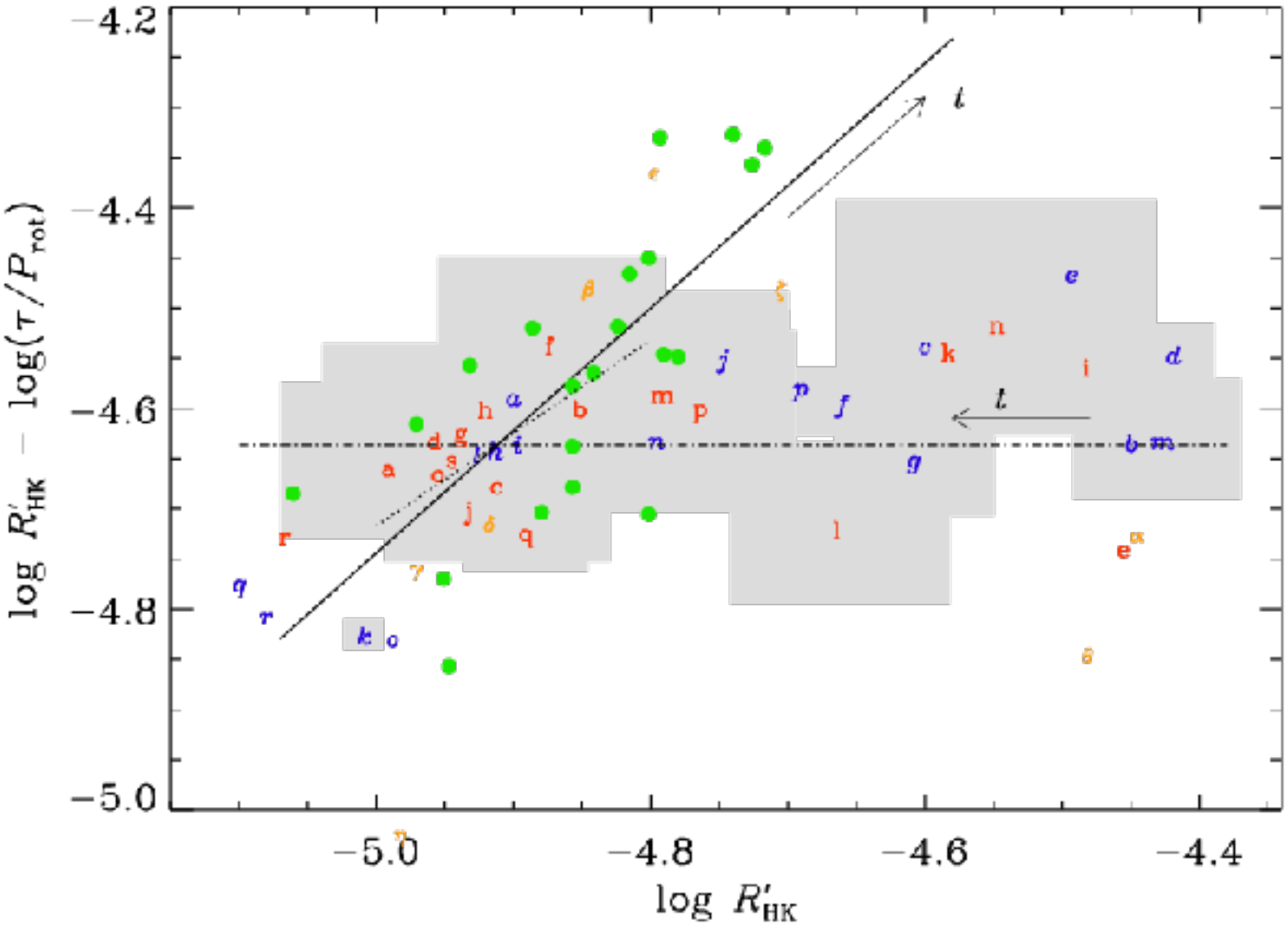
(Brandenburg, Mathur, Matcalfe (2017, ApJ 845, 7

- All cyclic stars (Wilson stars + more)
  - Red: K dwarfs
  - Blue: G,F dwarfs
- Linear relation for Wilson sample
  - Residual flat
- Intrinsic noise (cyclic variability)



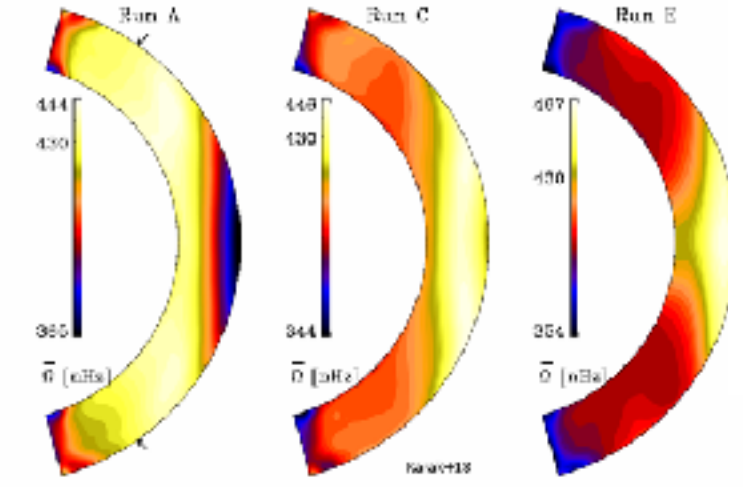
M67 stars added to Rotation-Activity residual (green)

- Clear departure
- Slow stars (small τ/P_{rot}): excess activity
- How to understand?
- Are the other stars?



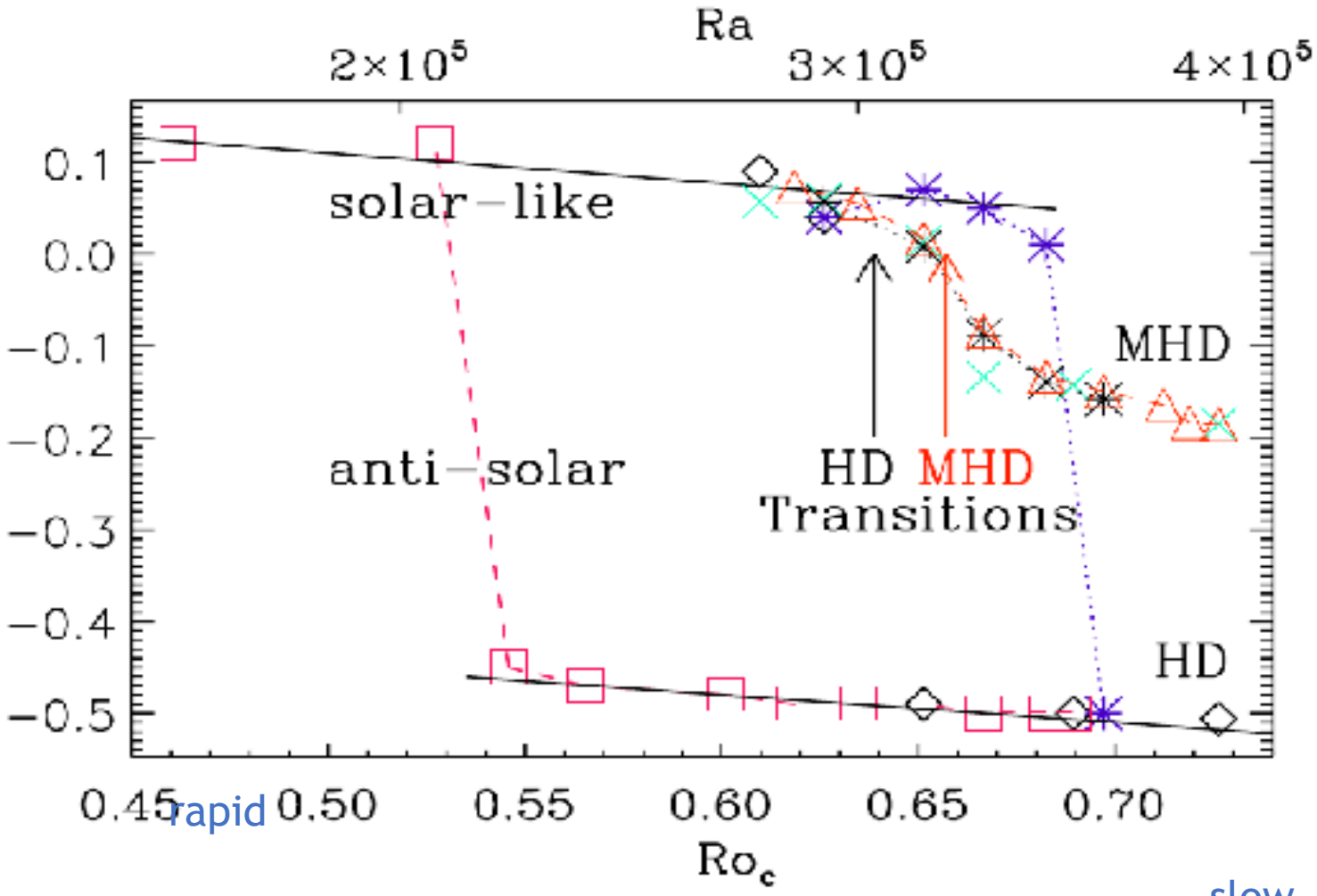
Slow rotation ←→ antisolar differential rotation

- Known since Gilman 1977
- Problem for solar simulators!
  - Solar models are antisolar?
    - Brown, Browning, Brun, etc.
  - i.e. slow equator, fast poles
    - Side effect: larger differential rotation when antisolar!



Yellow: fast

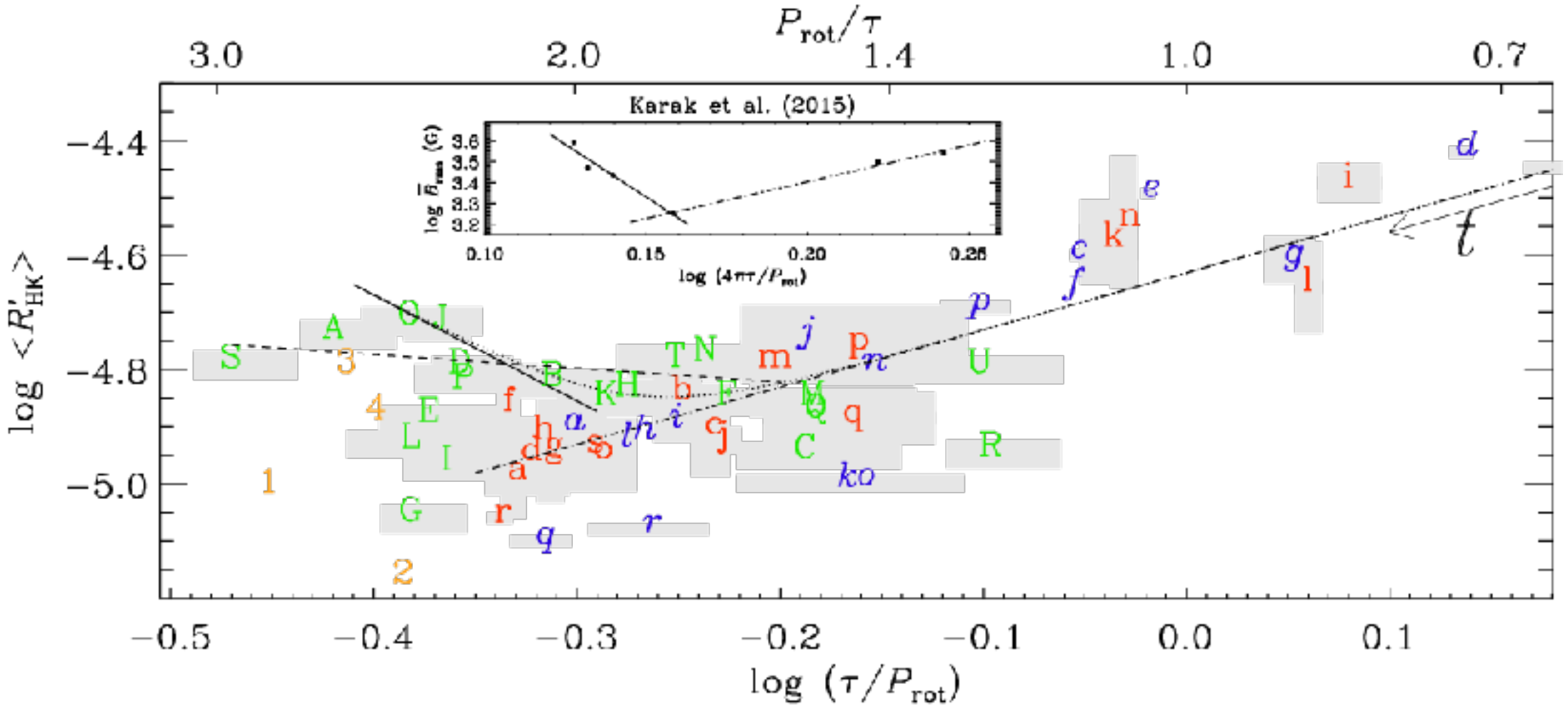
Blue slow



Enhanced stellar activity at slow rotation → large P_{rot}/τ

- Slow: large P_{rot}, large Rossby number
- $\langle R'_{HK} \rangle$ increases, B_{rms} increases (Karak+15)

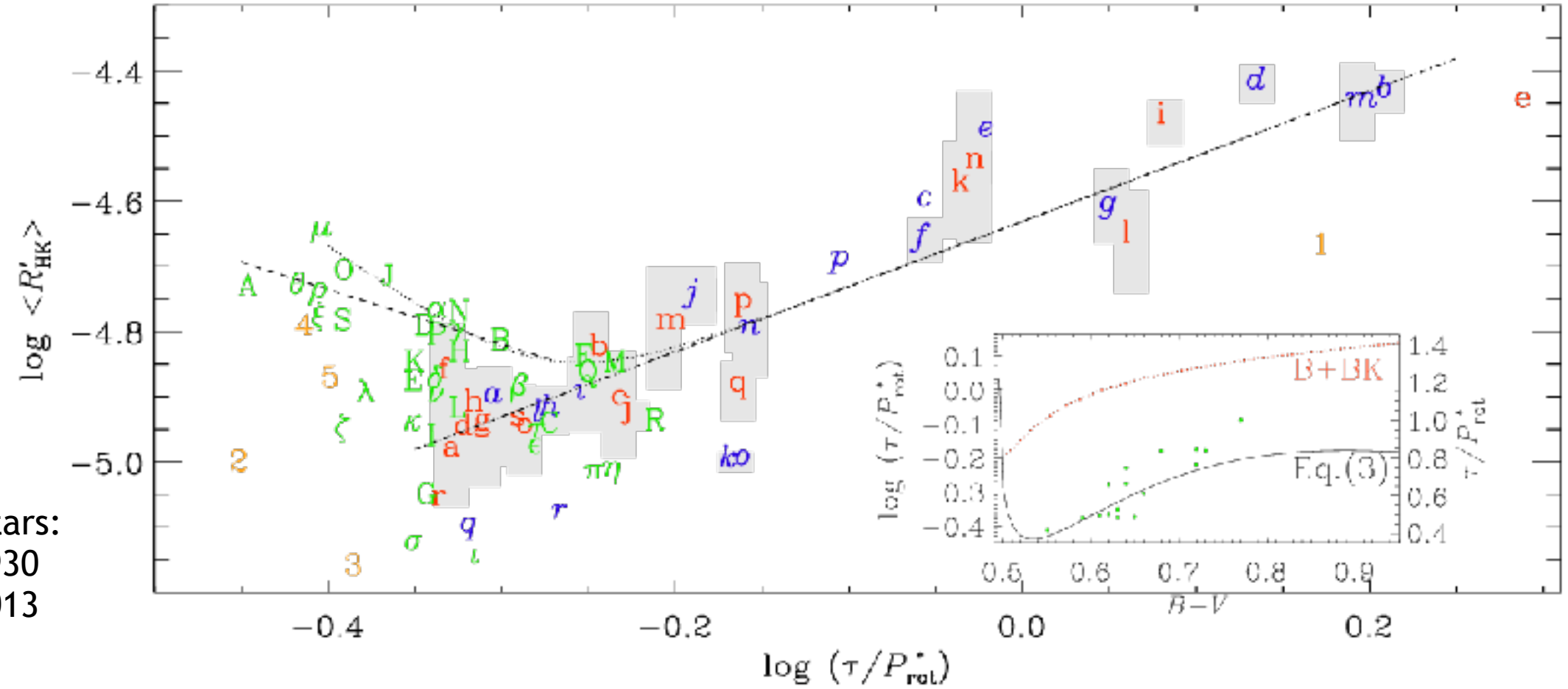
Brandenburg & Giampapa (2018, ApJL 855, L22



Compare with computed P_{rot} values

- $P^*_{rot} = 0.407(B - V - 0.495)^{0.325}\, t^{0.565}$
- Greek letters: confirms measured periods

Brandenburg & Giampapa (2018, ApJL 855, L22



+field stars:
HD 224930
HD 187013

An evolutionary story

- Stars experience magnetic breaking
- → Slow down → less active → less breaking
- At $P_{rot}/\tau \sim 2$, ***two things can happen*** (bifurcation!):

1. Remain rapidly spinning as again inactive star
   - see van Saders et al. (2016), Metcalfe (2017)
2. Others go antisolar & become more active
   - Antisolar diff rot may also explain superflares on main sequence stars
   - Katsova et al. (2018, Astron. Rep. 95, 78)
   - Future: to verify from (i) light curves, (ii) asteroseismology

See also Poster 53 about other dynamo transitions

Backup:

- Color-magnitude
- Filled: single stars
- Open: binaries
- No evidence for departure from MS