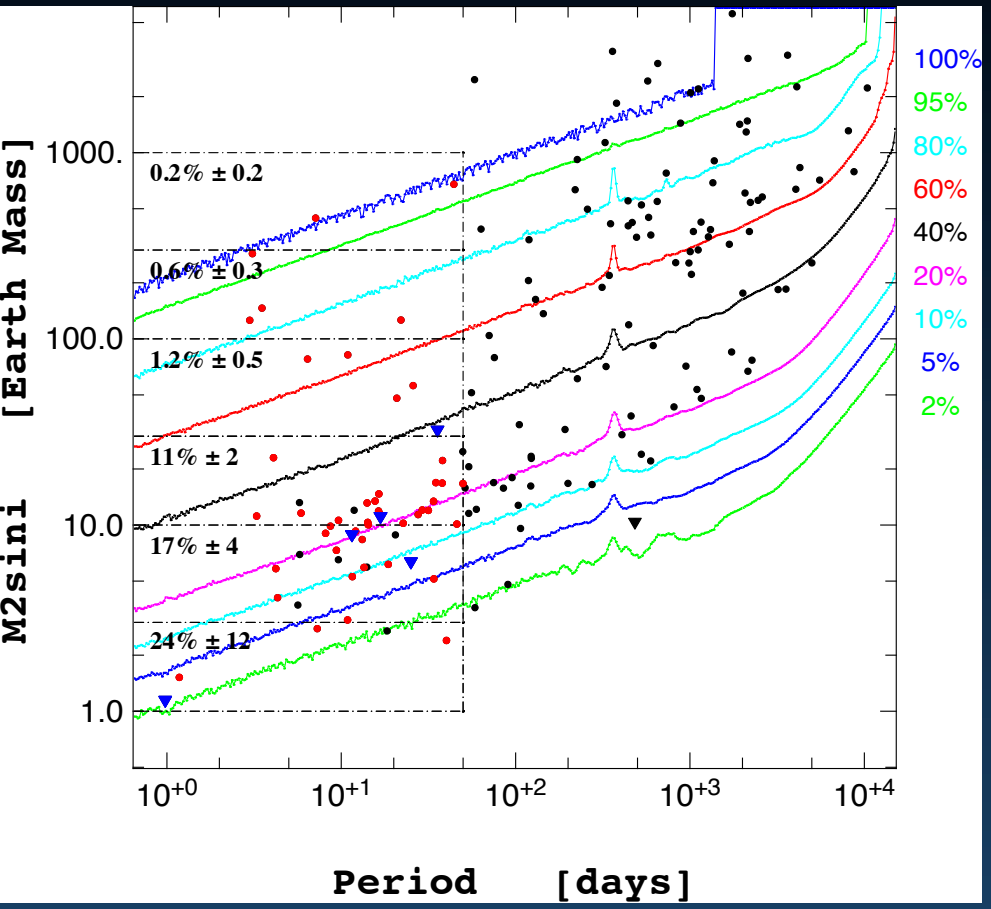
Extreme Solar Systems II, Jackson Lake, 12-16 September 2011

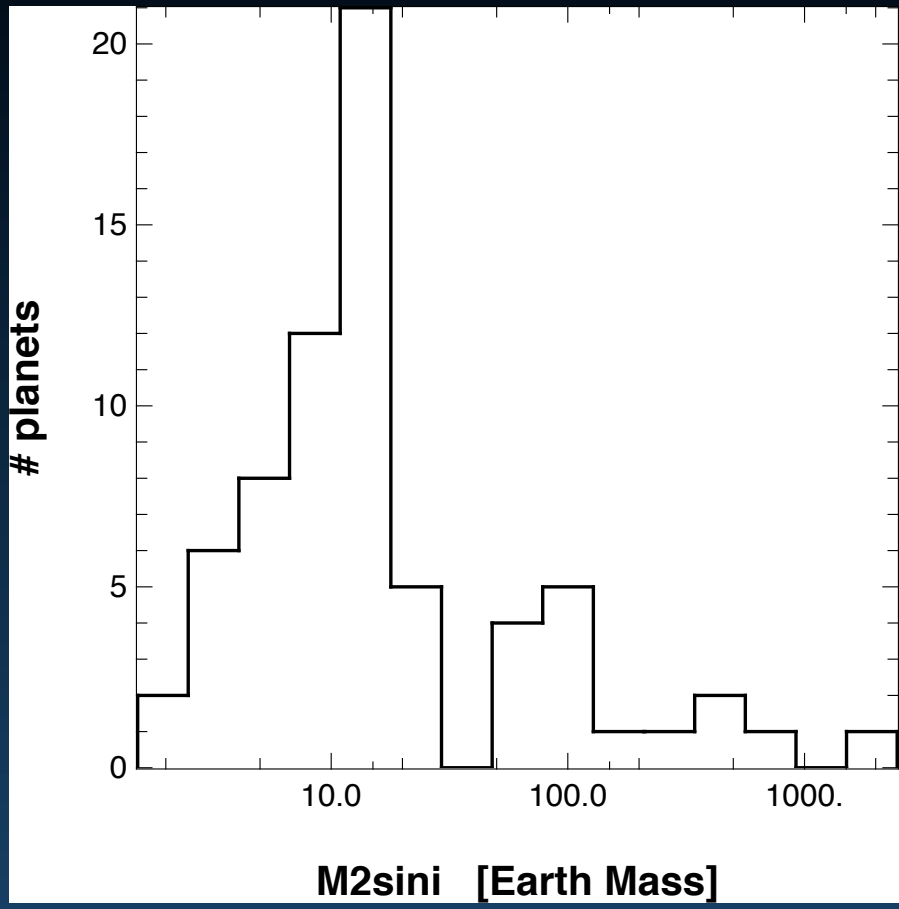
HARPS Long-Term Results: Effects of Stellar Magnetic Cycles, and Planet Detection Limits

Christophe Lovis
University of Geneva

in collaboration with:
X. Dumusque, N.C. Santos, F. Bouchy, M. Mayor, F. Pepe, D. Queloz, D. Ségransan, S. Udry

HARPS & CORALIE global results



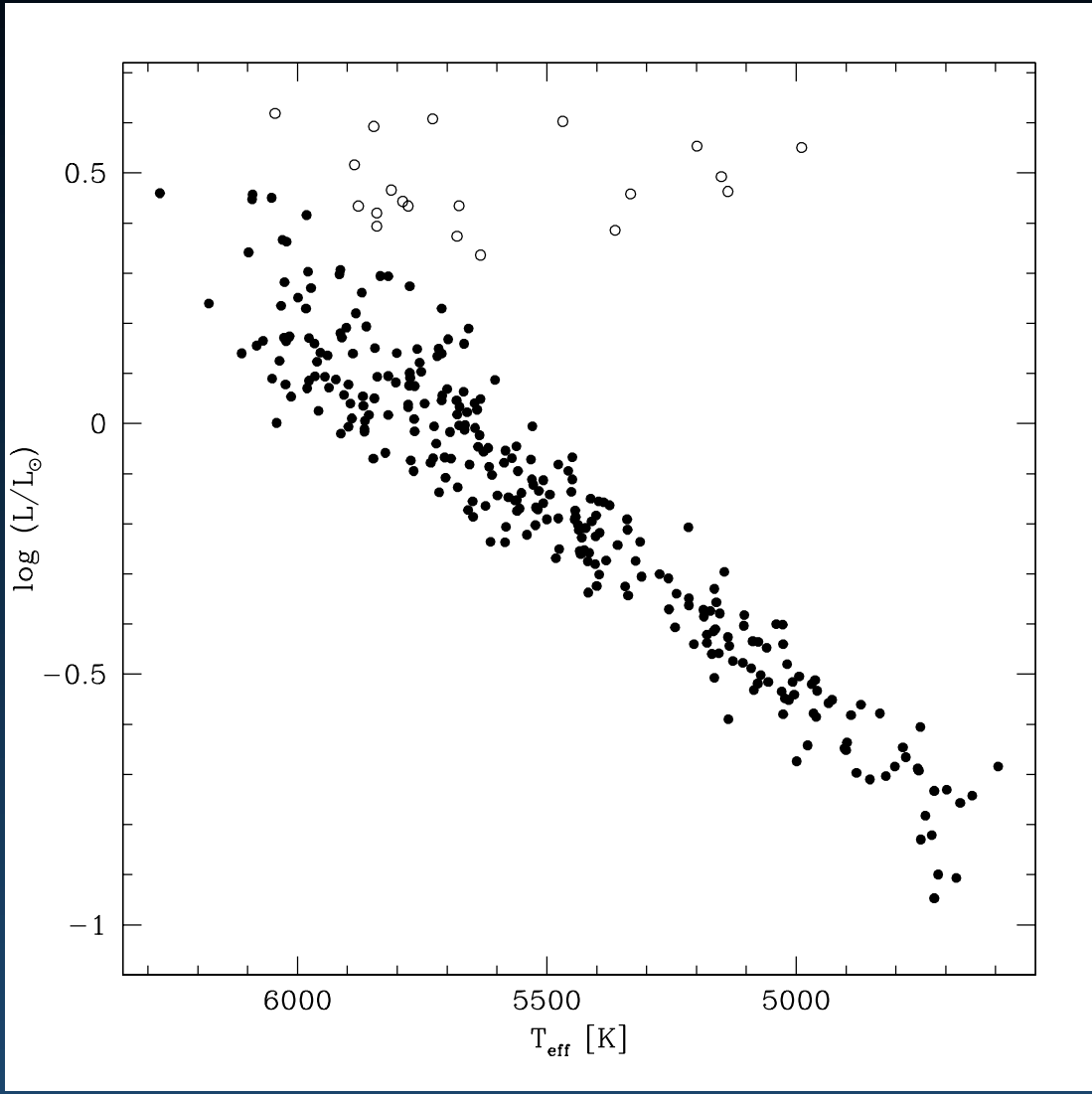


See Michel Mayor's talk!

Challenges to detect the low-mass planet population

- Instrument precision: reaching < 1 m/s is fundamental
- Stellar RV noise at different timescales:
  - p-mode oscillations, granulation (Dumusque et al. 2011, A&A 525, 140)
  - rotational modulations (Dumusque et al. 2011, A&A 527, 82)
  - magnetic cycles (Santos et al. 2010, A&A 511, 54, Lovis et al., arXiv:1107.5325, Dumusque et al., arXiv:1107.1748)

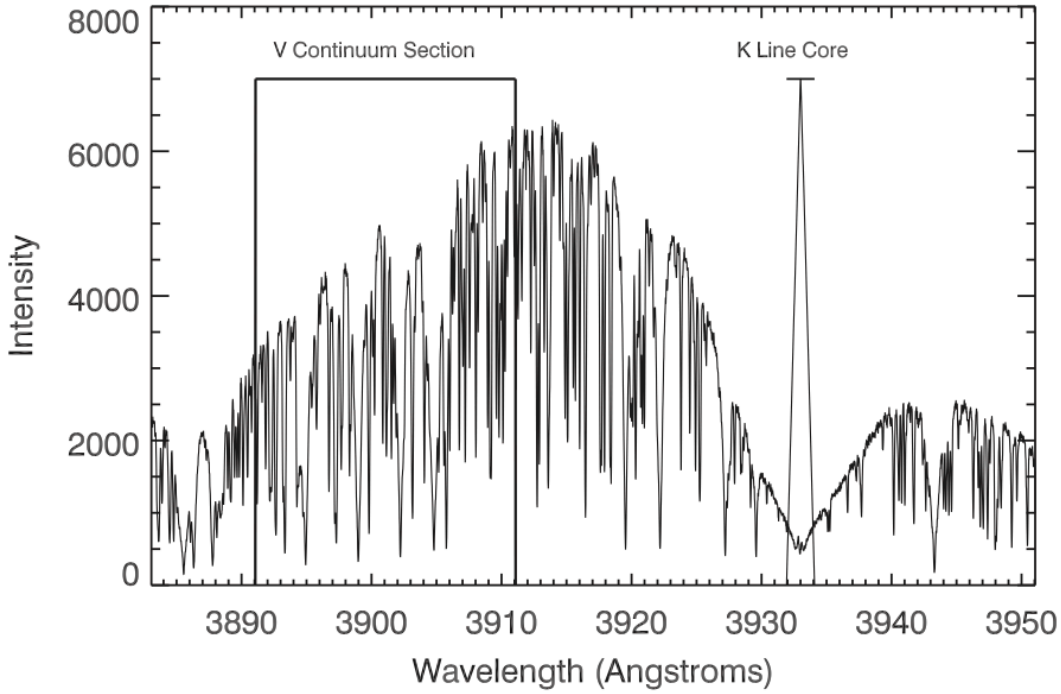
Stellar sample: 304 old FGK stars

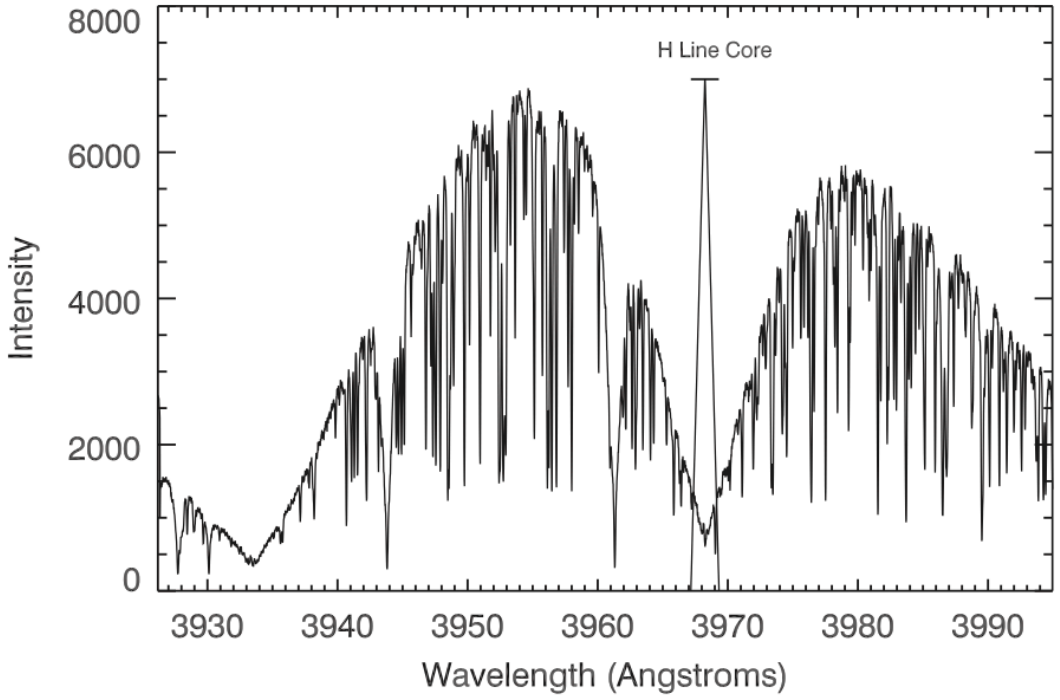


Ca II H&K lines
Mt Wilson S index
R'_{HK} activity index

$$S = \alpha \frac{H + K}{R + V}$$

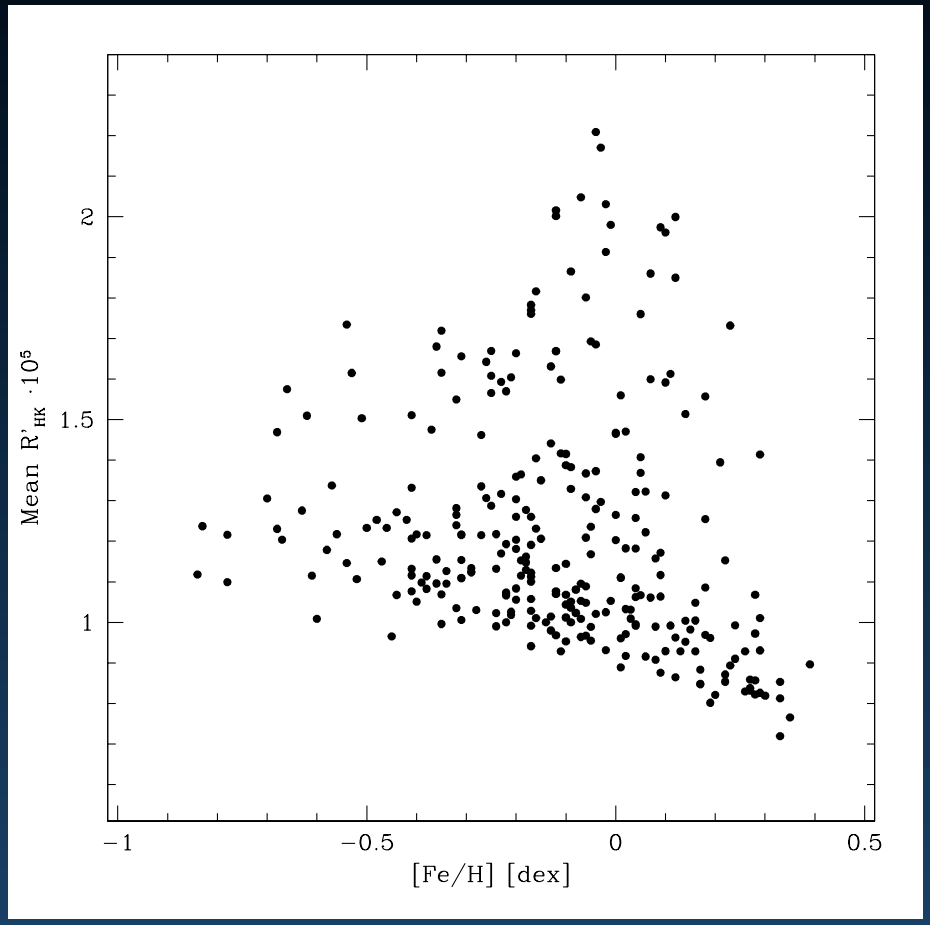
$$R'_{HK} = C_{cf}(B - V) \cdot S - R_{phot}(B - V)$$

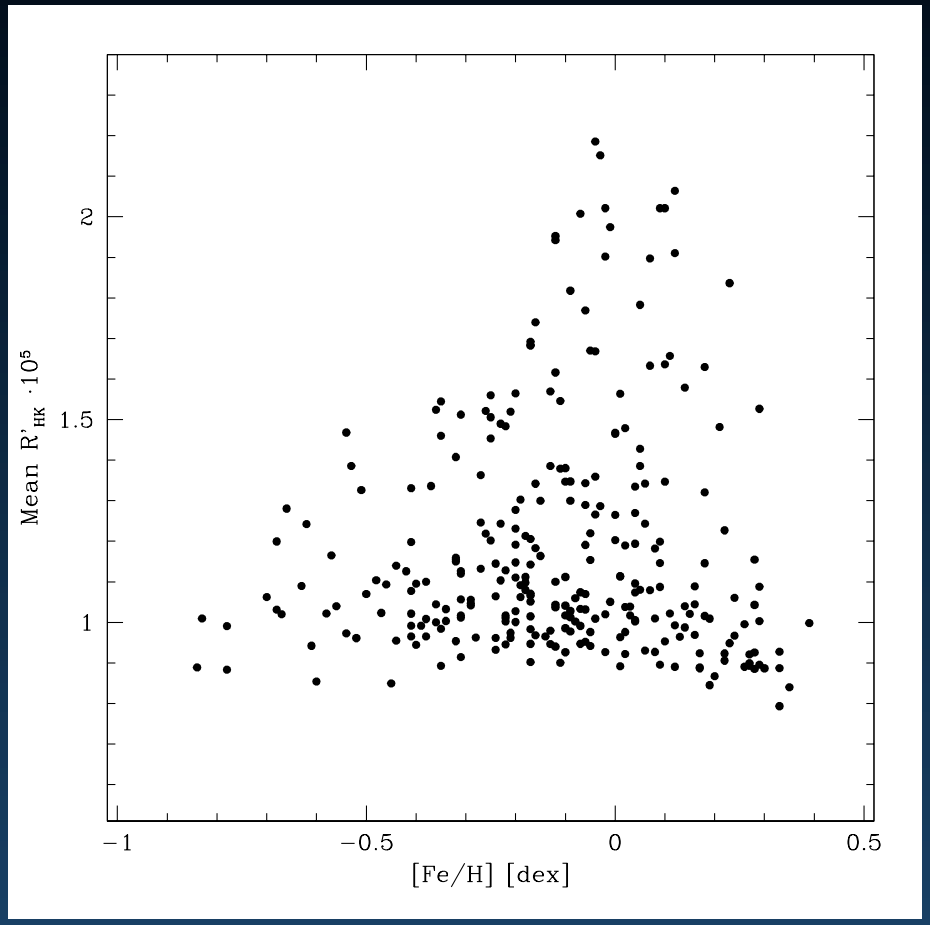




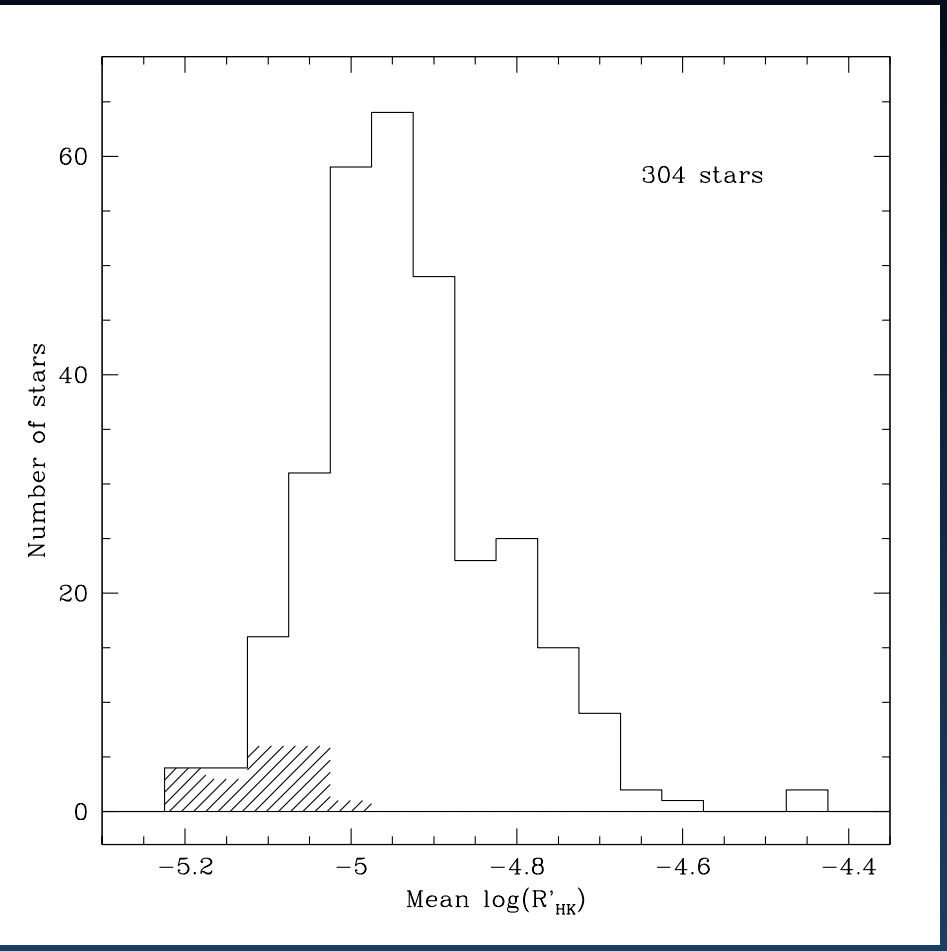
Isaacson & Fischer 2010

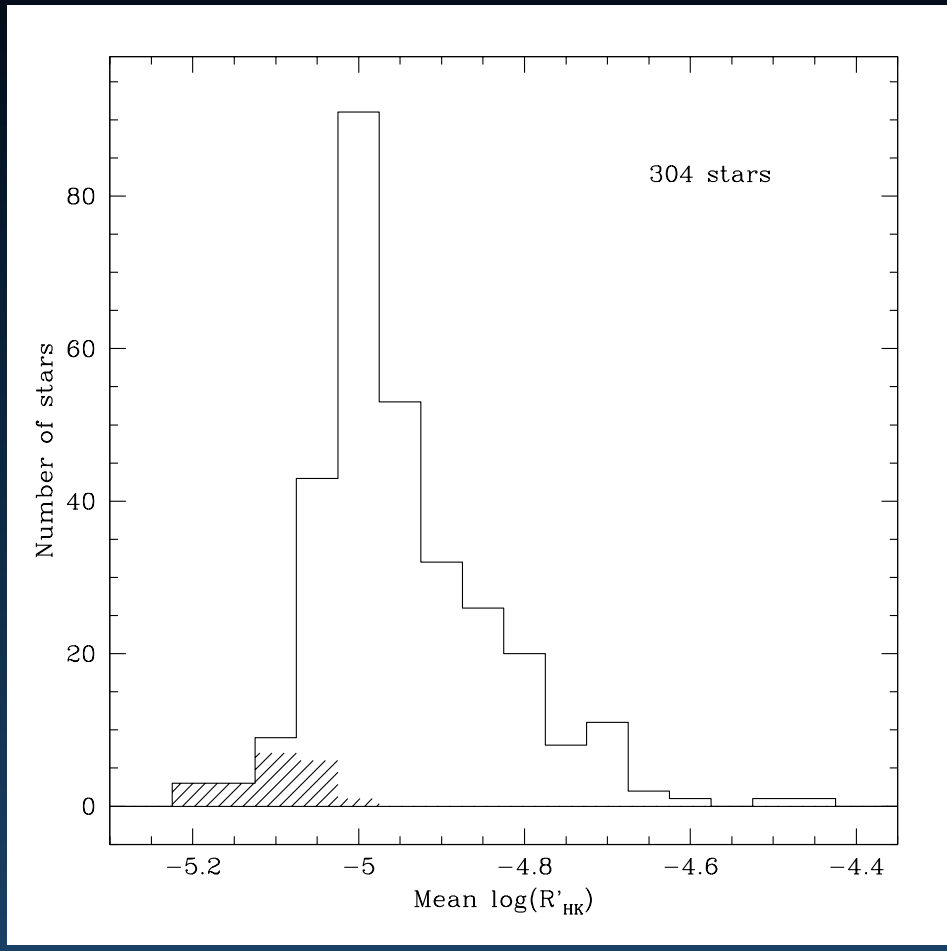
Effects of metallicity on R'_{HK}



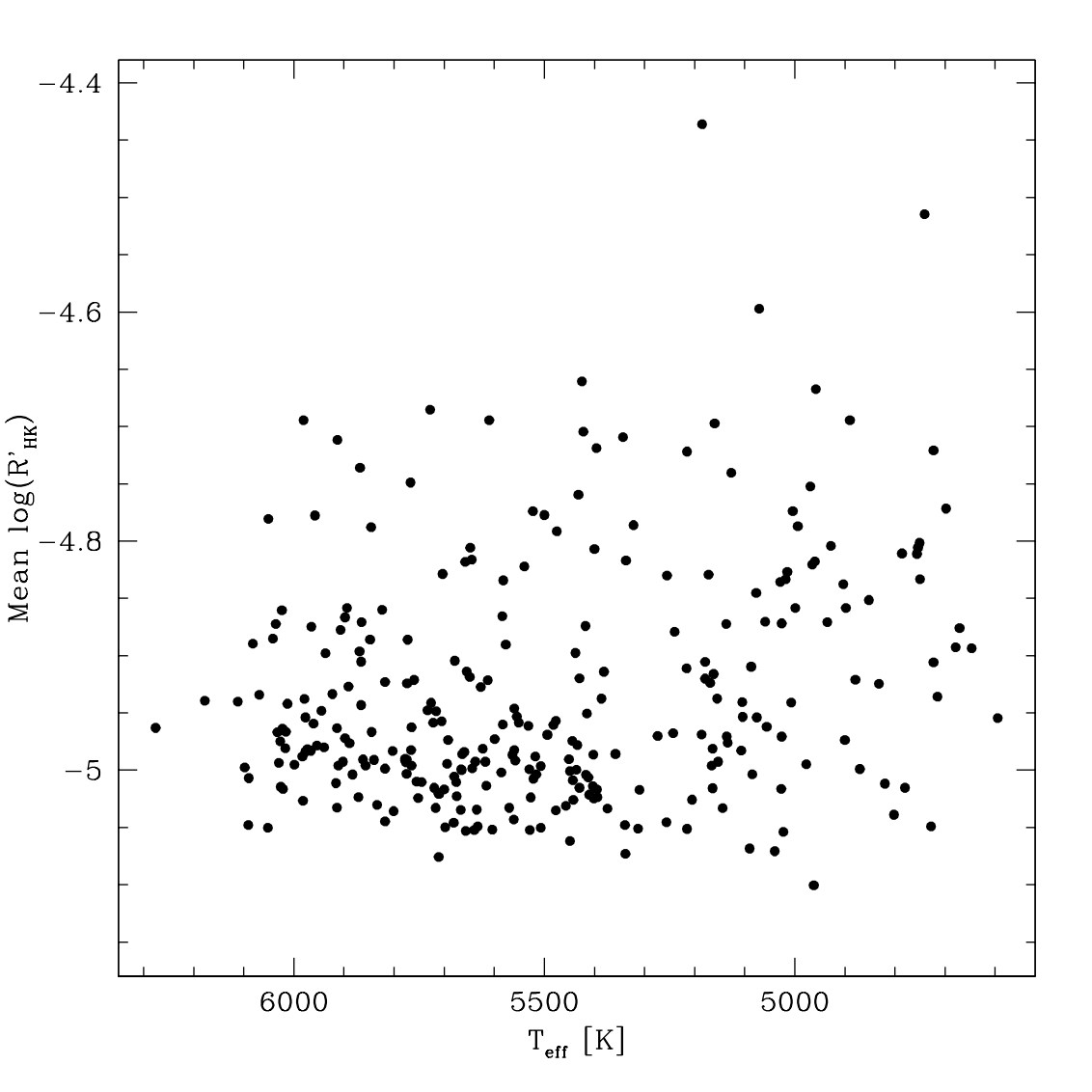


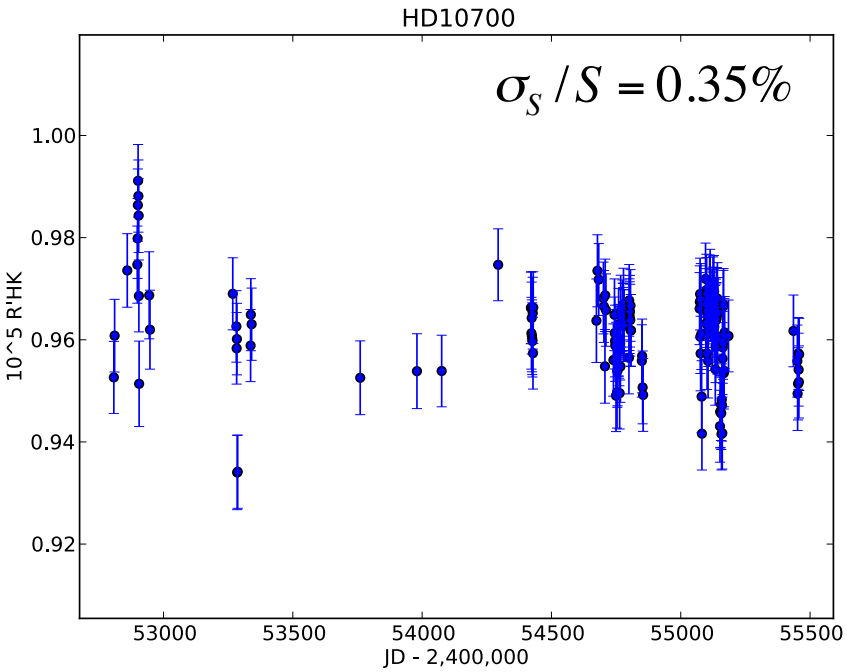
Effects of metallicity on R'_{HK}

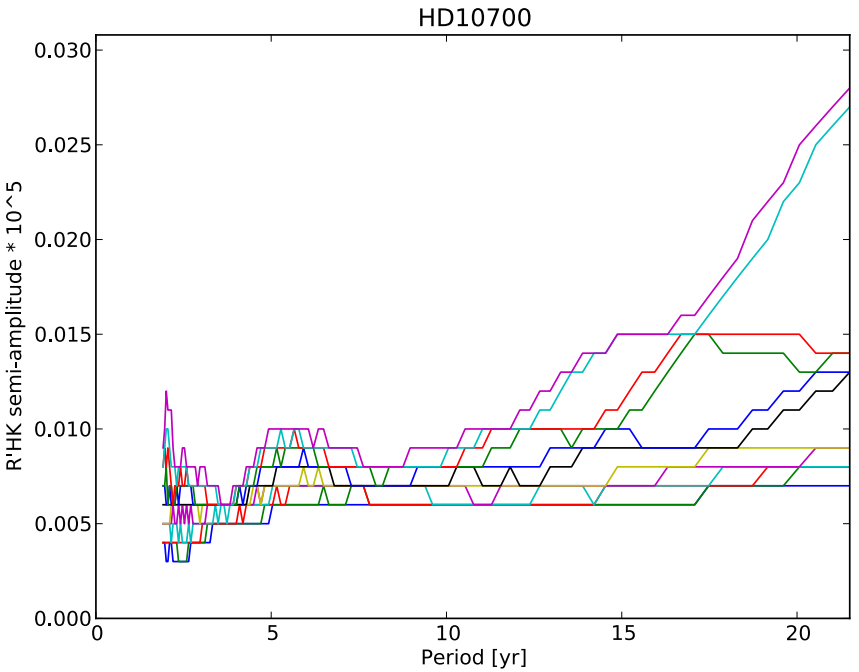


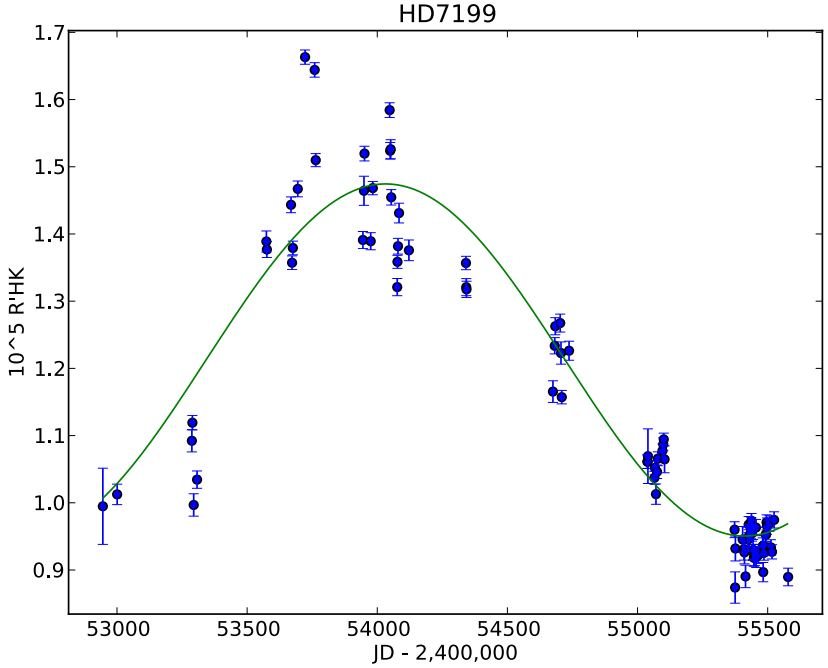


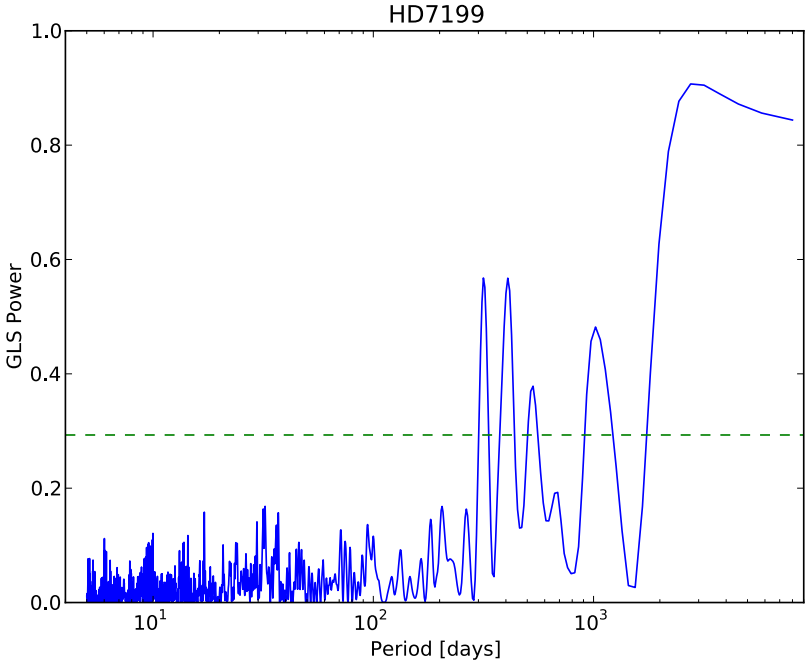
$\log(R'_{HK})$ vs. T_{eff}




HD10700
$\sigma_S / S = 0.35\%$
10^5 R'HK
JD - 2,400,000


HD10700
R'HK semi-amplitude * 10^5
Period [yr]


HD7199
10^5 R'HK
JD - 2,400,000

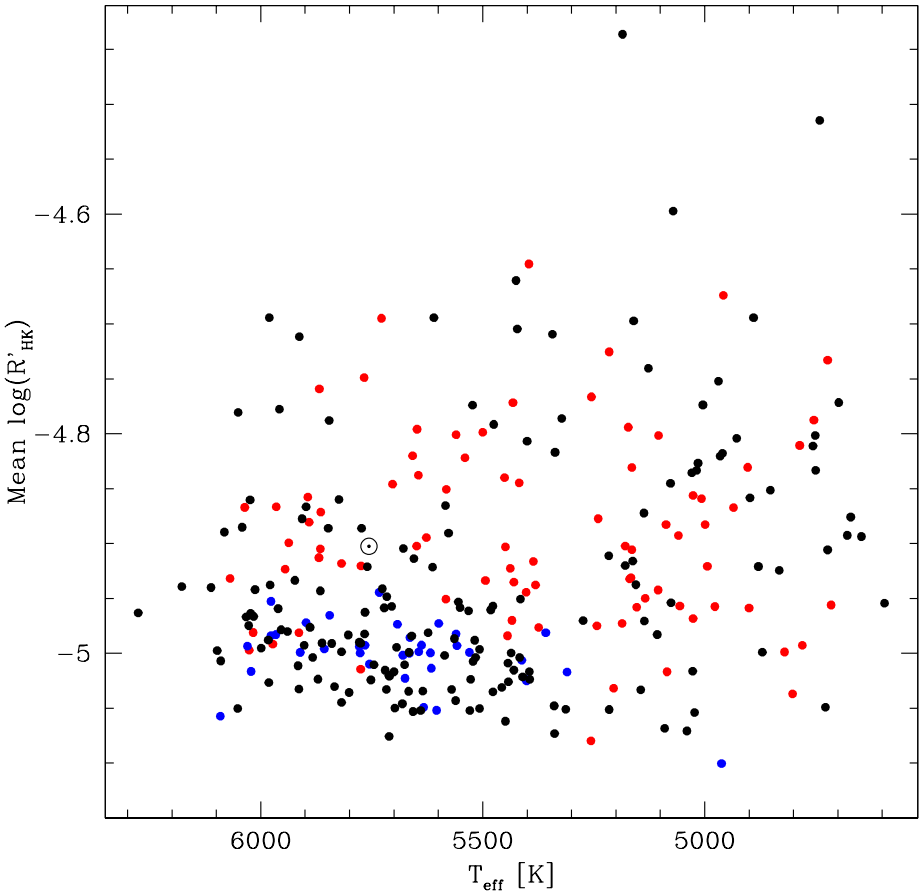

HD7199
GLS Power
Period [days]

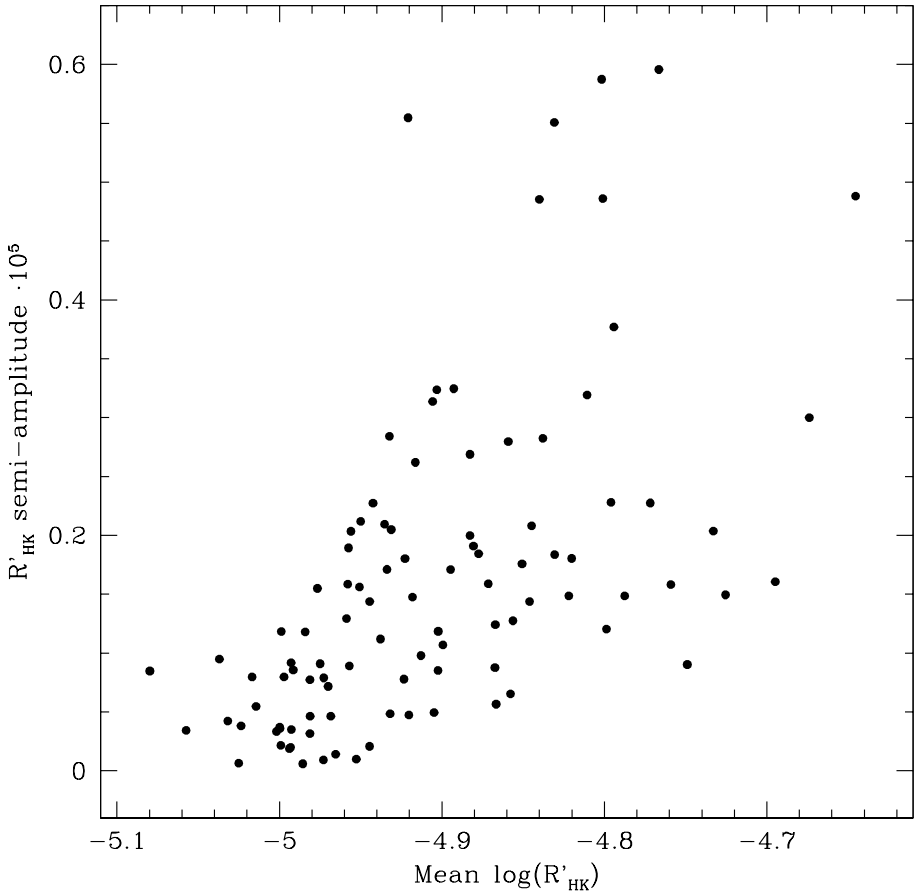
Global results on magnetic cycles

- 284 main-sequence stars
- 83 stars with cycle (A > 0.04)
- 36 stars with no cycle (A < 0.04)
- 165 stars with undetermined status

→ 61 ± 8 % of older solar-type stars show a magnetic cycle, while 39 ± 8 % do not.

Global results on magnetic cycles

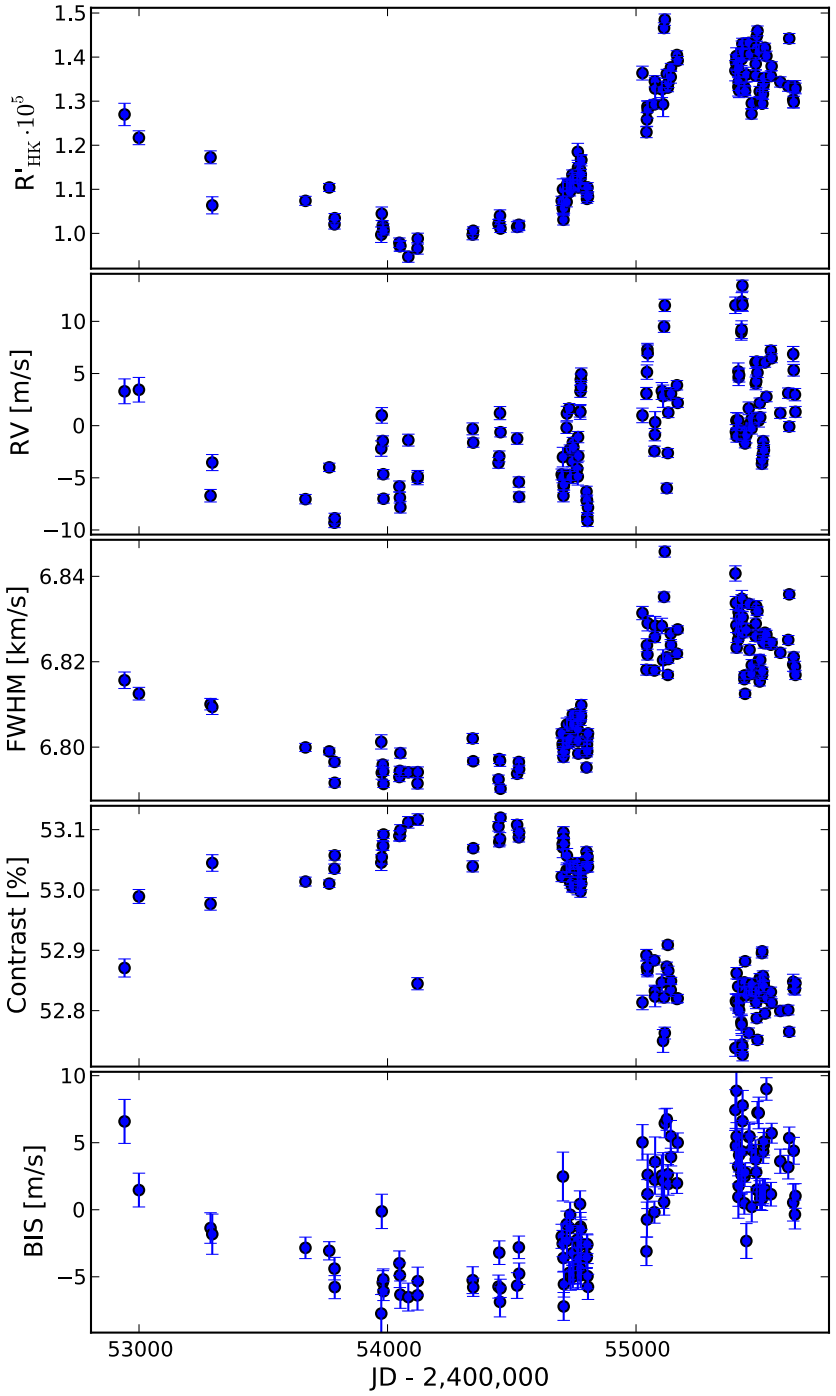




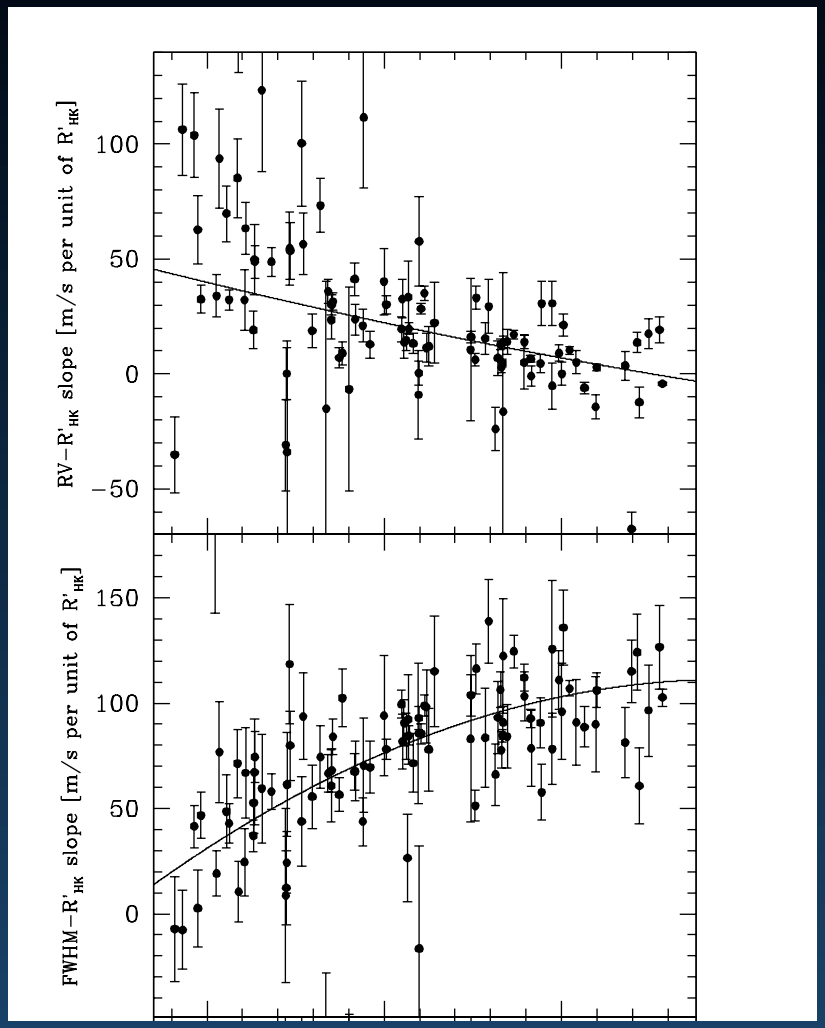
61 ± 8 % of older solar-type stars show a magnetic cycle, while 39 ± 8 % do not.

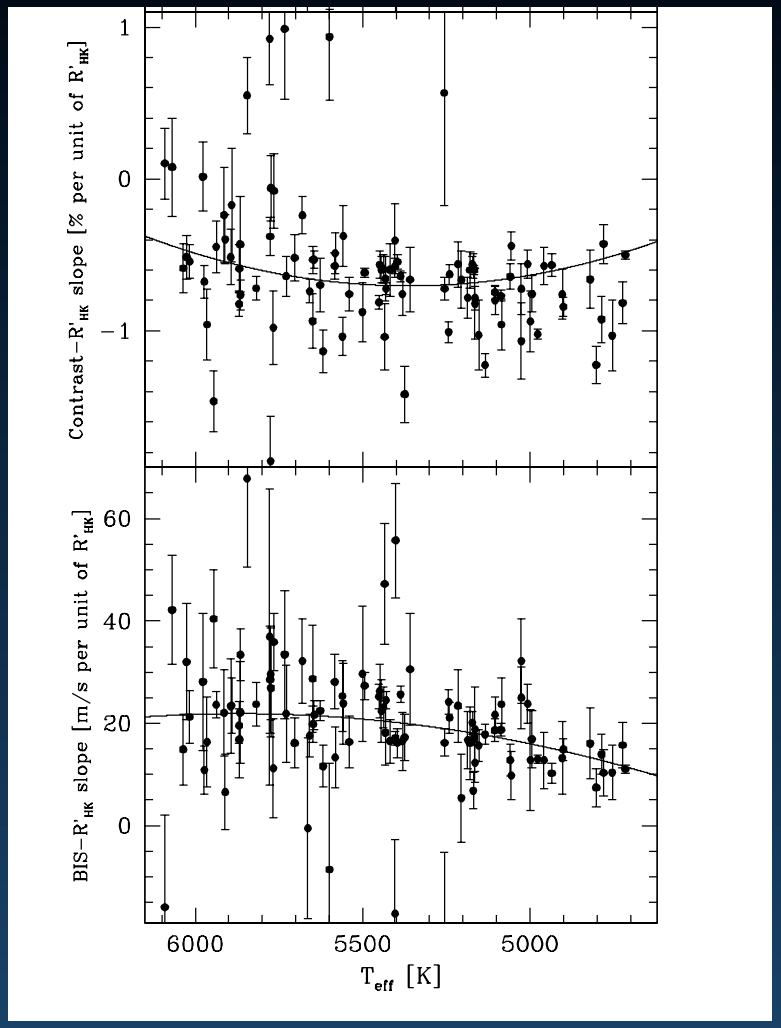
Impact of magnetic cycles on RV and CCF parameters

Example: HD 21693 (which by the way has two short-period planets, Mayor et al. 2011)

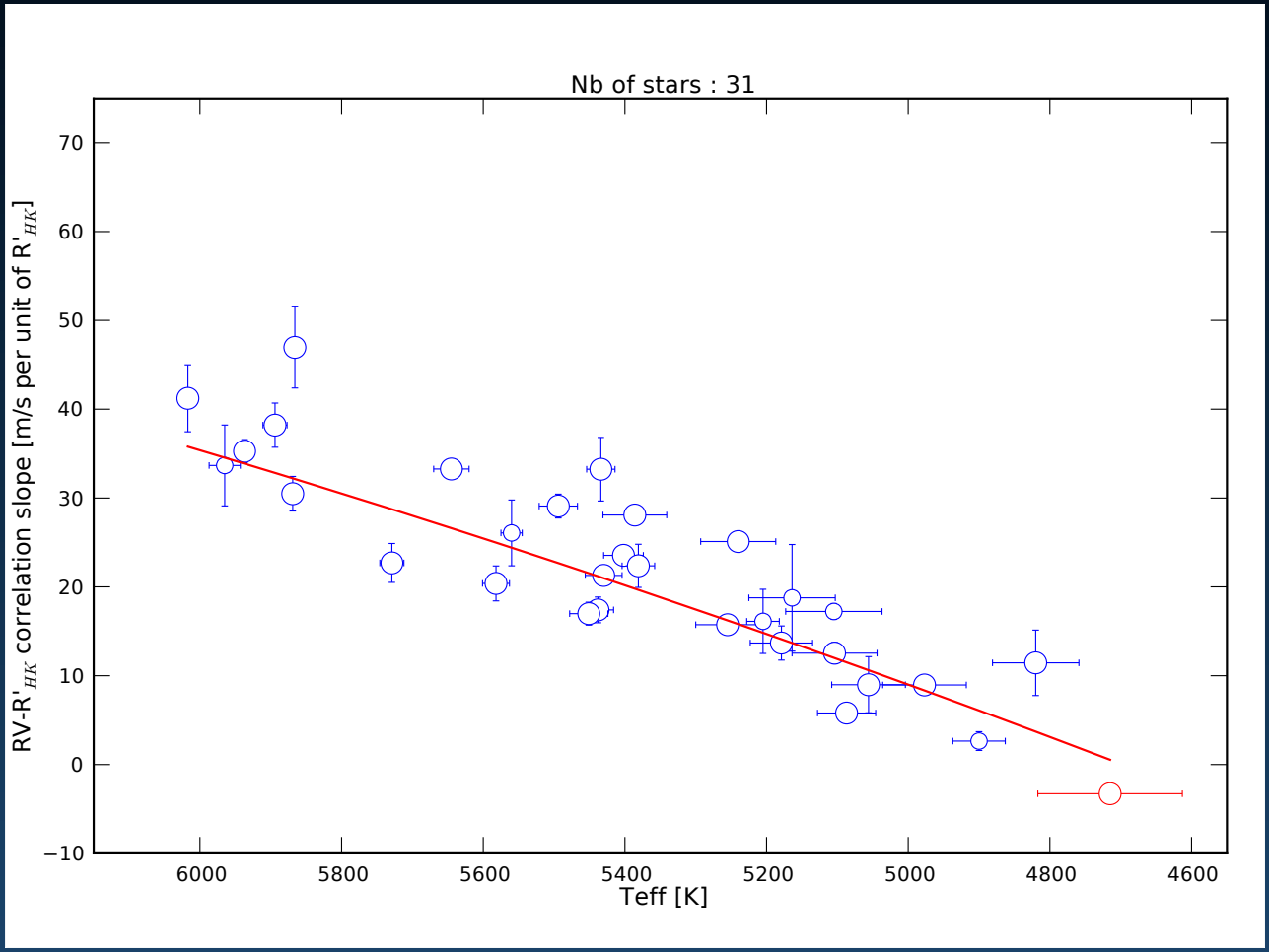


Sensitivity of CCF parameters to R'_{HK} variations





Sensitivity of radial velocities to R'_{HK} variations



Sensitivity of CCF parameters to R'_{HK} variations

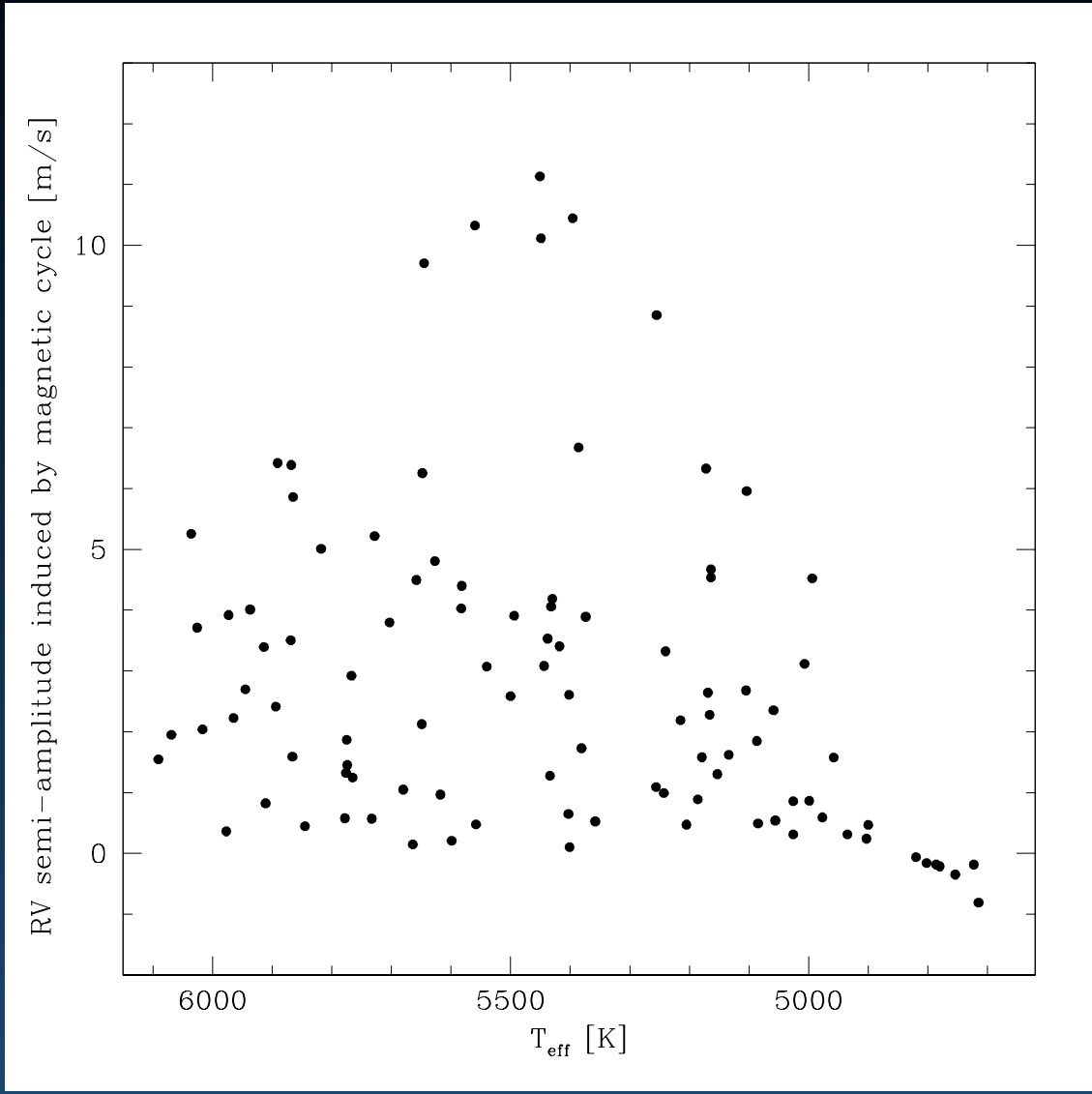
$$C_{RV} = (19.04 \pm 0.62) + (3.20 \pm 0.20) \cdot 10^{-2} \cdot \tilde{T}_{eff} + (4.5 \pm 3.1) \cdot 10^{-6} \cdot \tilde{T}_{eff}^2 + (17.8 \pm 3.1) \cdot [Fe/H] + (24.3 \pm 5.2) \cdot [Fe/H]^2 \quad (9)$$

$$C_{FW} = (83.2 \pm 1.4) - (6.46 \pm 0.36) \cdot 10^{-2} \cdot \tilde{T}_{eff} - (3.71 \pm 0.79) \cdot 10^{-5} \cdot \tilde{T}_{eff}^2 + (33.7 \pm 6.8) \cdot [Fe/H] + (38 \pm 17) \cdot [Fe/H]^2 \quad (10)$$

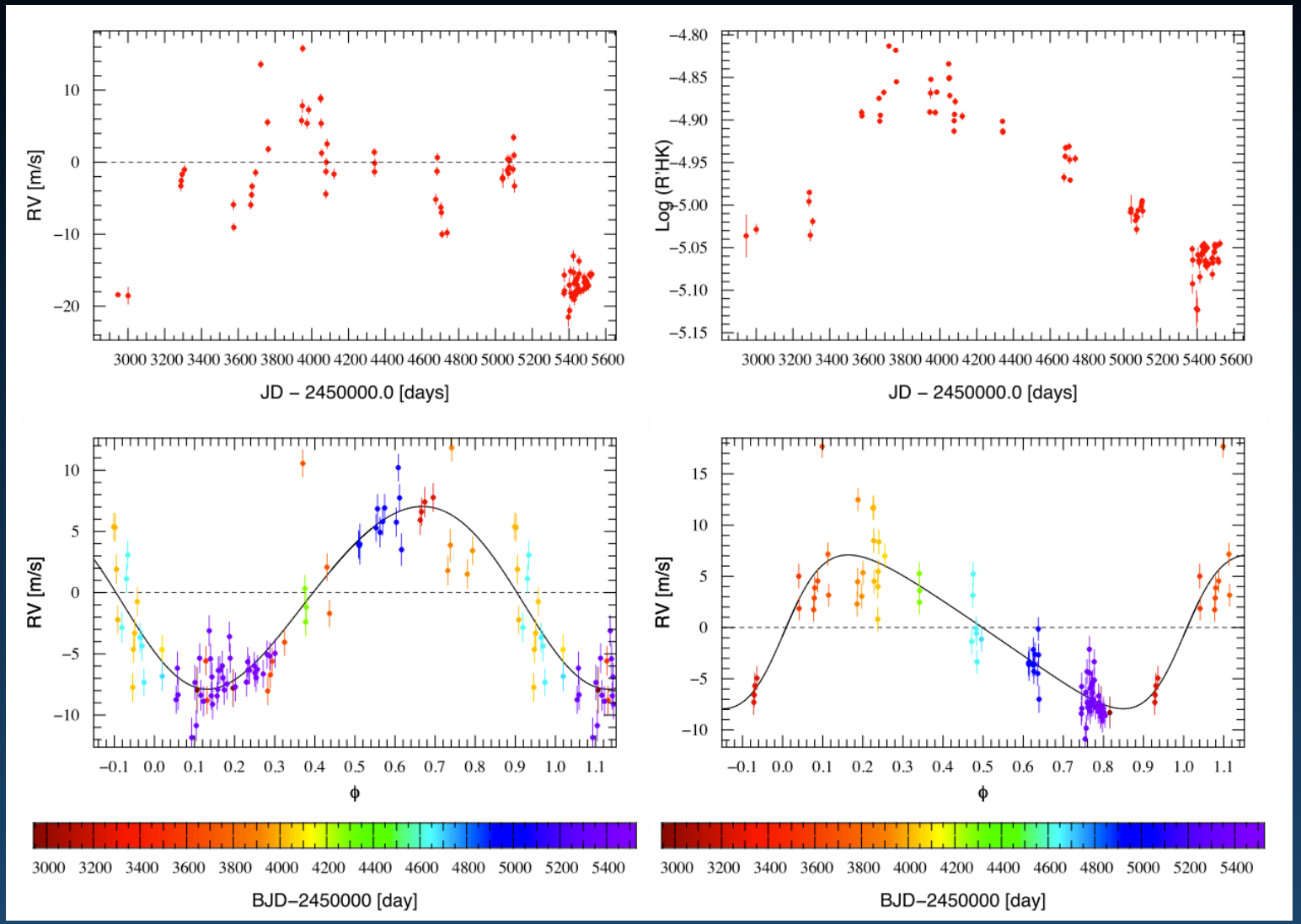
$$C_{CO} = (-0.703 \pm 0.012) + (3.9 \pm 3.4) \cdot 10^{-5} \cdot \tilde{T}_{eff} + (5.28 \pm 0.67) \cdot 10^{-7} \cdot \tilde{T}_{eff}^2 + (0.333 \pm 0.055) \cdot [Fe/H] - (0.15 \pm 0.13) \cdot [Fe/H]^2 \quad (11)$$

$$C_{BIS} = (20.18 \pm 0.44) + (7.3 \pm 1.3) \cdot 10^{-3} \cdot \tilde{T}_{eff} - (7.8 \pm 2.4) \cdot 10^{-6} \cdot \tilde{T}_{eff}^2 + (8.2 \pm 2.3) \cdot [Fe/H] + (13.7 \pm 5.1) \cdot [Fe/H]^2 \quad (12)$$

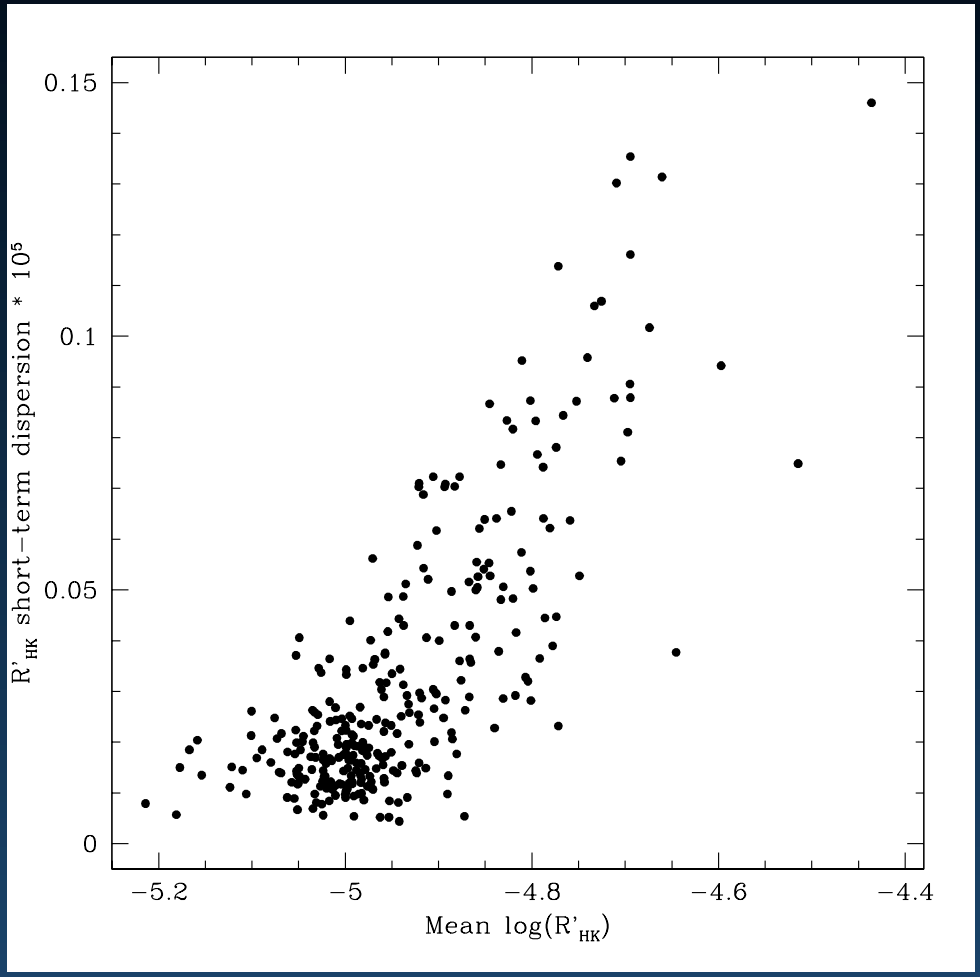
Effective impact on radial velocities



Disentangling planets and magnetic cycles: the example of HD 7199 (Dumusque et al. 2011)



Short-term R'_{HK} variations: rotational modulations



Short-term R'_{HK} variations: rotational modulations

See poster 20.04 by X. Dumusque on Alpha Cen B!

« All included » package:
binarity, magnetic cycle, rotational modulations, barycentric correction, and...
low-mass planets around Alpha Cen B ?!