

HARPS-N radial velocities from the Sun-as-a-star

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Andrew Collier Cameron & the HARPS-N Solar Telescope Team

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UNIVERSITY OF
CAMBRIDGE

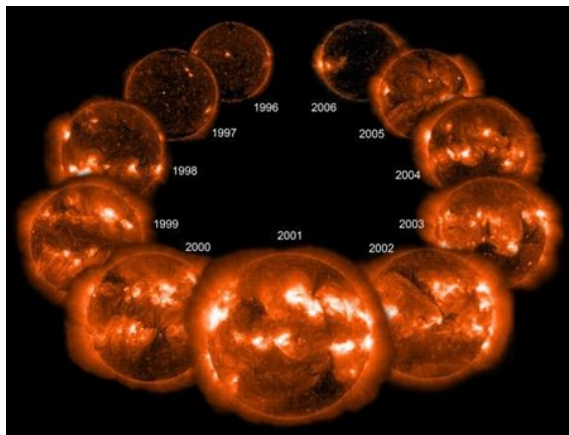


ESPRESSO: high-res spectrograph - $\sigma_{RV} \sim 0.1 \text{ m/s}$



Instruments can do it.
Let's find all those Earths!

The most problematic 'noise': the star



(NASA/ESA)

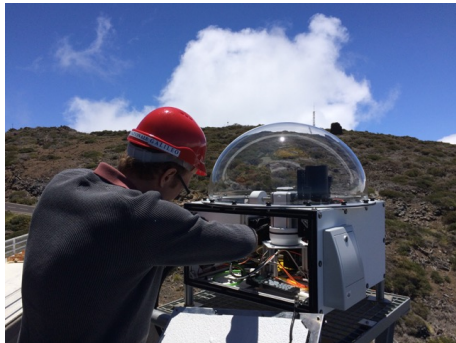
To ever really find and characterise an Earth twin,
we will need to understand stellar variability.

The solar telescope feeding into HARPS-N



Courtesy: A. Glenday

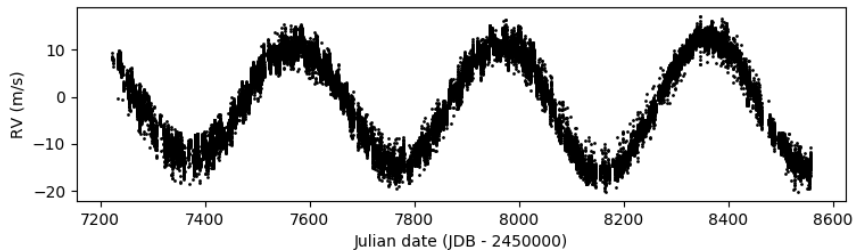
The solar telescope feeding into HARPS-N



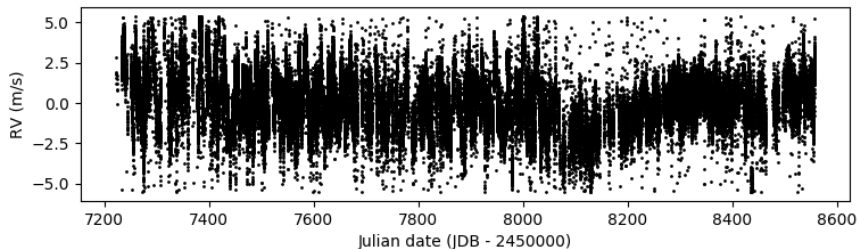
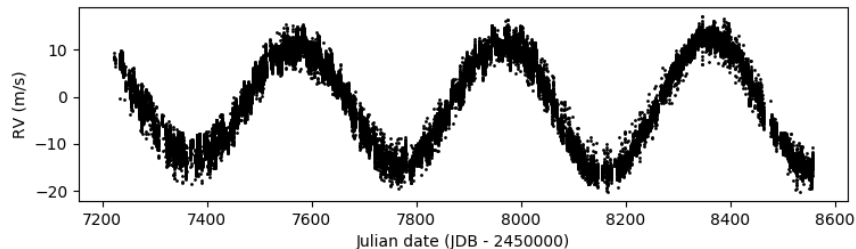
Operational since July 2015.
Daily 5-minute exposures from 9am till ~4pm.

Courtesy: A. Glenday

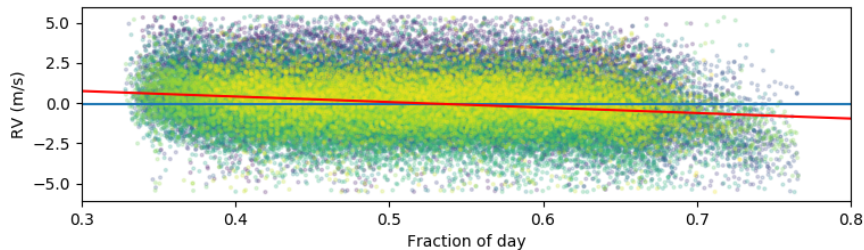
Jupiter clearly detected



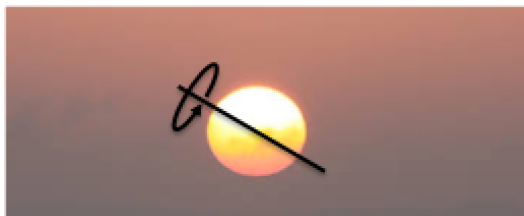
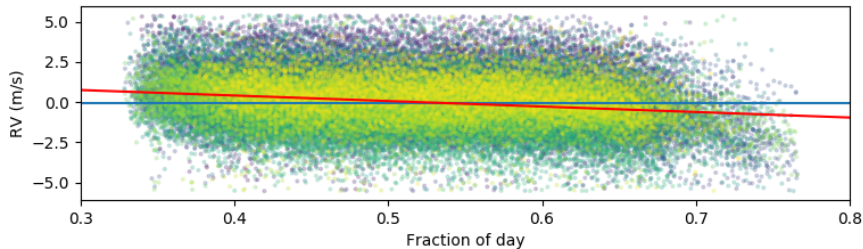
Jupiter clearly detected - corrected using JPL Horizons



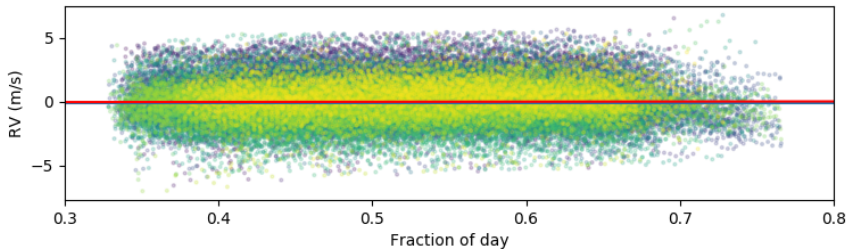
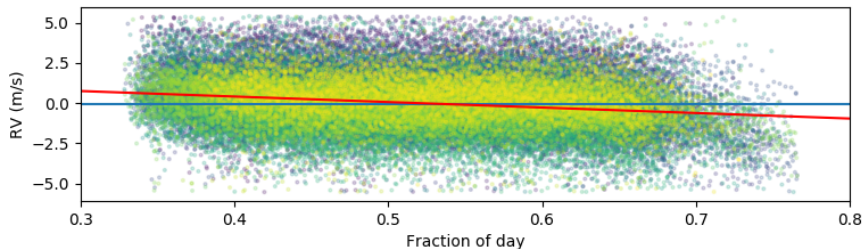
Daily downwards trend



Daily downwards trend - due to differential extinction?

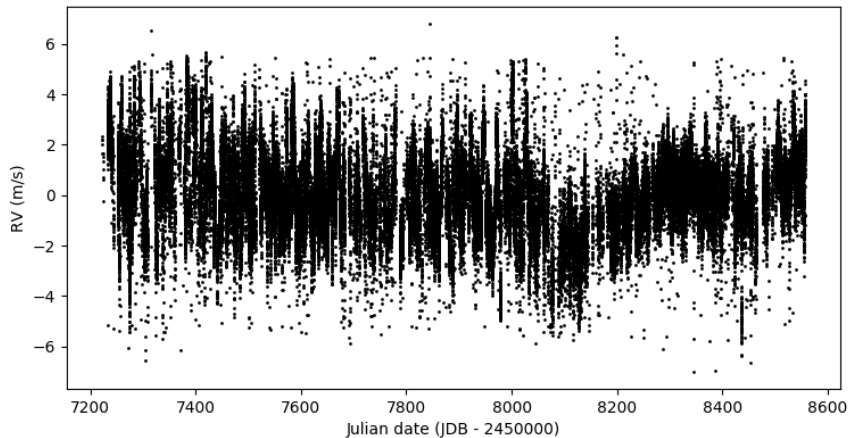


Correct for differential extinction - rms still 1.6 m/s!!

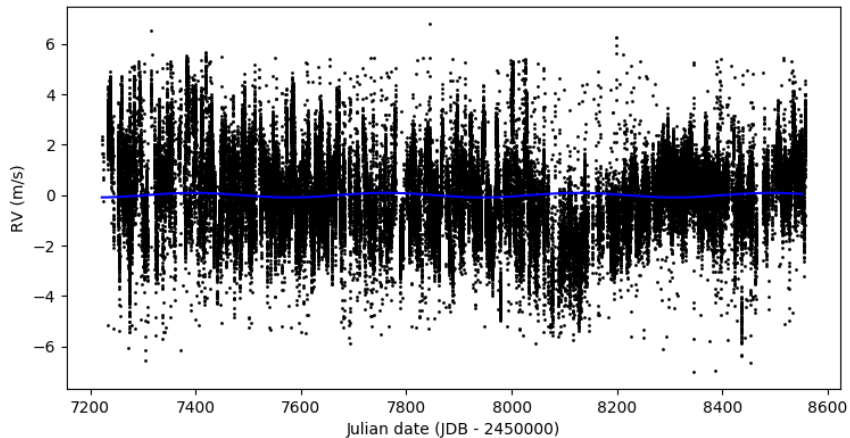


(Collier Cameron, Mortier et al. 2019, submitted to MNRAS)

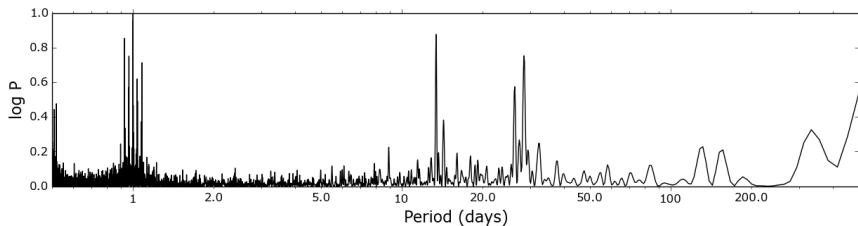
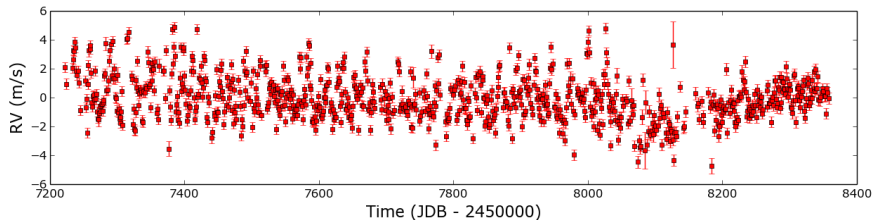
Stellar activity - a little perspective



Stellar activity - a little perspective

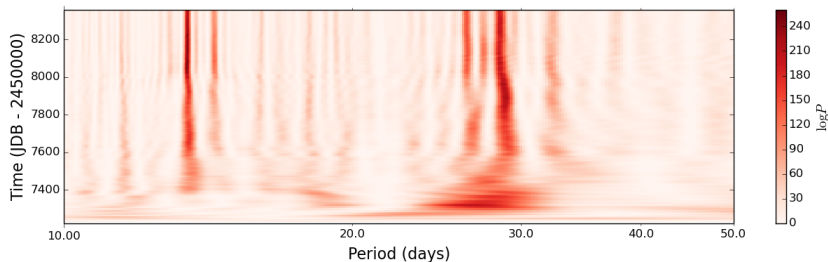


Solar RVs for ~ 3 years - binned per day



(BGLS periodogram - Mortier et al. 2015)

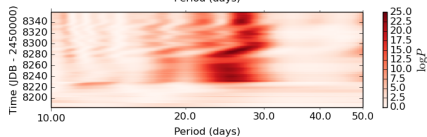
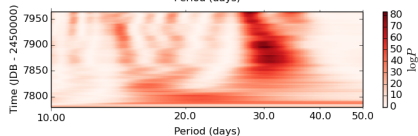
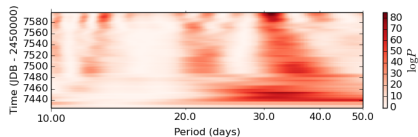
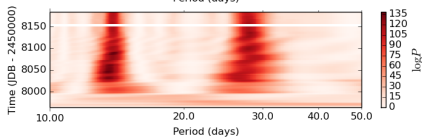
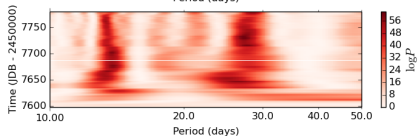
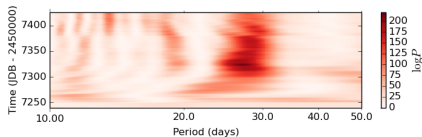
Solar rotation



Solar rotation at ~ 28 days
and its harmonic at ~ 13 days
clearly visible and unstable over time.

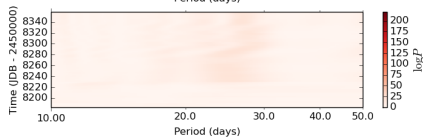
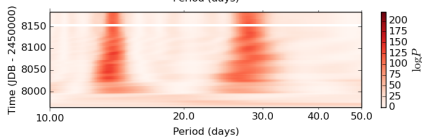
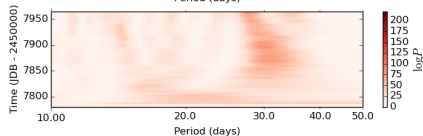
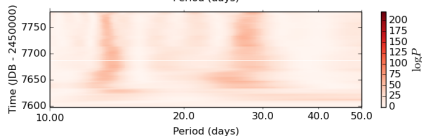
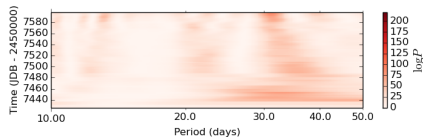
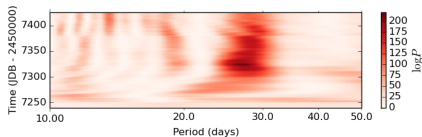
(Stacking periodograms - Mortier et al. 2017)

Data split in semesters



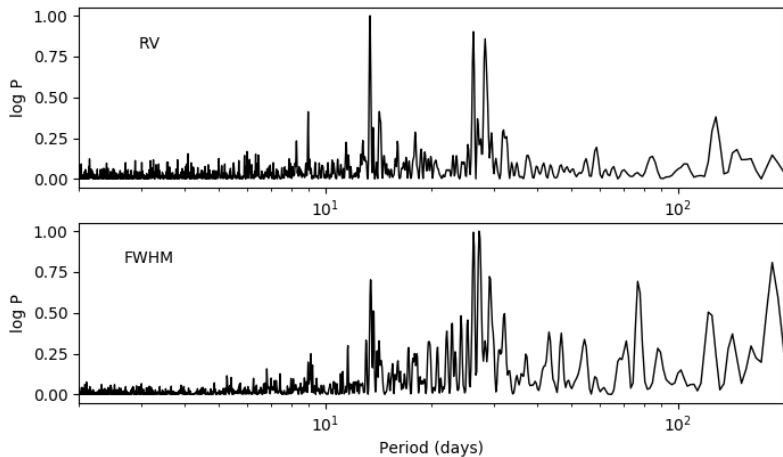
Strongest periodicity and its strength highly variable.

Data split in semesters

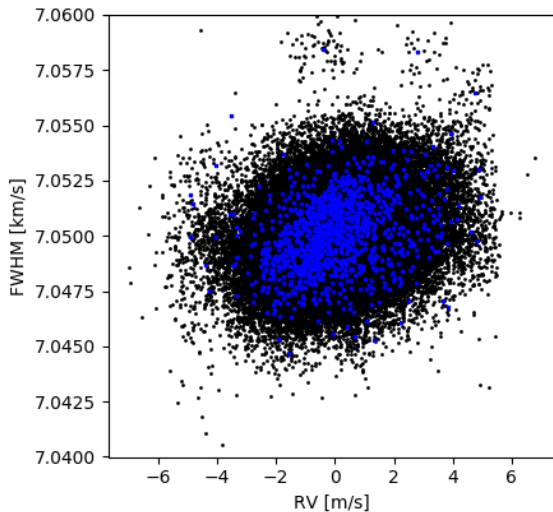


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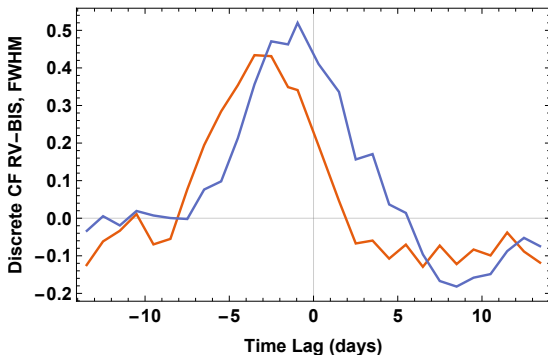
What about our 'activity indicators'?



Similar periodicity behaviour - no correlation?



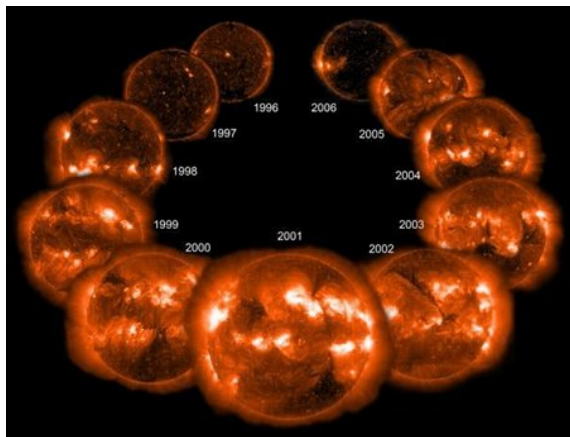
Time lag between RV, FWHM, BIS



(Collier Cameron, Mortier et al. 2019, submitted to MNRAS)

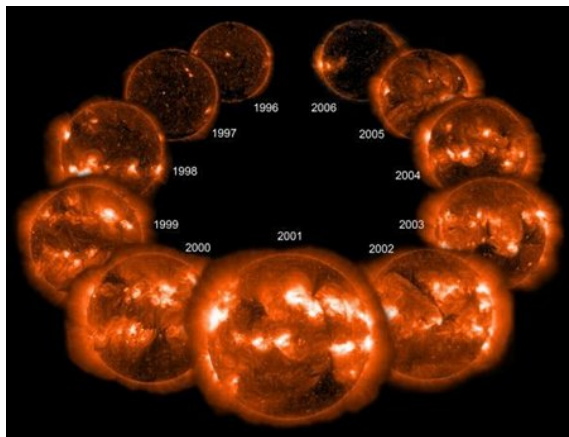
Temporal offset between RV, FWHM, BIS weakens their correlation. The delay is caused by the faculae suppressing the convective blueshift, combined with the fit of a Gaussian to the asymmetric CCF.

To know the planet is to know its star



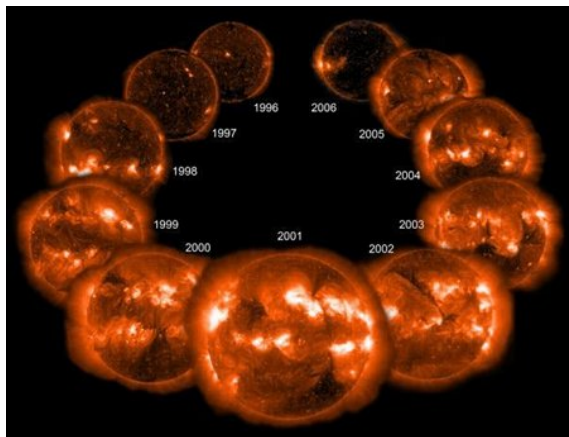
Studying the Sun-as-a-star helps us understand 'the noise',

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will allow us to test models and algorithms,
is the way forward to detecting a true Earth twin