

# Phase shifts between RVs and stellar variability indicators

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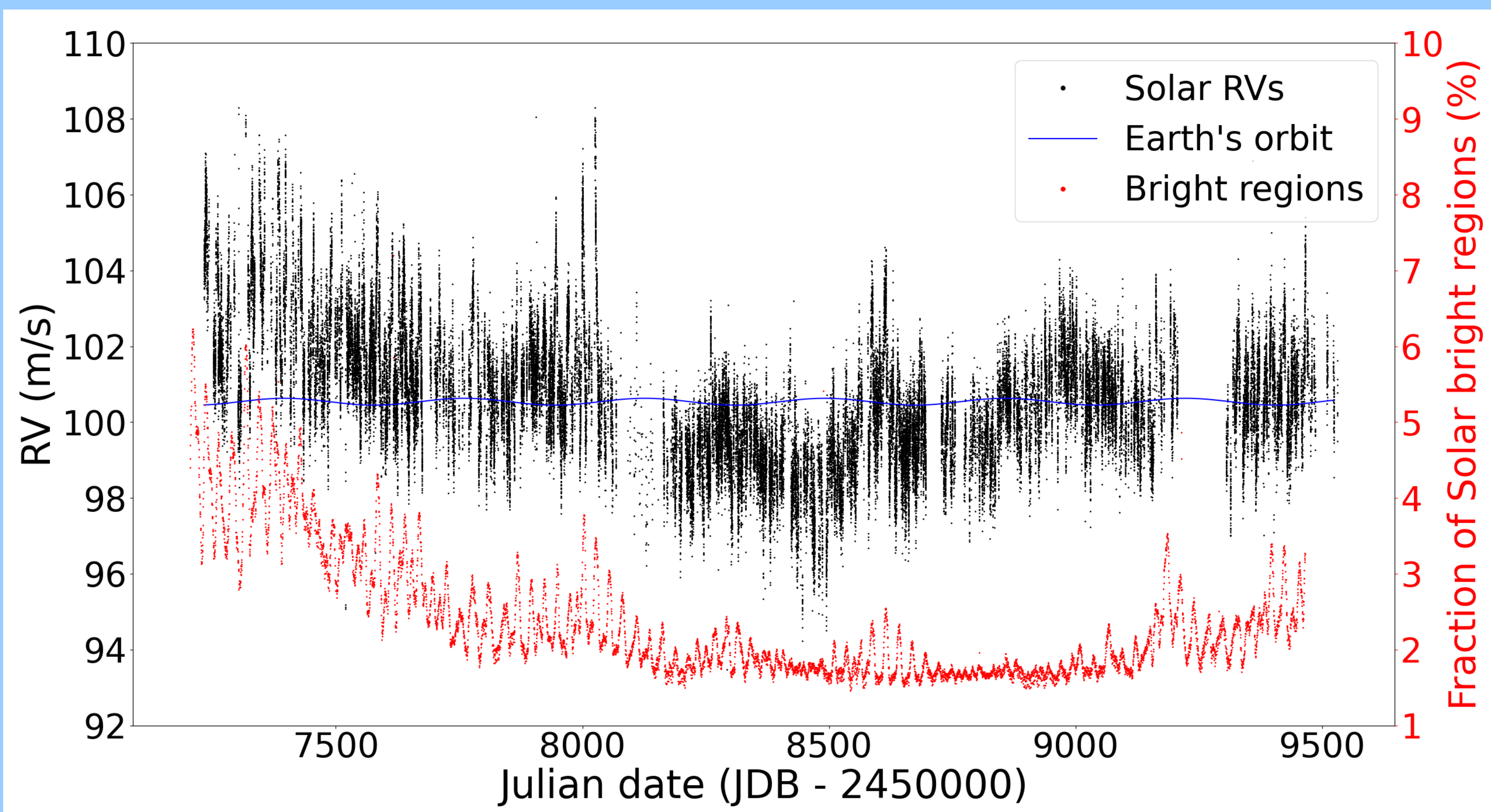
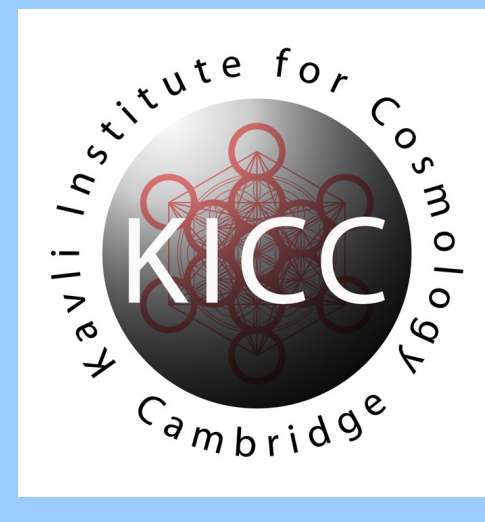
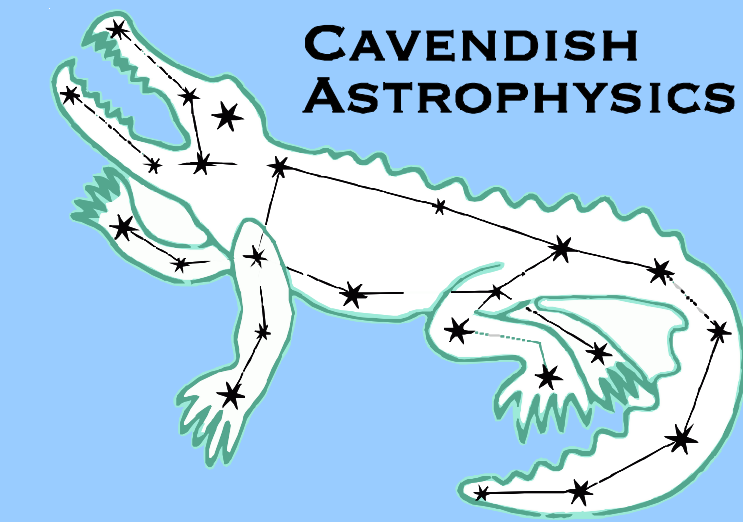
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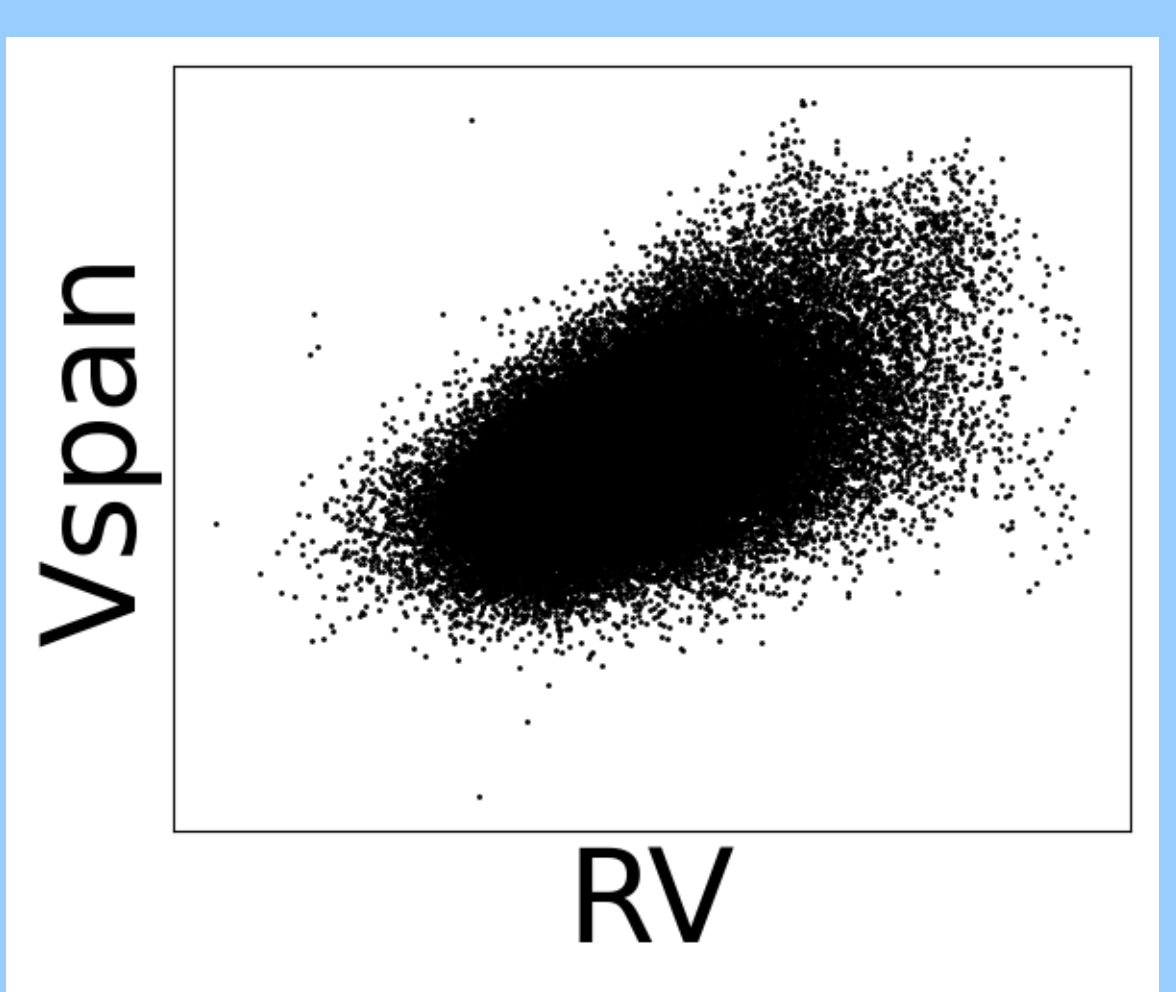
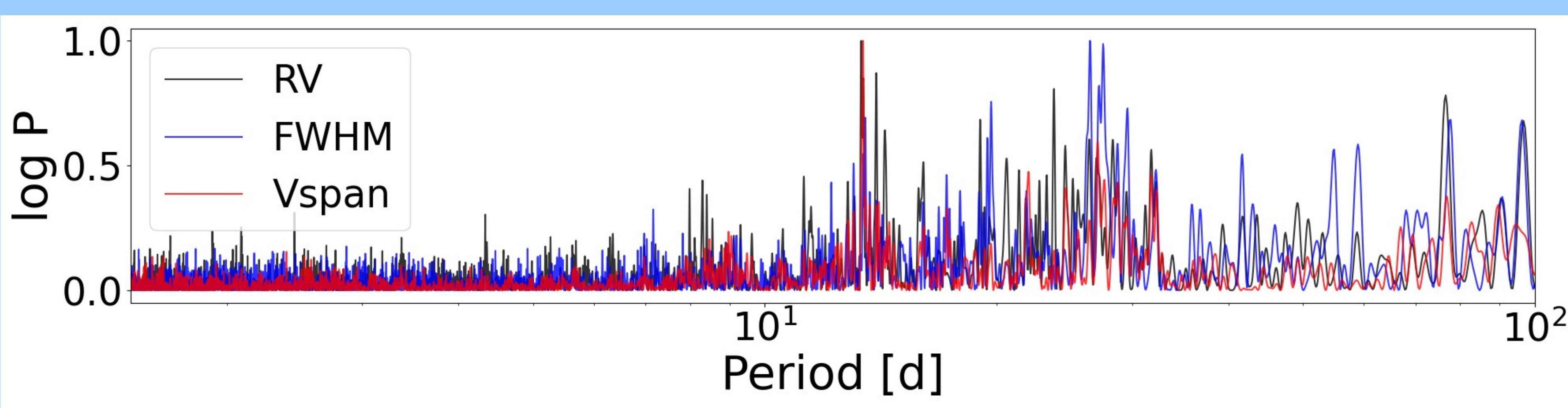
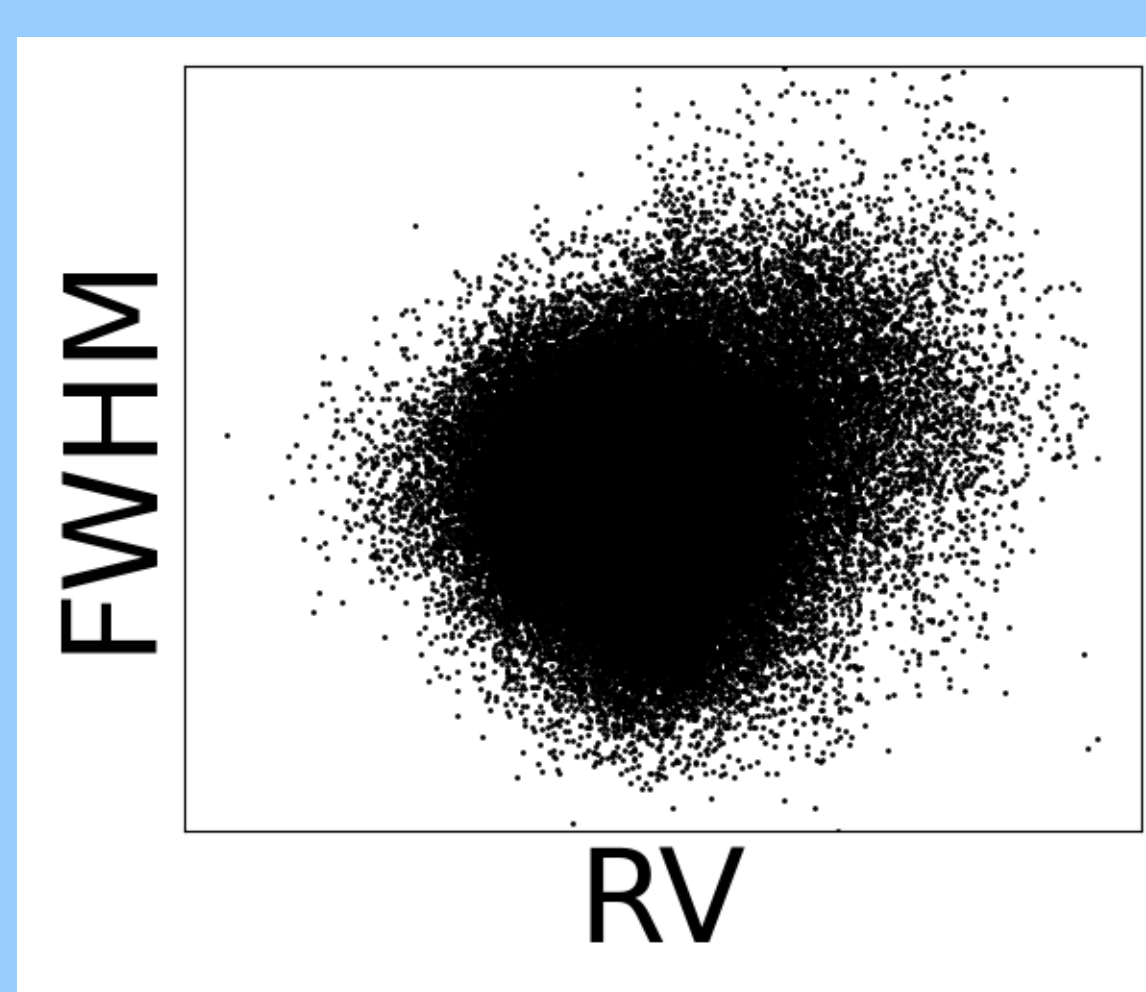


# Phase shifts between RVs and stellar variability indicators

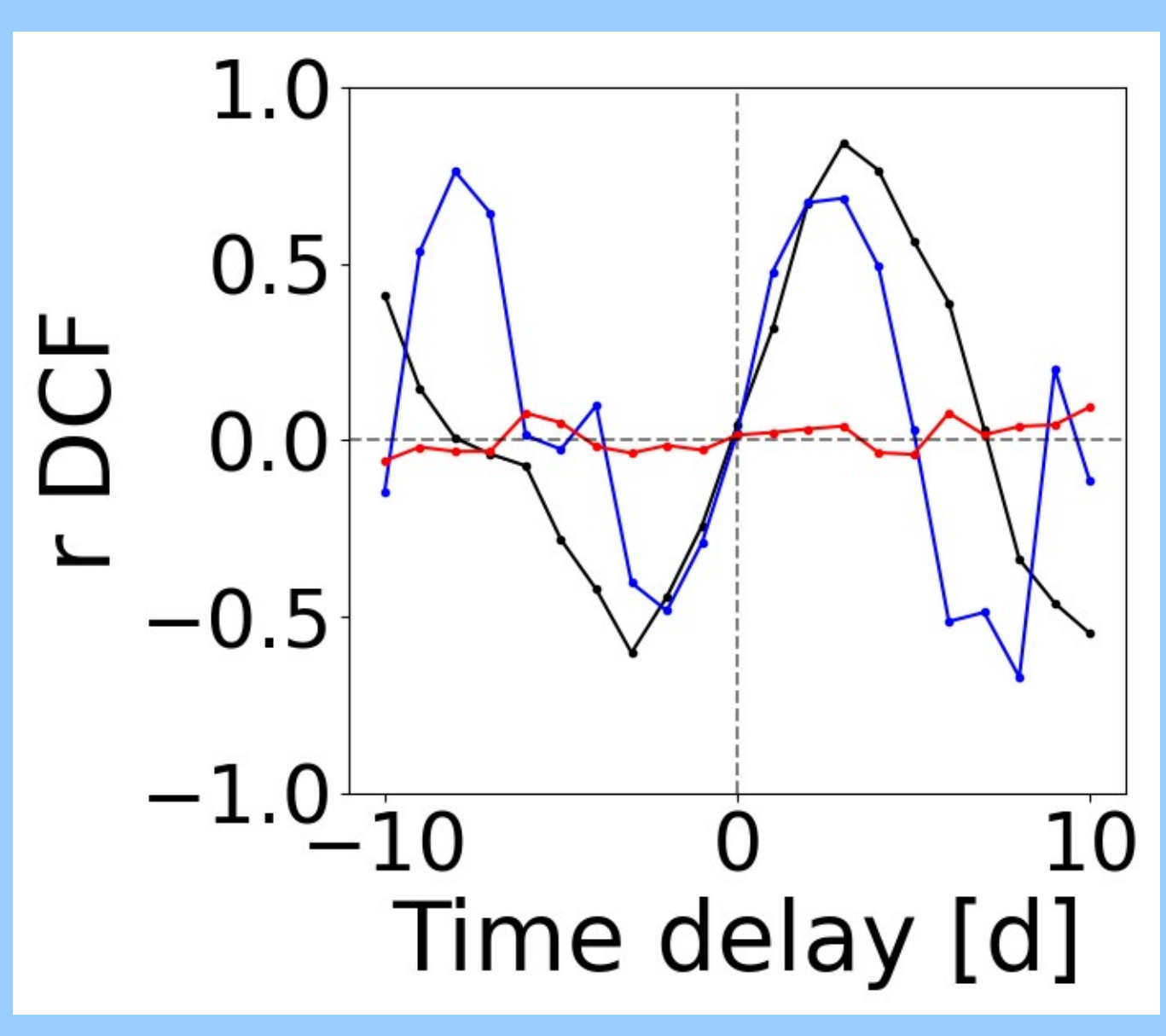
Annelies Mortier and the HARPS-N Solar Team



The HARPS-N Collaboration started **observing the Sun-as-a-star** in July 2015. We correct the Solar RVs for any effects of Solar System bodies and atmospheric extinction. This dataset thus provides a unique test case to understand the behaviour of stellar variability in RVs. The downwards slope represents the long-term variability of the Sun's magnetic field as tracked by the fraction of bright regions on the Sun. The (blue) RV signal of our Earth is an order of magnitude below the stellar variability scatter.

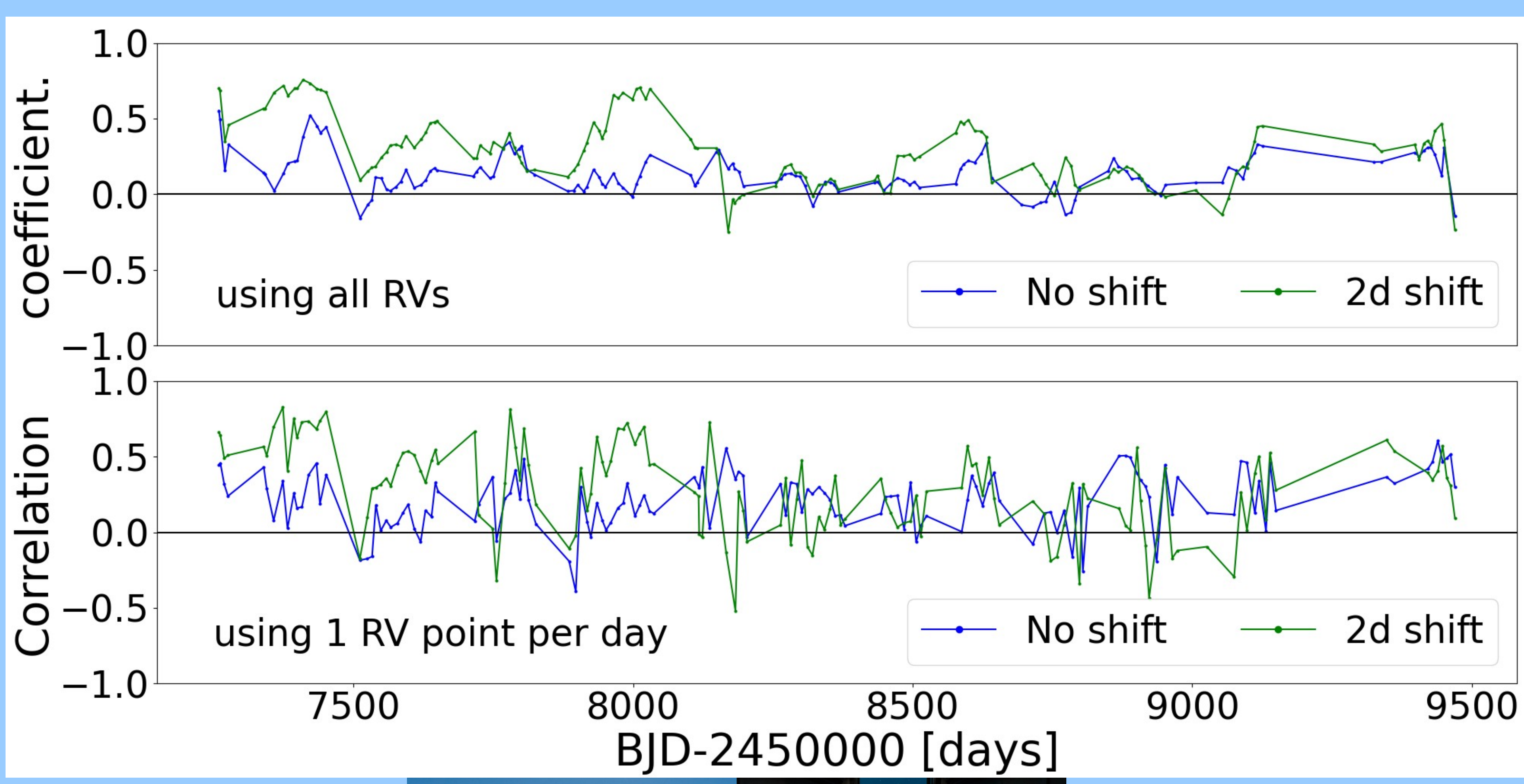


- Calculate a variety of line profile indicators tracking width (FWHM), depth and asymmetry (eg Vspan – Boisse et al. 2011) of the cross correlation function (CCF).
- Periodic behaviour of RV and indicators found to be very similar with Solar rotation period and first harmonic clearly detectable.
- Correlation between RV and indicators is present but not strong.



- Get discrete correlation function coefficient ← Blue during highest activity, red during lowest activity, black in between.
- When a strong correlation is present, the shift is between 2 and 3 days, corresponding to 30 to 45 degrees in longitude on the Solar surface (see also Boisse et al. 2011).
- The exact same behaviour is seen in all line profile indicators.

- Split the data in overlapping chunks of 60 days, with the next data chunk starting roughly 10 days later.
- Get DCF between RV and indicator for each chunk to study long-term behaviour.
- Repeat by taking one random time per day – mimicks real stellar observations.



**CONCLUSIONS**

- The HARPS-N Solar data shows that line profile indicators track the behaviour of RVs well, but fall behind by 2-3 days. Dense sampling is crucial to track this.
- When surface activity is low, the RV scatter is not mimicked in these indicators.



The HARPS-N project has been funded by the Prodex Program of the Swiss Space Office (SSO), the Harvard University Origins of Life Initiative (HUOLI), the Scottish Universities Physics Alliance (SUPA), the University of Geneva, the Smithsonian Astrophysical Observatory (SAO), the Italian National Astrophysical Institute (INAF), the University of St Andrews, Queen's University Belfast, and the University of Edinburgh. The HARPS-N solar team and TNG staff perform the processing of the solar data and maintain the solar telescope.



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