Following the Flows: Coordinated observations of stellar supergranulation with EPRV facilities across the globe

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Novel Challenges in the Extreme Precision Regime

The latest generation of EPRV spectrographs has enabled studies of astrophysical signals at the <1 m s^{-1} level. Even for the quietest stars, intrinsic stellar variability in this regime presents a challenge to the detection of low-mass, long-period exoplanets such as Earth analogs. To overcome this obstacle, we must be able to reliably characterize sub-m s^{-1} stellar variations and disentangle these not only from the planet signals of interest, but also from instrument systematics.

A multi-facility approach to advancing EPRV exoplanet detection capabilities

By observing a star with multiple spectrographs simultaneously, we can isolate the **stellar RV signal** (shared across all observations) from the **instrumental contributions** (unique to each spectrograph).

With improved stellar characterization and an improved understanding of the instruments themselves, we can refine our treatment of both of these signals in RV exoplanet searches.

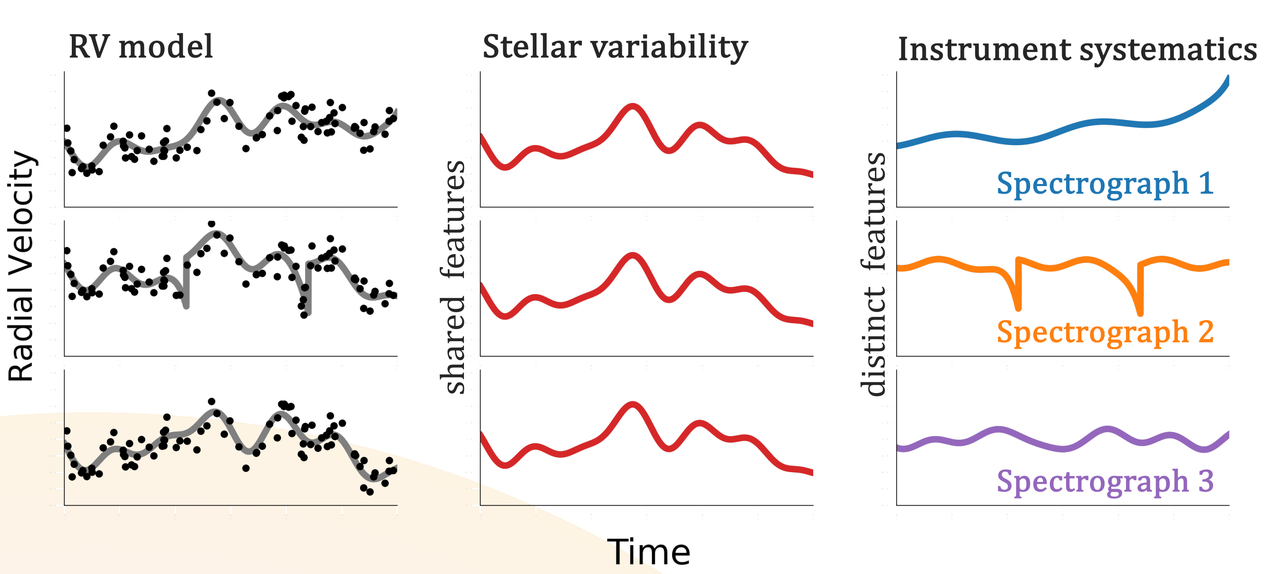


Fig. 1: (left) Simulated RV time series and model for measurements with three different spectrographs; (middle) isolated stellar variability component and (right) isolated instrumental RV contributions.

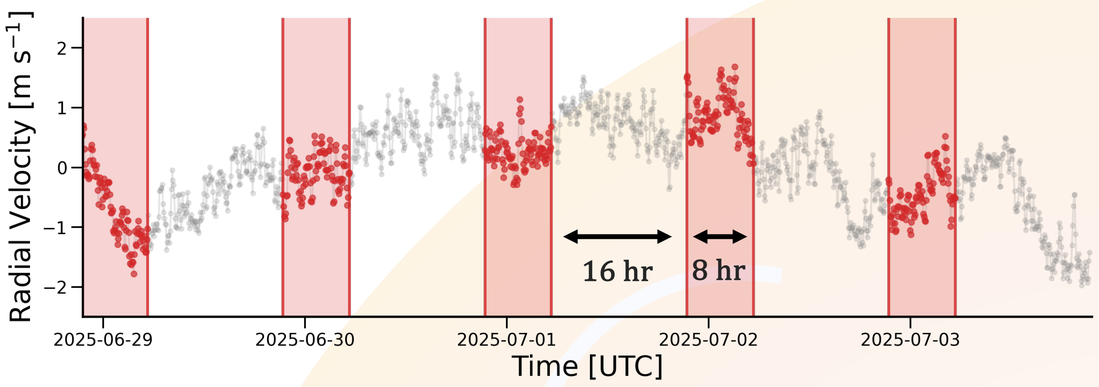


Fig. 2: Simulated supergranulation + granulation time series (grey points) and observability from a single telescope (red). Even with precise measurements and dense sampling, these observations will fail to capture variations on critical timescales.

Supergranulation

Supergranulation signals are expected to hamper exoplanet detection efforts, yet this remains one of the most poorly understood sources of RV variability. Because supergranulation operates on characteristic time scales of ~1 day for Sun-like stars, it is challenging to study with observations from a single facility.

The EPRV Research Coordination Network Standard Stars Project

A coordinated observing campaign was carried out in **September 2024** and **June 2025** to monitor a common set of stars with EPRV facilities across the globe. The goals of this project were twofold:

1. **Supergranulation characterization** – with instruments on multiple continents, we provide continuous coverage of up to 15 hours, extending the effective nightly baseline and minimizing gaps in the supergranulation time series.

2. **Instrument characterization** – overlapping RV baselines on common targets allow us to identify discrepancies caused by uncorrected instrument systematics

Early results to be presented at Splinter Session 6: Following the Flows!

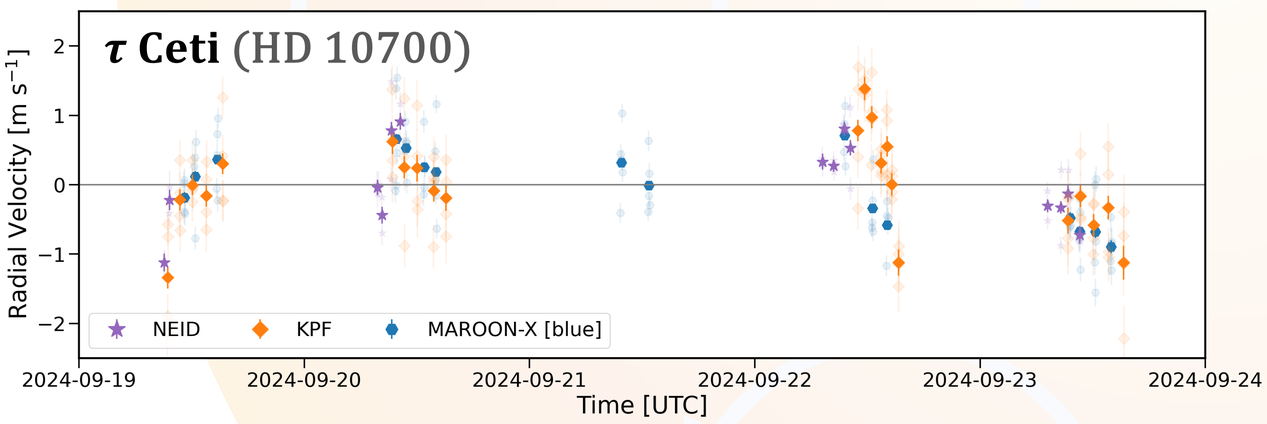


Fig. 3: RV time series for τ Ceti from our September 2024 campaign. Measurements from NEID (purple), KPF (orange), and MAROON-X (blue) are in general agreement. Data are binned to average out the p-mode signal.

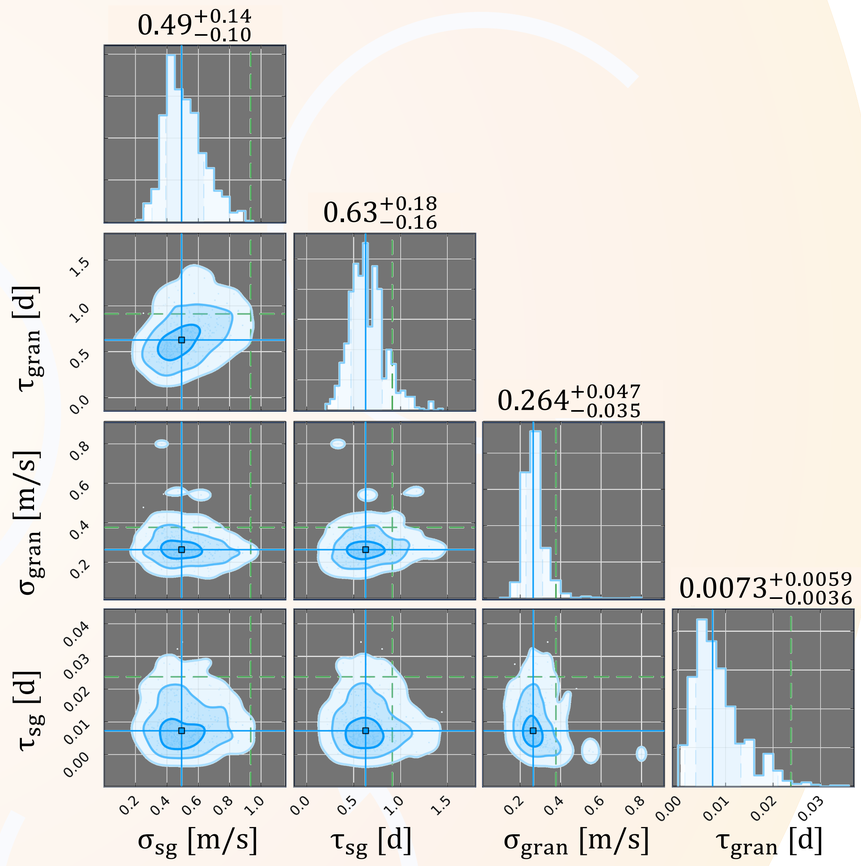
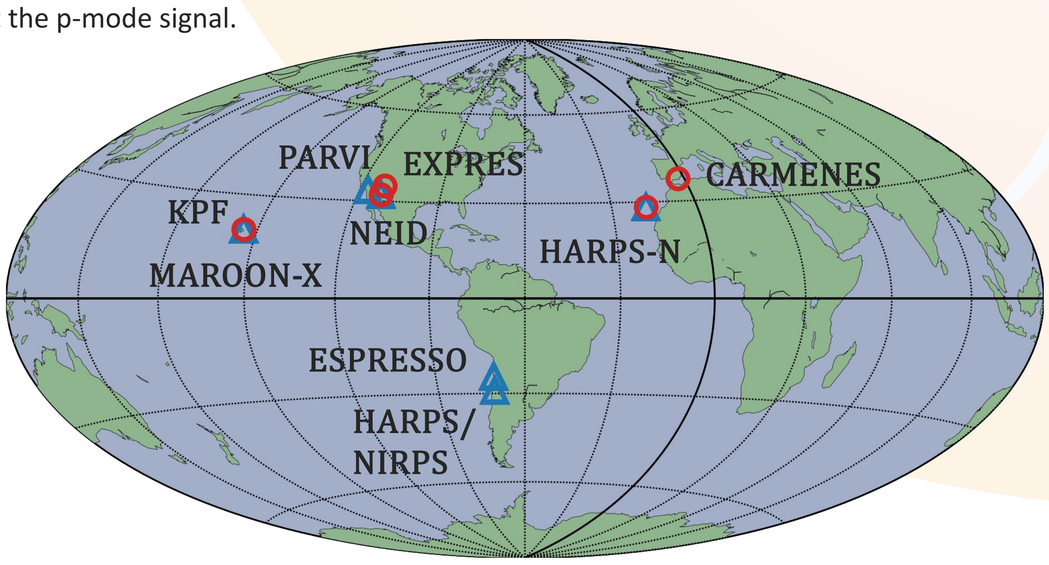


Fig. 4: Posterior distributions for the supergranulation and granulation amplitudes (σ) and timescales (τ) via a joint fit to the NEID, KPF, and MAROON-X RV measurements of τ Ceti.



○ : September 2024
- 4 late-G / early-K dwarfs
- CARMENES, HARPS-N, EXPRES, NEID, KPF, MAROON-X

△ : June 2025
- 2 early-G (Solar-type) stars
- HARPS-N, ESPRESSO, HARPS, NIRPS, NEID, PARVI, KPF, MAROON-X

Want to contribute?

DATA

Scan here to access the data, or join the discussion at Splinter Session 6: *Following the Flows* on Thursday