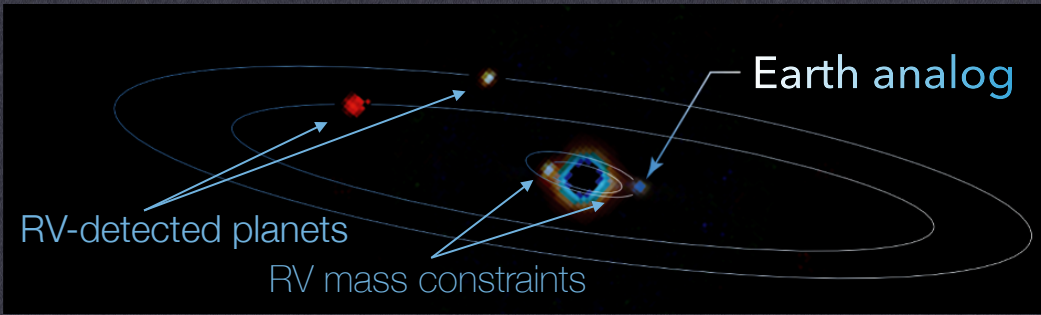# SPORES-HWO. II. COMPANION MASS LIMITS FOR FUTURE EXO-EARTH SURVEY TARGET STARS FROM >30 YEARS OF PRECISION RADIAL VELOCITY MONITORING

CALEB K. HARADA[1],[*], COURTNEY D. DRESSING[1], & STEPHEN R. KANE[2]

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Simulated image of a Solar System analog 30 light-years away, as captured by a large UV/O/NIR space telescope like HWO [STScI, NASA GSFC].

The **Habitable Worlds Observatory (HWO)** is a NASA mission concept for a large ultraviolet/optical/near-infrared space telescope that aims to directly image and spectroscopically characterize ~25 Earth-like exoplanets orbiting nearby stars to search for signatures of global biospheres.

Precursor studies of promising survey targets for HWO are critical for reducing mission design risk by enabling science and engineering trade studies and providing necessary context for the interpretation of HWO spectra of possible exo-Earths.

SPORES-HWO (**S**ystem **P**roperties & **O**bservational **R**econnaissance for **E**xoplanet **S**tudies with **HWO**) aims to maximize precursor knowledge of the most promising target stars for the future HWO exo-Earth survey.

PAPER I

Harada et al. (2024)

Synthesized information for **164 provisional HWO target stars** (ExEP List; Mamajek & Stapelfeldt 2023), including fundamental stellar properties, UV-MIR photometry, abundances, and flare rates (see also Tuchow et al. 2024).

PAPER II (THIS WORK)

Harada et al. (2025)
[in revision]

Analyzing **all publicly-available (E)PRV observations** of SPORES-HWO stars to place limits on undetected planets, refine properties of known planets, search for new planet candidates, and identify false positives.

Example HWO Precursor Science Drivers:

- Massive planets orbiting in the habitable zone (HZ) can preclude long-term dynamical viability of exo-Earths (e.g., Kane et al. 2024), which informs target prioritization for the HWO exo-Earth survey.
- Non-detections of HZ exoplanets by (E)PRV place upper mass limits on planets imaged by HWO and hence inform HWO's onboard astrometry requirements.

Key Science Questions:

- Are exoplanet systems that host detectable biospheres similar to the Solar System in terms of their overall system architectures?
- Is there a particular planetary system architecture (and hence planet formation/evolutionary pathway, which tends to produce Earth-like planets, or are there many possible evolutionary routes that can lead to habitability?

SPORES RV Hunters: a Community Science Effort

Over **70 undergraduate volunteers** from UC Berkeley Astronomy assisted in searching for published (E)PRV datasets for 164 stars. Volunteers followed detailed guidelines, collaborated with other students, attended regular office hours, and submitted data via an online portal. All data underwent **automated & manual vetting**.

- RVs and stellar activity indicators obtained for **141 stars**
- **153,490** individual RV measurements span **36 years**
- **27** unique spectrograph/telescope configurations
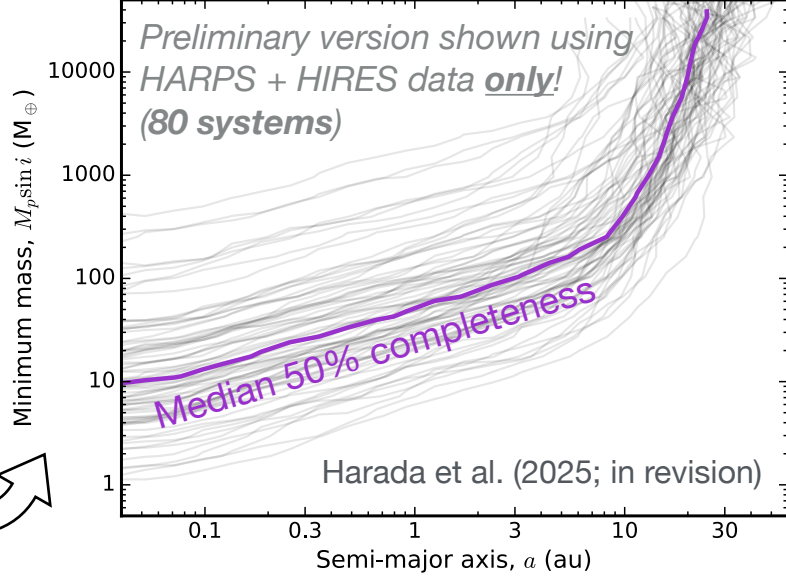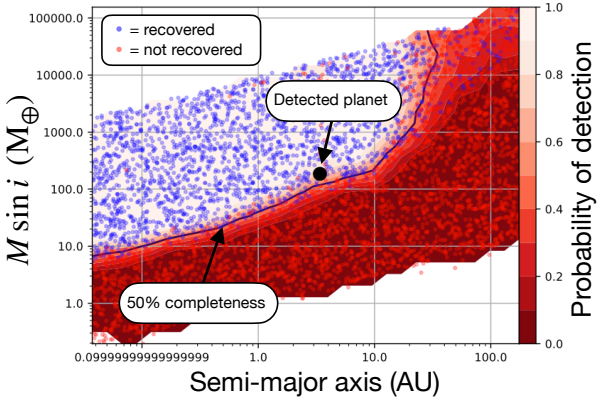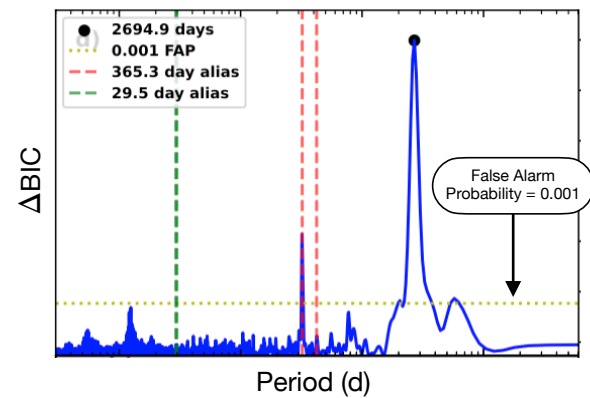- **36** data source papers cited

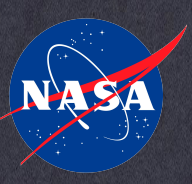We then analyzed a total of **120 systems** with 20+ nights of RVs using *RVSearch* (Rosenthal et al. 2021).
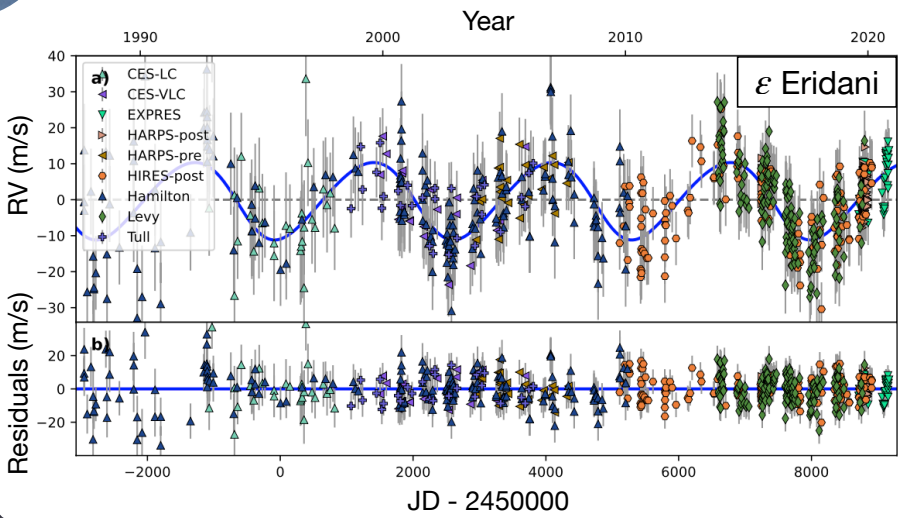
Preliminary RV Search Results:

We computed Lomb-Scargle and Δ BIC periodograms, fit Keplerian orbits, measured search completeness, and plotted stellar activity correlations for each star (see also, e.g., Howard & Fulton 2016; Laliotis et al. 2023). Analysis **PDF reports,** final **compiled RV data sets,** and a list of **new planet candidates** will be made public at the time of publication.

Preliminary version shown using HARPS + HIRES data **only**! (80 systems)

Median 50% completeness

Harada et al. (2025; in revision)

Our results help facilitate planning for future (E)PRV efforts. We have ongoing observing programs to monitor "neglected" HWO target stars with **APF/Levy** and **Keck/KPF** (as of 2025A).

SPORES
System Properties & Observational Reconnaissance for Exoplanet Studies with HWO