



The Kepler Giant Planet Search. I:

A Decade of Kepler Planet Host Radial Velocities from the W. M. Keck Observatory

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51 Pegasi b 30 Année, OHP

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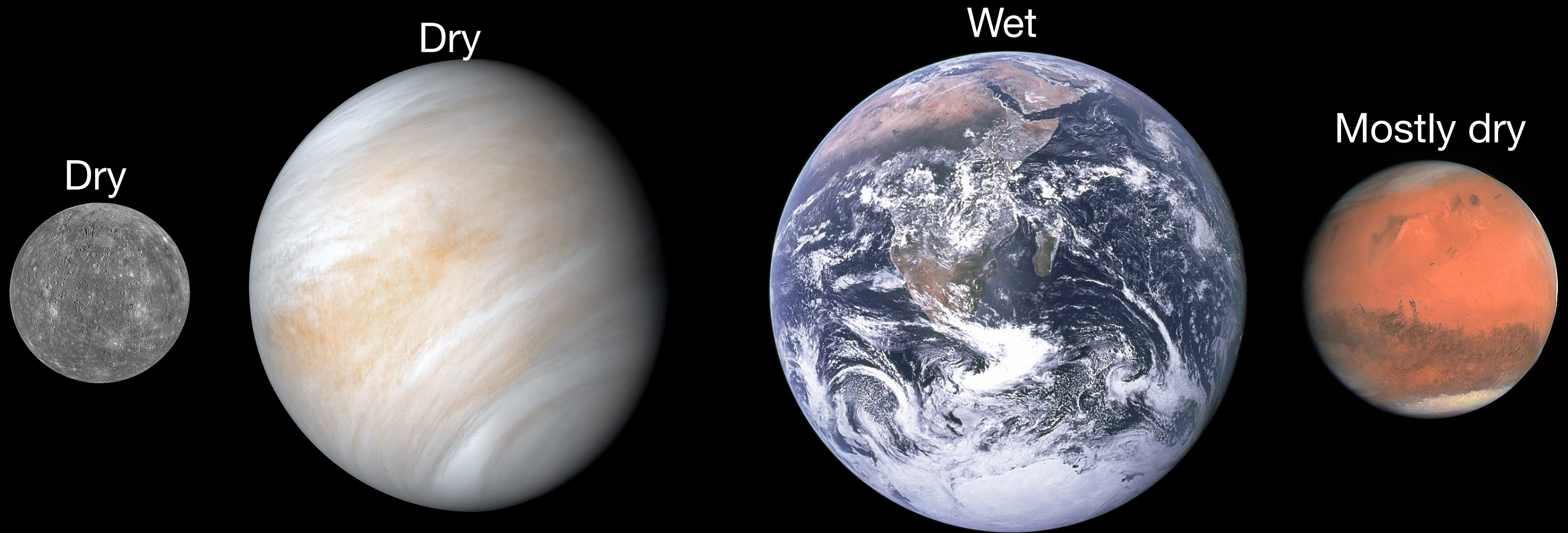
Support from NASA XRP, NASA KSMS, NASA JPL



**How long is
a decade?**

Grad student
visiting OHP (Merci
a Guillaume H. et
Alex S.!)

THE TERRESTRIAL PLANETS (TO SCALE)



- What accounts for the sizes (and size diversity) of terrestrial planets?

What is the role of giant planets in the origin of exo-Earths (and their water)?



- Theories disagree on whether giant planets help or hinder the growth of small planets (Levison & Agnor 03, Tsiganis+05, Walsh+11, Lambrechts+19, Chen+20, Schlecker+21, Bitsch & Izidoro 23, Best+24, 25)
- Observational results disagree on whether the occurrence of Jovians is enhanced in systems with super-Earths (Zhu+18, Bryan+19, Rosenthal+22, Bonomo+23,25, Bryan&Lee24,25, VanZandt+24,25, Weiss+ in prep.)

The Kepler Giant Planet Search

- Goal: find the Jovian companions to small transiting planets
- Targeted 63 sun-like host stars of 157 transiting planets containing sub-Neptunes with $P < 100$ days
- Collected 2,844 RVs over a decade!



W. M. Keck Observatory, Maunakea (photo credit Ethan Tweedie)

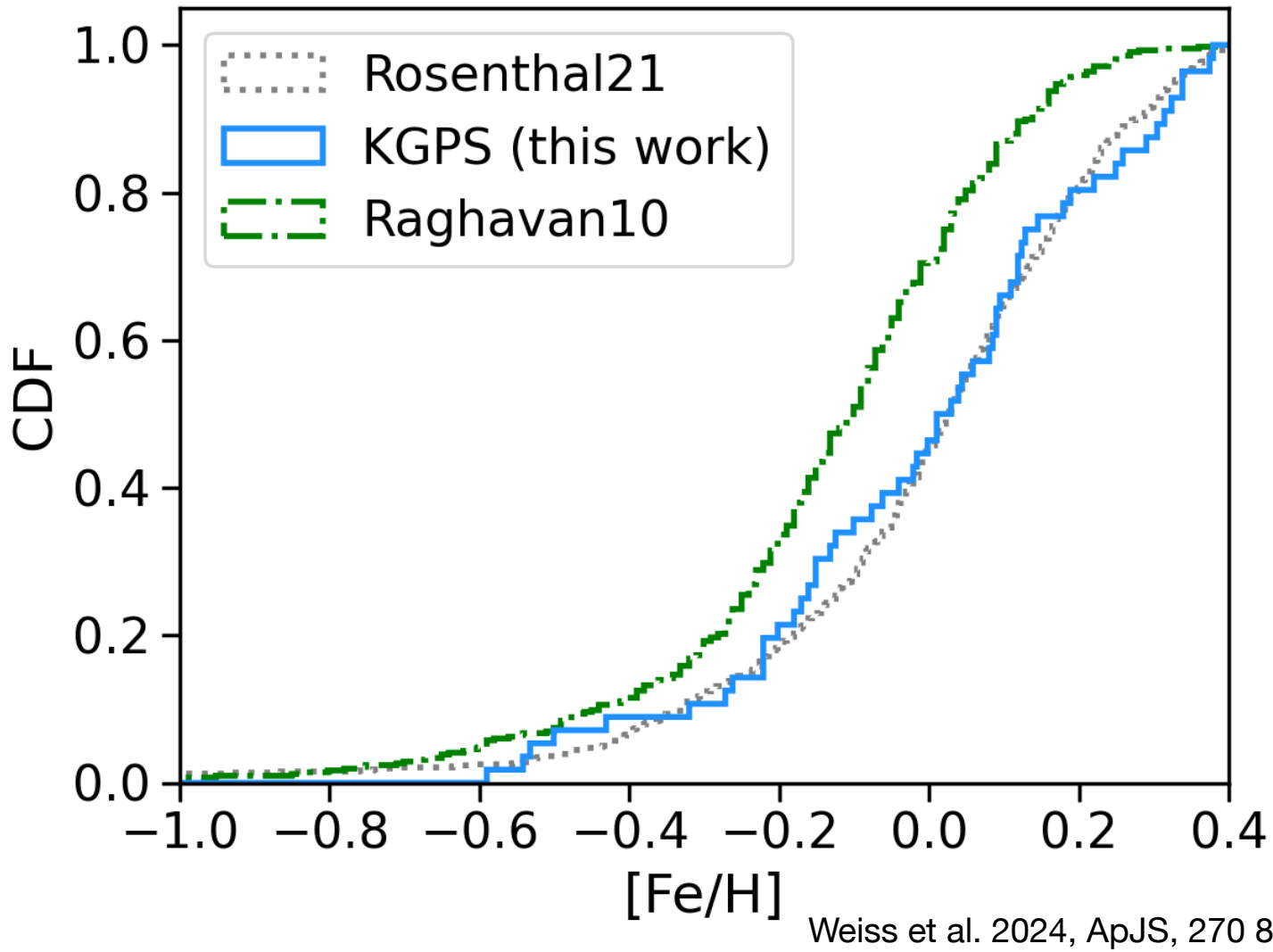
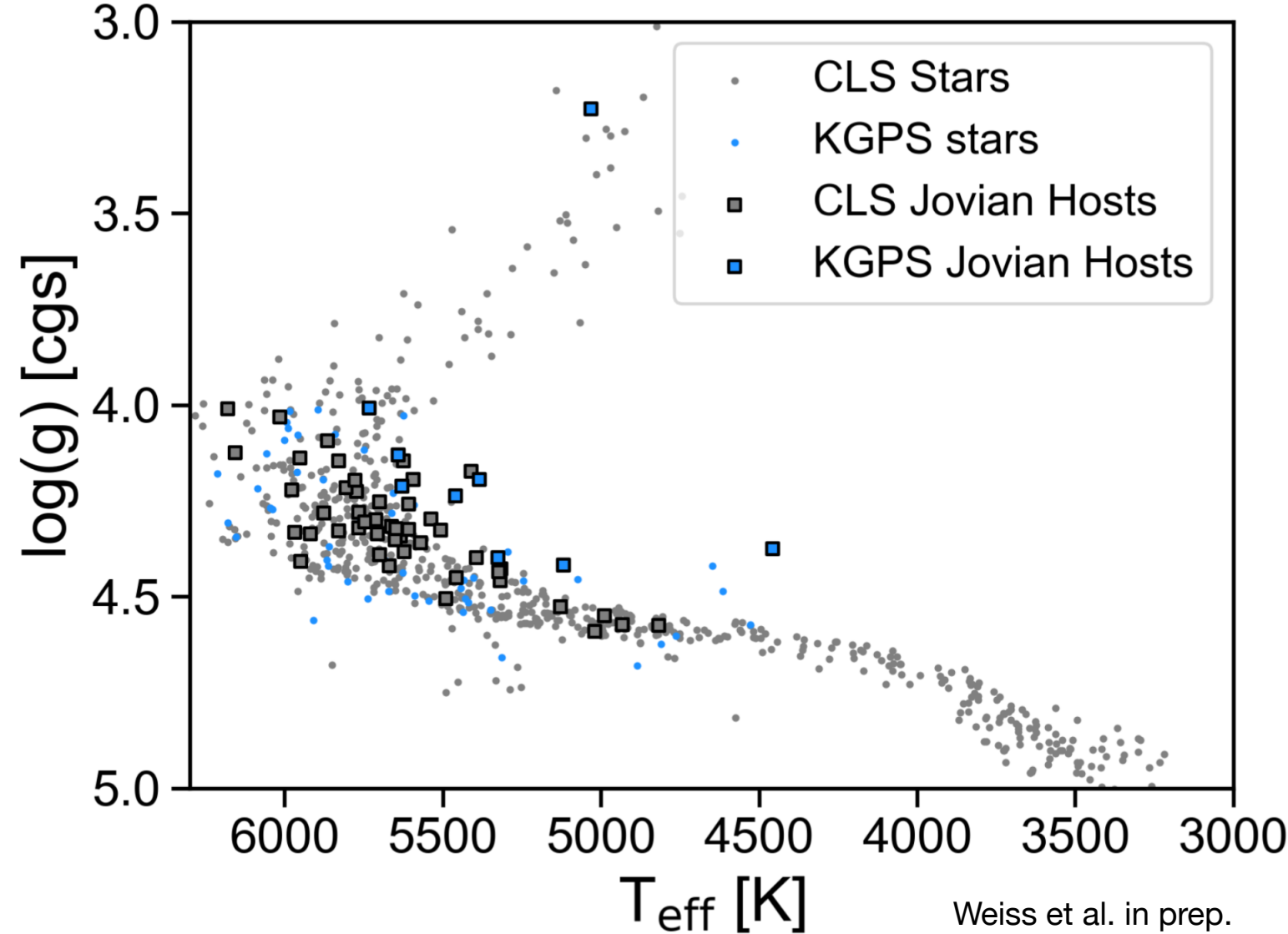
Table 1: Kepler Giant Planet Search (KGPS) Paper Series

		No.	Title
Weiss et al. 2024, ApJS, 270:8	→	KGPS I	A Decade of Kepler Planet Host Radial Velocities from M. W. Keck Observatory
Weiss+ in prep.	→	KGPS II	The Occurrence of Jovian Companions to Small Transiting Planets
	→	KGPS III+	Additional Patterns in the Architectures of Systems with Small and Jovian Planets
He & Weiss 2023, AJ, 166:36	→	[A new pattern between small planets and Jovians!]	

The KGPS sample is primarily main-sequence stars that are comparable to the field stars used for blind RV surveys.

Our selection criteria were:

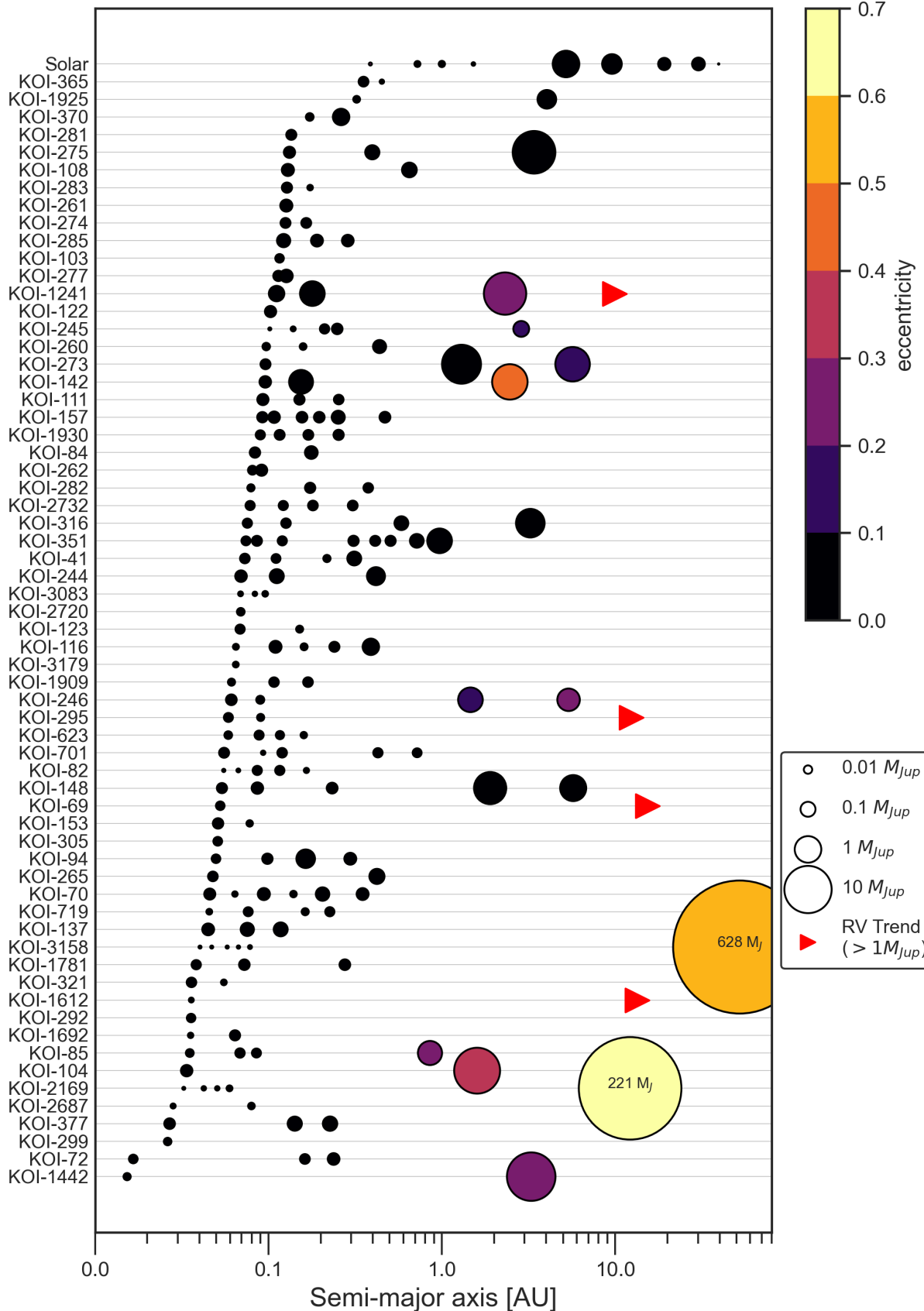
- Kepler stars with at least one transiting planet having $R_p < 4 R_{\text{Earth}}$, $P < 100$ days
- At least 10 RVs
 - At least 5 years of RV observation
- Sun-like properties:
 - $V < 13.6$
 - $4300 \text{ K} < T_{\text{eff}} < 6300 \text{ K}$
 - $V \sin i < 10.1 \text{ km/s}$
 - $\log(g) > 4.0$
 - $\log(R'_{\text{HK}}) < -4.8$



Kepler Giant Planet Search I:

A Decade of Kepler Planet Host Radial Velocities from W. M. Keck Observatory

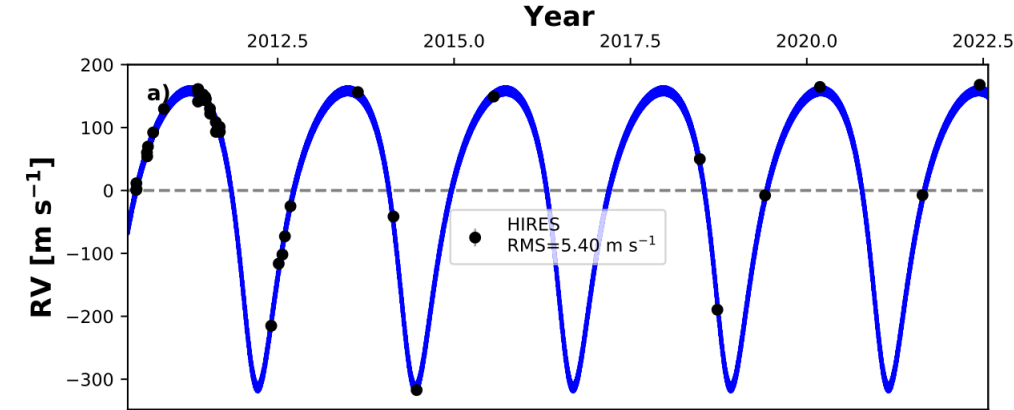
- Detected 27 non-transiting companions around 20 stars:
 - 13 Jovians ($0.3 M_{\text{Jup}} < M \sin i < 13 M_{\text{Jup}}$, $0.5 \text{ AU} < a < 7 \text{ au}$)
 - 8 sub-Saturns ($M \sin i < 0.3 M_{\text{Jup}}$)
 - 3 stars ($M_{\text{Jup}} > 13 M_{\text{Jup}}$)
 - 3 ambiguous trends
- Updated masses of 84 transiting planets
- One of the longest-running and most data-rich collections of RVs of the NASA Kepler systems yet (see also Bonomo et al. 2023!)
- Some patterns are emerging!



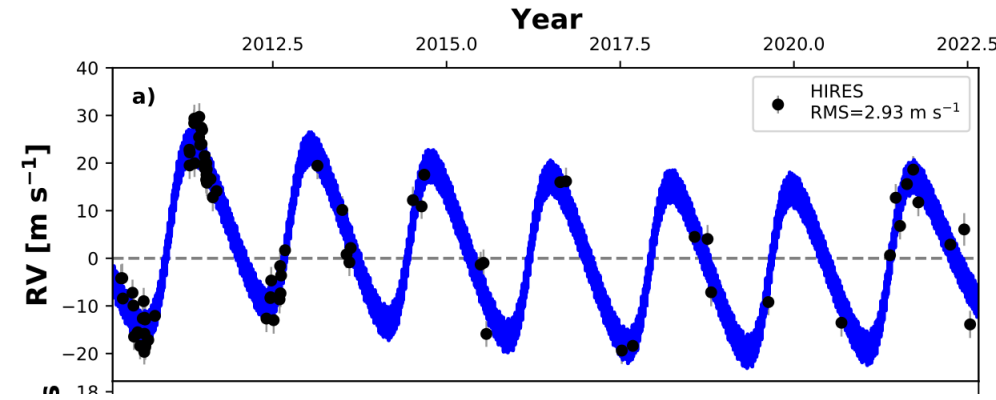
13 Jovian Companions

Weiss et al. 2024, ApJS, 270 8

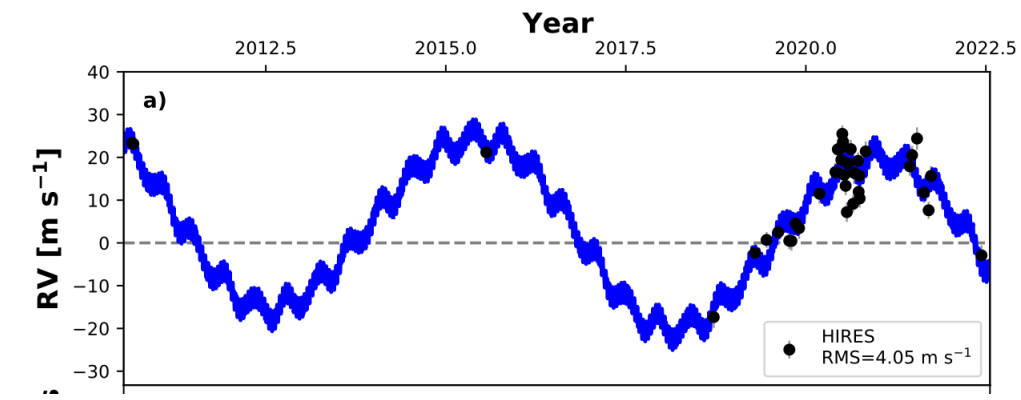
KOI-104 c



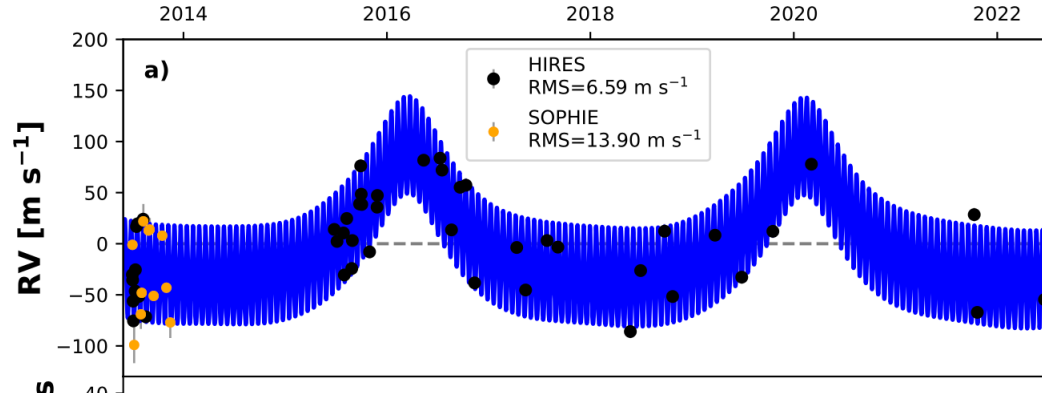
KOI-246 d, e



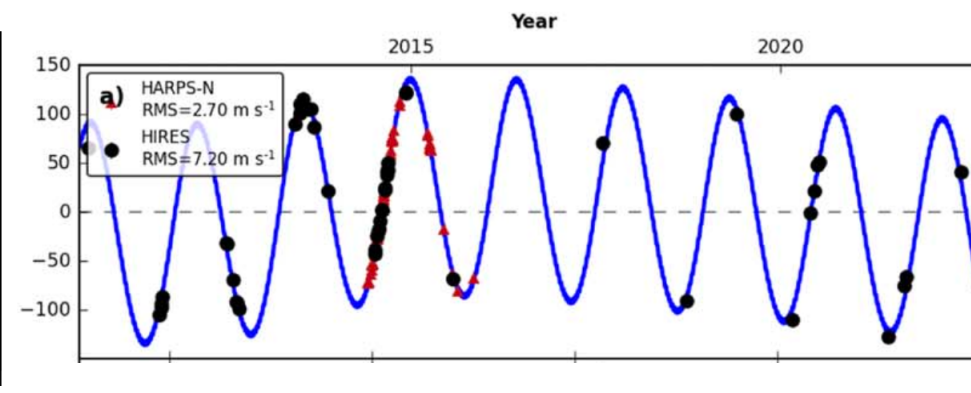
KOI-316 e



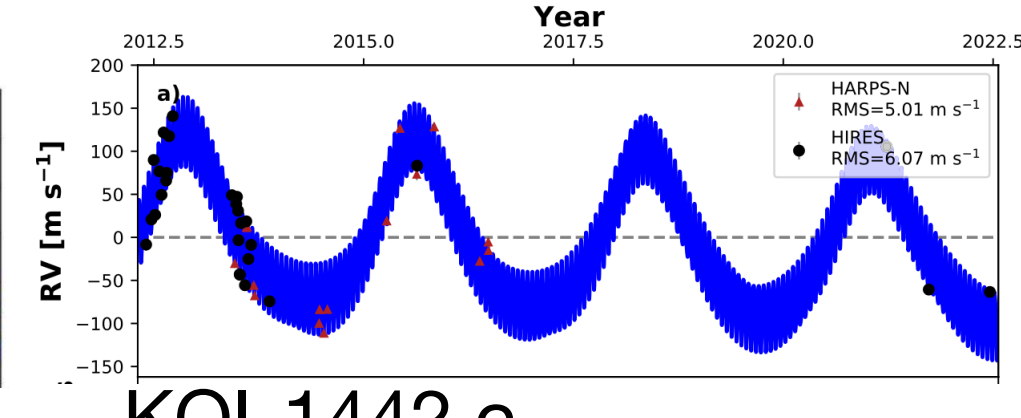
KOI-142 c, d



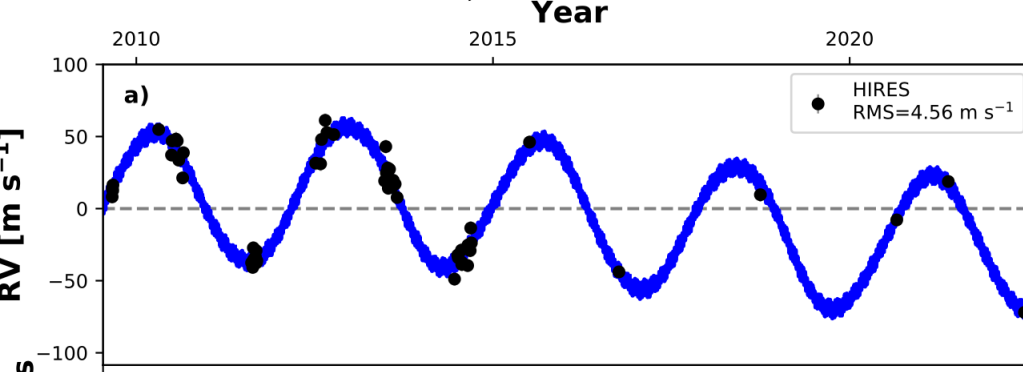
KOI-273 c, d



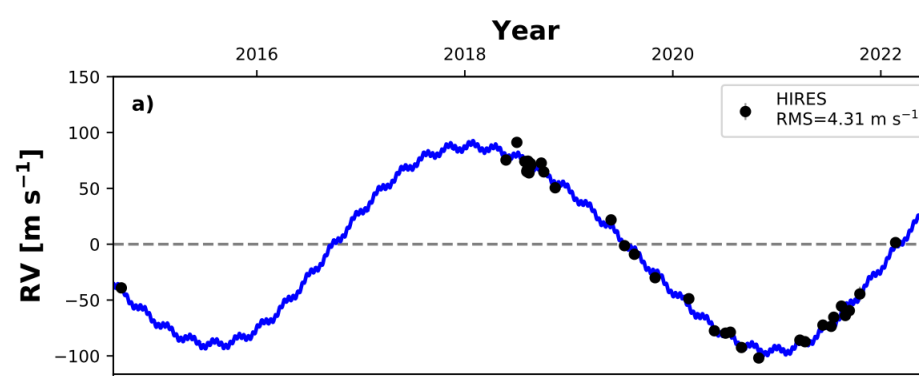
KOI-1214 d



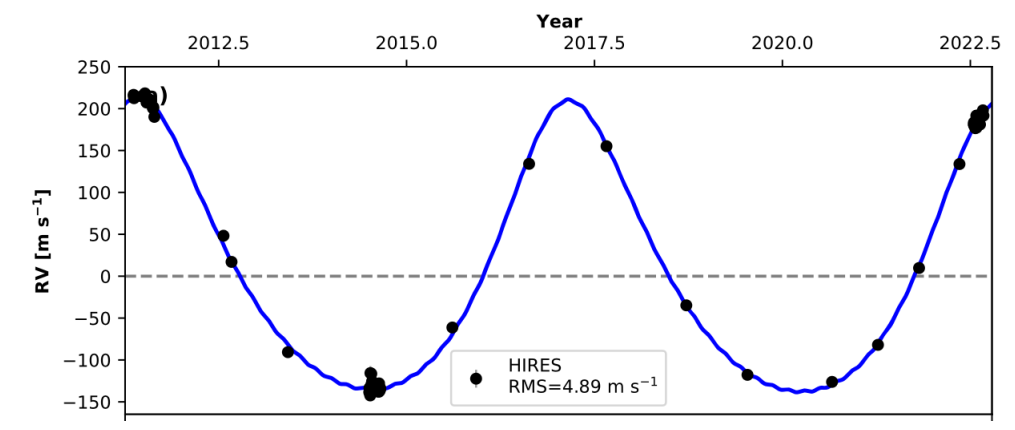
KOI-148 e, f



KOI-275 d

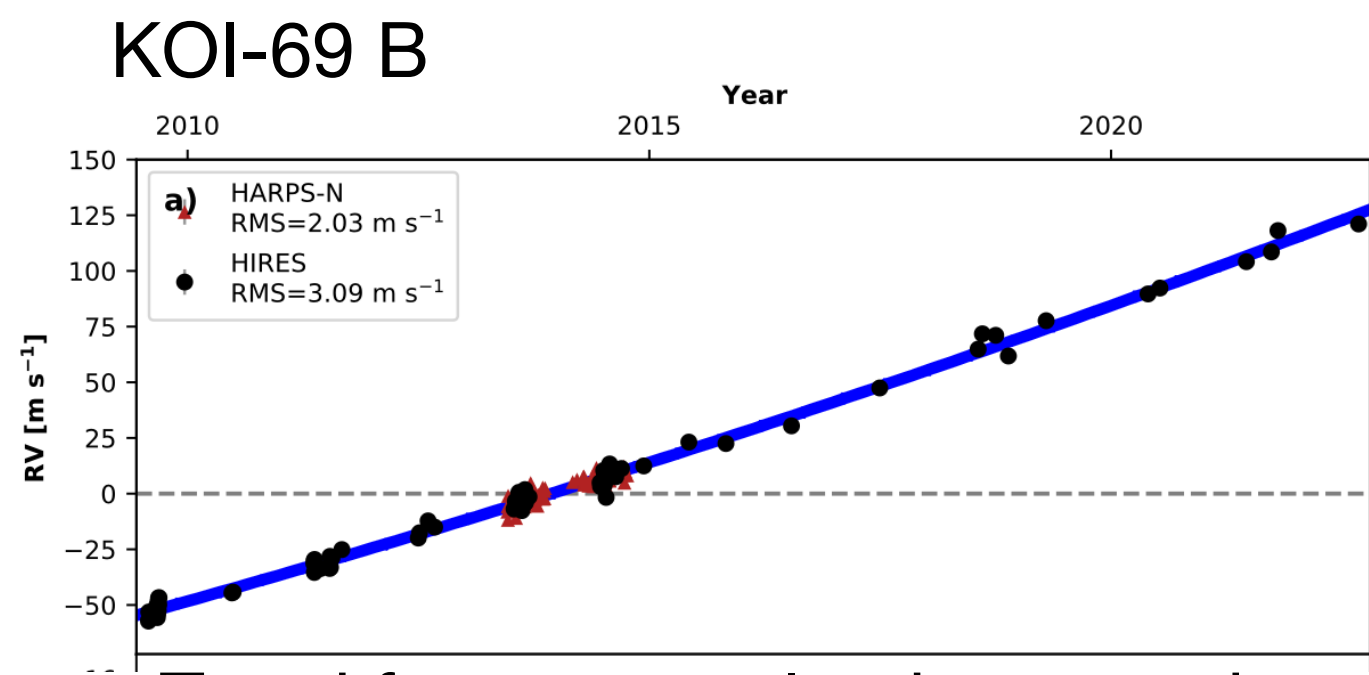


KOI-1442 c

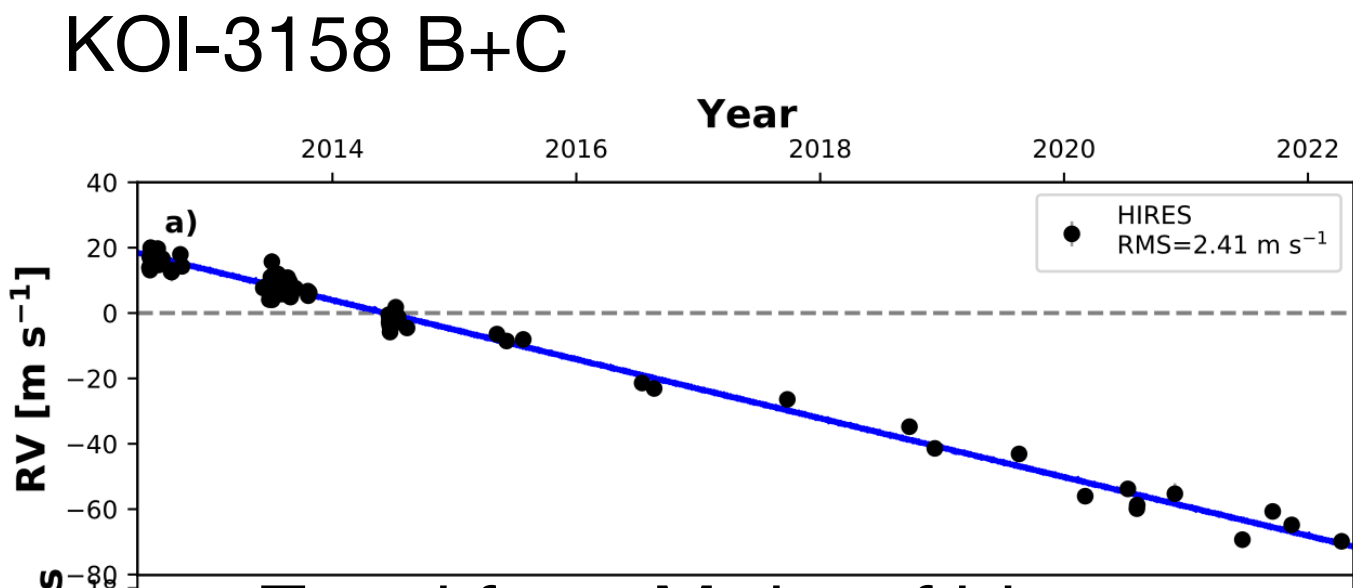


3 BD/Stellar Companions

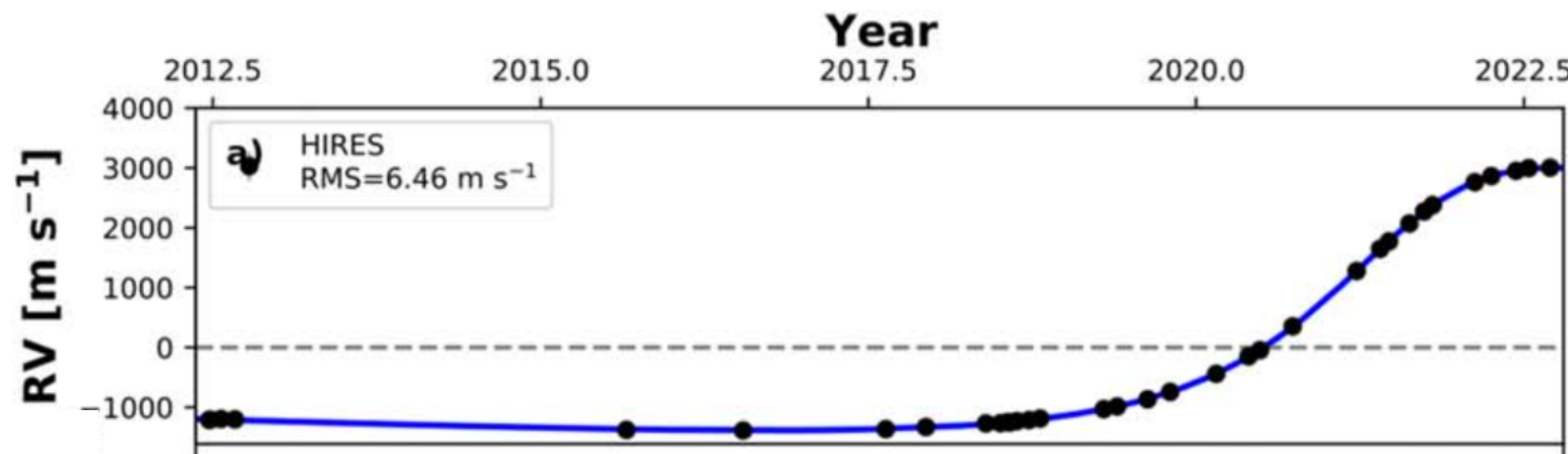
Weiss et al. 2024, ApJS, 270 8



Trend from unresolved companion
 $M \sin i > 15 M_{\text{Jup}}$



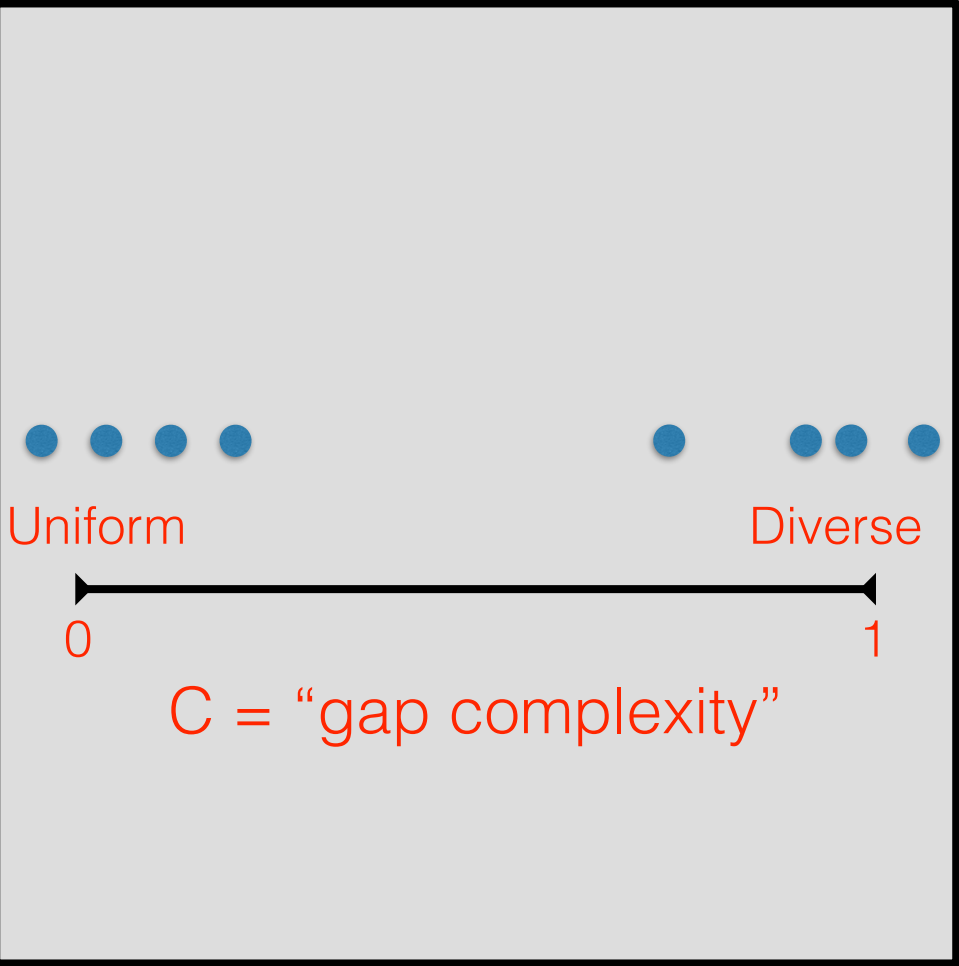
Trend from M dwarf binary



Trend from unresolved late M companion

A Strong Dynamical Relationship between Outer Giant Planets and Inner Transiting Planets:

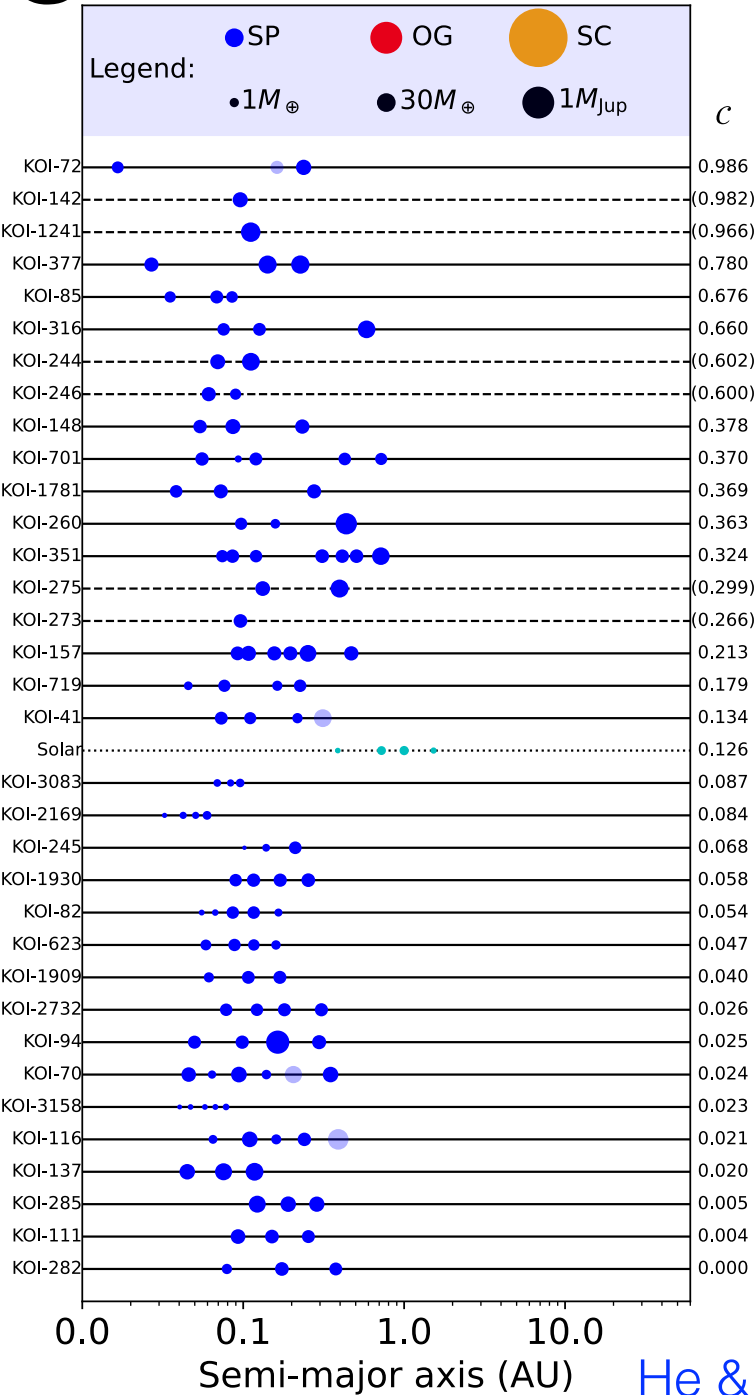
How diverse are planet spacings?



Gilbert & Fabrycky (2020)

Transiting planets with gaps in their spacing

Transiting planets without gaps

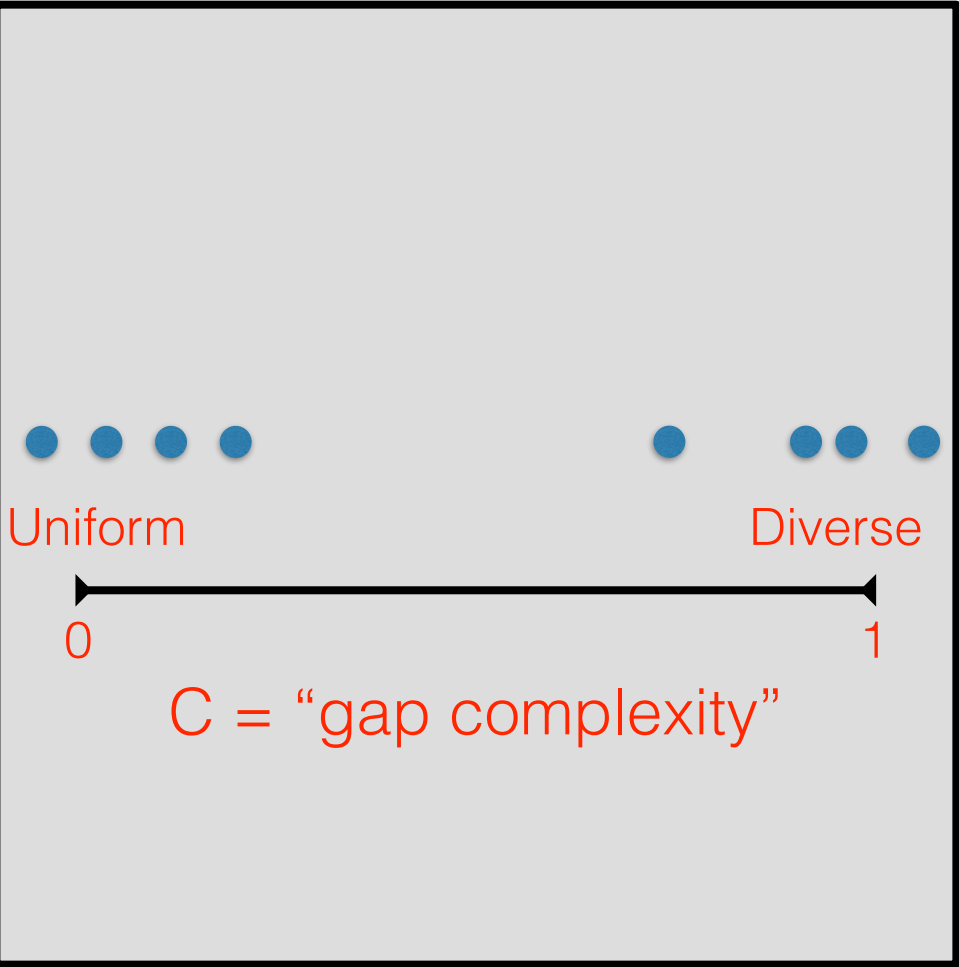


Sorted by gap complexity

He & Weiss (2023)

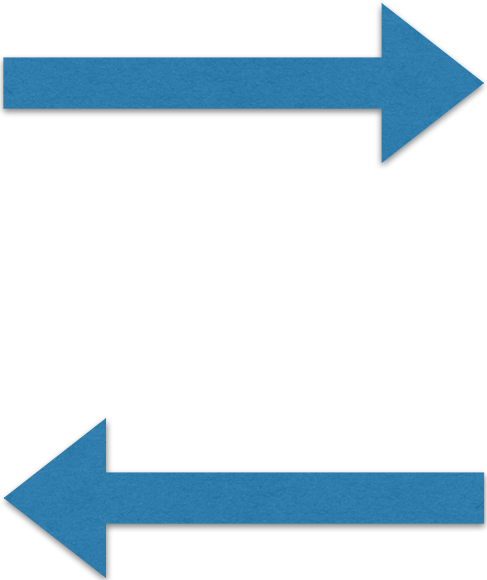
Long-Period Giant Planets Correlate with Gaps in Multiplanet systems!

How diverse are planet spacings?

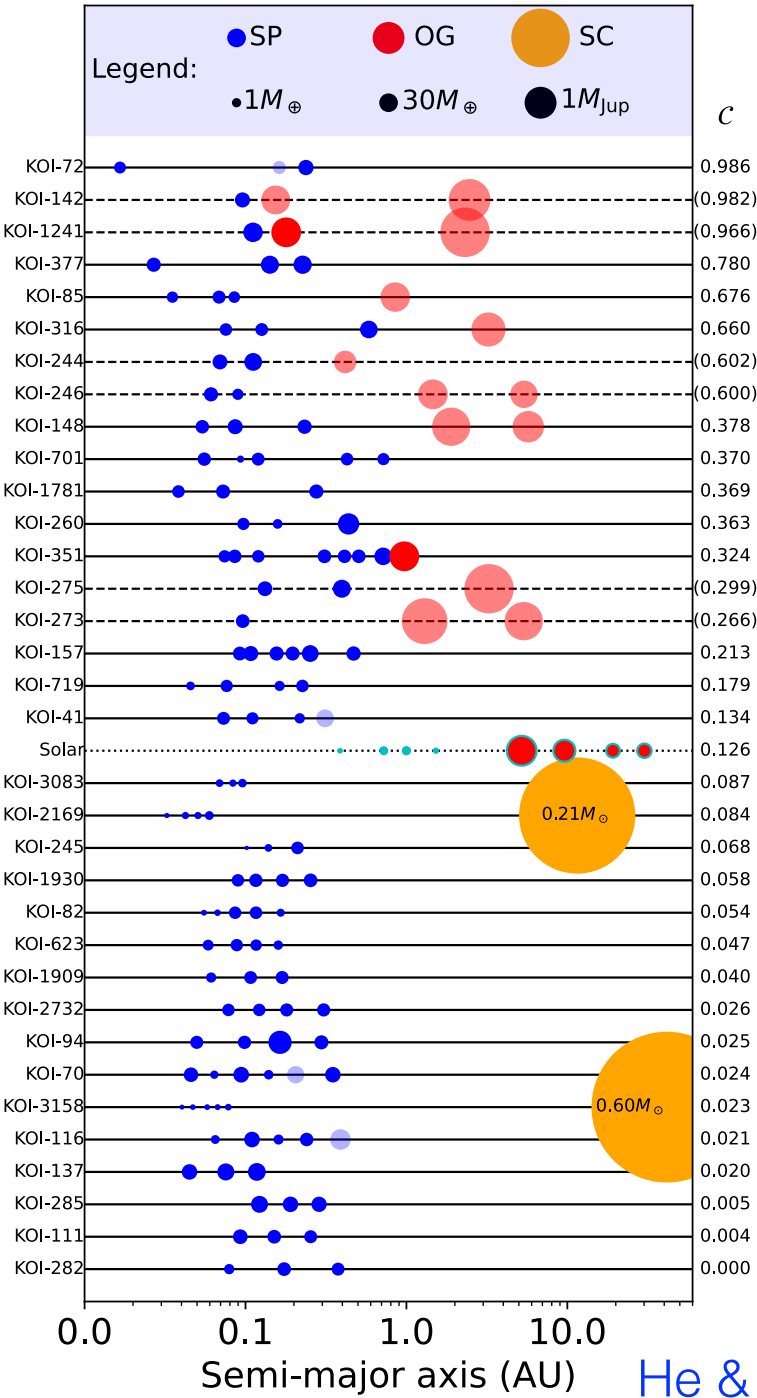


Gilbert & Fabrycky (2020)

Transiting planets with gaps in their spacing often have outer giants



Transiting planets without gaps



Sorted by gap complexity

Secular perturbations from outer giant? (Livesey & Becker 2024)

Secular perturbations ruled out? (Lammers & Winn 2025)

He & Weiss (2023)

Summary



- Kepler Giant Planet Search I: A catalog of 2,844 RVs of 63 host stars of 157 Mars-Neptune sized transiting planets from the Kepler Prime Mission (Weiss et al. 2024)
- Long-period giant planets correlate with *gaps* in multi-transiting systems (He & Weiss 2023), with multiple proposed dynamical pathways (Livesey & Becker 2024, Lammers & Winn 2025)
- If time: bonus slides w/ preliminary results on non-enhancement of the occurrence, sizes, and masses of transiting planets in systems with outer giants; examination of host star metallicities