A Classification of the Architectures of Planetary Systems

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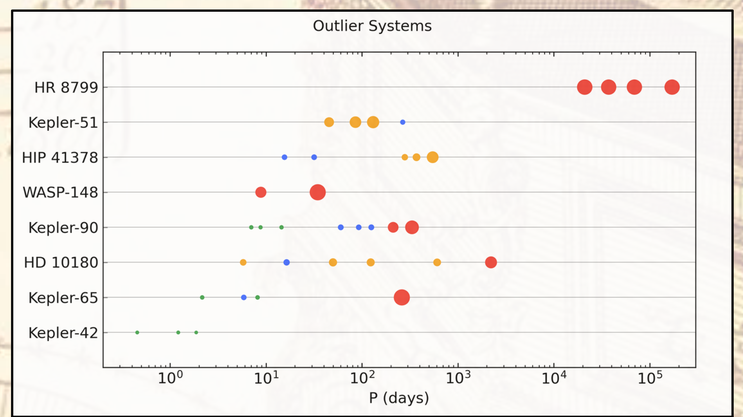
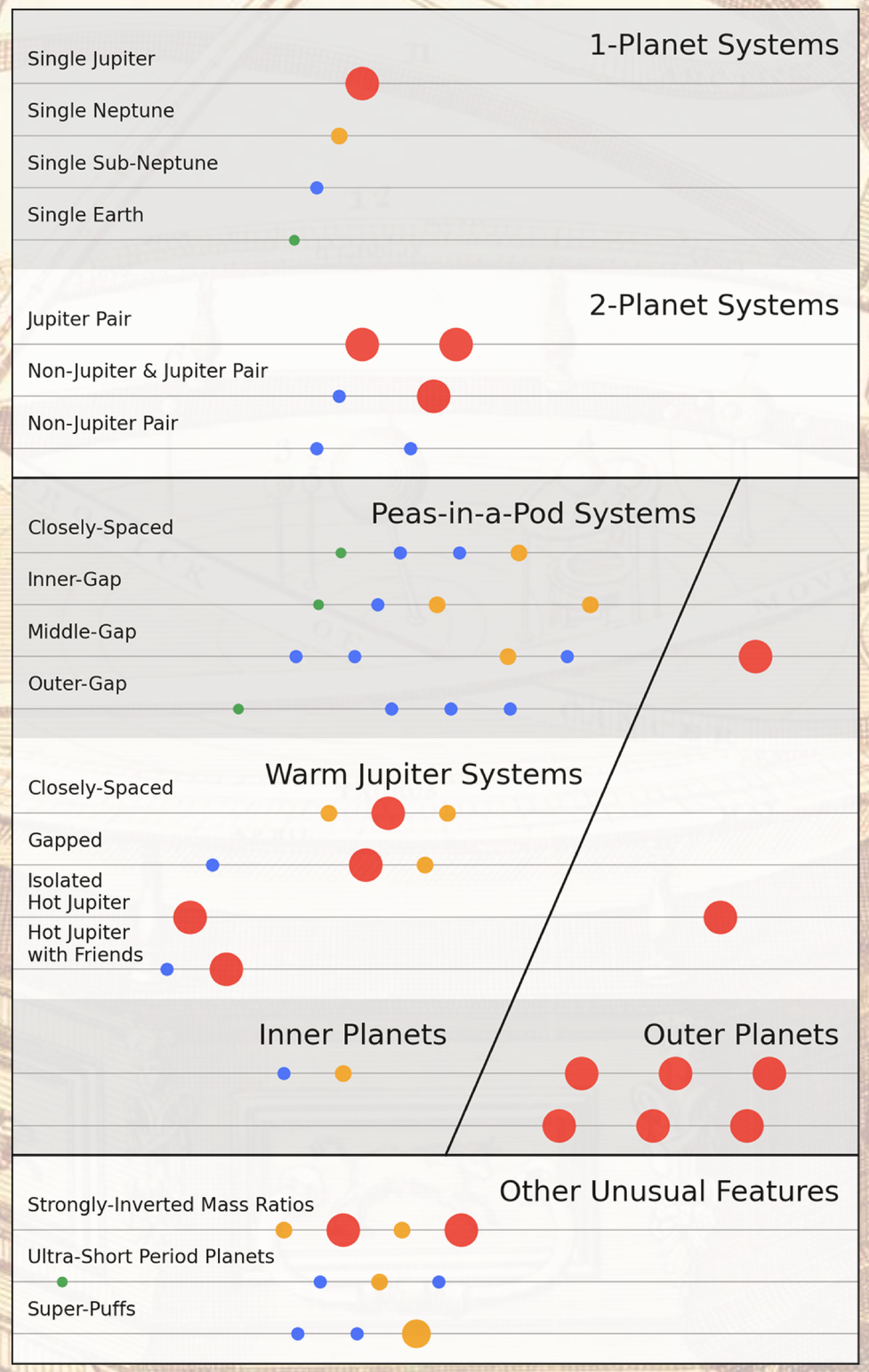
Overview

- Nearly 6000 exoplanets have been confirmed to date.
  - Including nearly 1000 multiplanet systems.
  - Including over 300 systems with 3 or more planets.
- The census has reached the point where it is both feasible and useful to classify planetary systems as distinct astrophysical objects.
- **We have defined a classification of planetary systems based on a complete survey of masses and orbital periods in the NASA Exoplanet Archive.**
- Addition research into host star properties as well as eccentricities and inclinations is underway.

Classification

1. Are there distinct inner and outer planets?
   a. Outer planets defined by:
      - Period >130 days.
      - Period ratio >5 from any interior planets (if applicable).
      - (Heuristics based on observations and dynamical theory.)
2. Are there any jovian planets among the inner planets?
   a. If yes, it is a "warm jupiter" (WJ) system.
      - May also classify traditional "hot jupiters" (HJs) separately.
   b. If no, it is a "peas-in-a-pod" (PP) system.
3. Is there a gap with a period ratio >5 among the inner planets?
   a. If yes, it is a "gapped" system (GPP or GWJ).
   b. If no, it is a "closely-spaced" system (CPP or CWJ).
4. Other distinctive features are classified separately.
   a. Ultra-short period planets (USPs).
   b. "Inverted mass ratios" (IMRs) with small planets exterior to large ones.
      - We have 2 in our Solar system, but it's rare among observed exoplanets.
   c. Super-puffs (SPs) with anomalously low densities.
   d. Outlier systems.





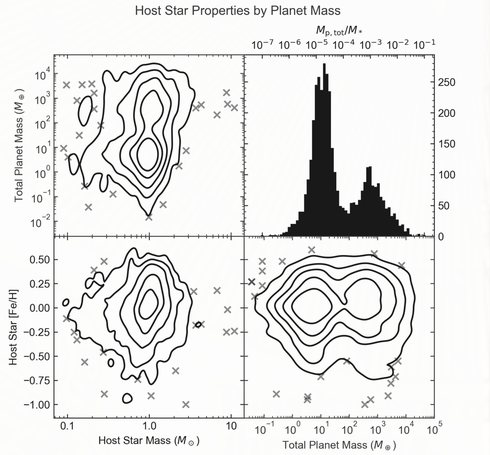
Host Star Properties

Masses and metallicities of host stars compared with the total detected planet mass in each system.

Confirms previously detected trends that larger and more metal-rich stars have larger planets on average.

No detectable correlations with most specific architectures. (Need more data!)

Tentative correlations for super-puffs and hot jupiters.

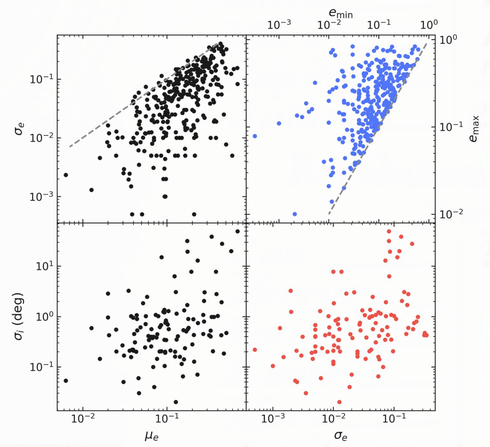


Future Work

Searching for correlations with eccentricities and inclinations of planets with classes defined by masses and periods.

Early results suggest some structure is present in the parameter space.

One new outlier system identified:
Kepler-65.
(Peas-in-a-pod plus eccentric warm Jupiter.)



Systems with measured non-zero eccentricities and inclinations.

Papers

Architectures I (the classification system):
Howe, Becker, Stark, & Adams, *AJ* **169**, 149

Architectures II (host star properties):
Howe, Becker, & Adams, submitted to *PASP*

Architectures III (eccentricities and inclinations):
Howe, Becker & Adams, in prep.

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