

Hot Jupiters & Stellar Clustering

The Role of Host Star Demographics

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TL;DR: The observed correlation between hot Jupiter occurrence and phase space density reflects differences in host star demographics. Future population studies of exoplanets should carefully control for biases in stellar properties to avoid confounding effects.

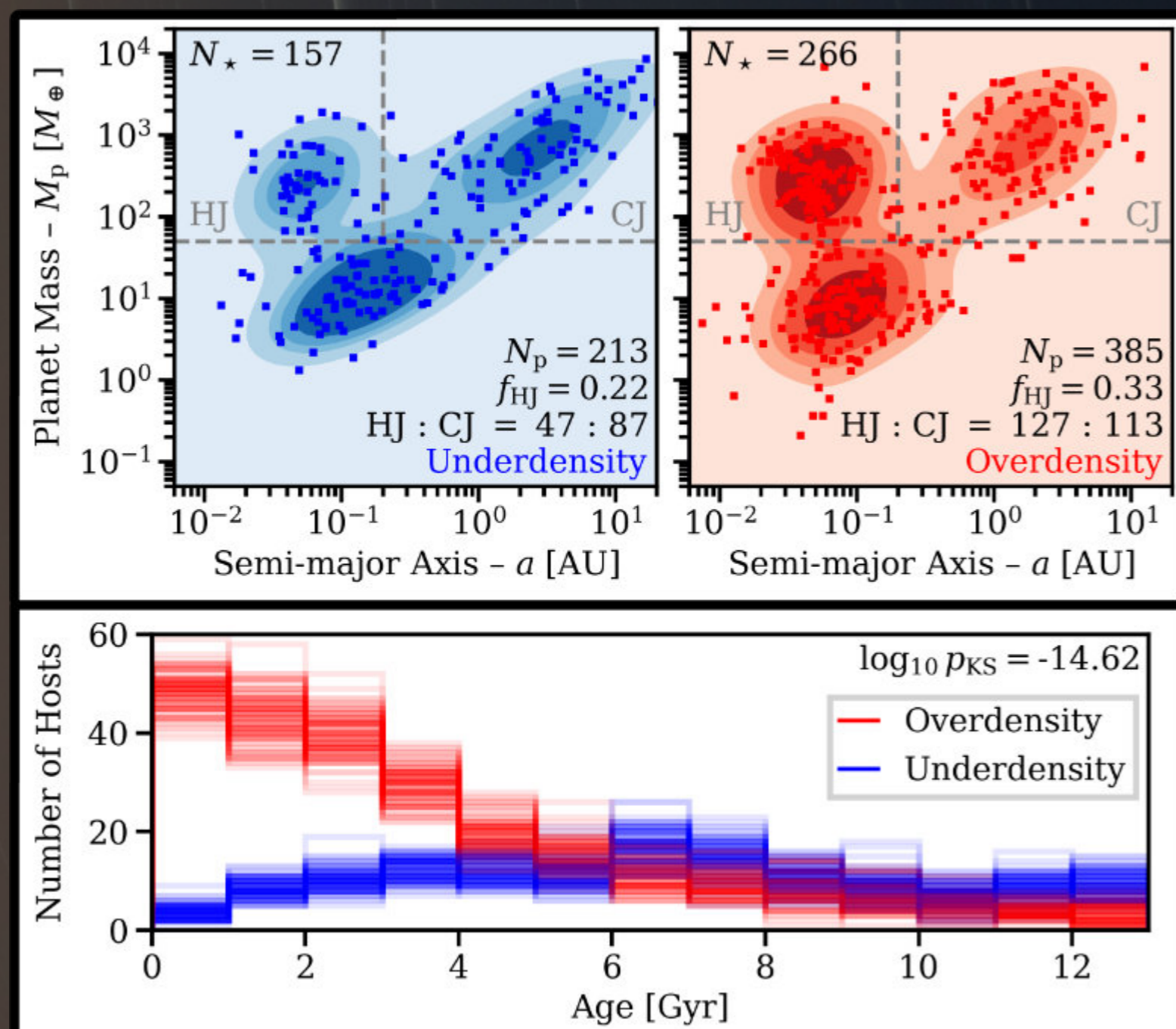
BACKGROUND

- Recent work by Winter et al. (2020; W20) identified a correlation between hot Jupiter occurrence and stellar clustering, as quantified by the **Mahalanobis phase space density**.
- This could imply enhanced formation in clustered environments.
- Mustill et al. (2022) pointed out that the phase space density is largely dictated by **kinematics**, with host stars in overdensities being kinematically colder.
- Whether the correlation is driven by an **environmental effect** or simply reflects an **age bias** is not fully established.

METHODS

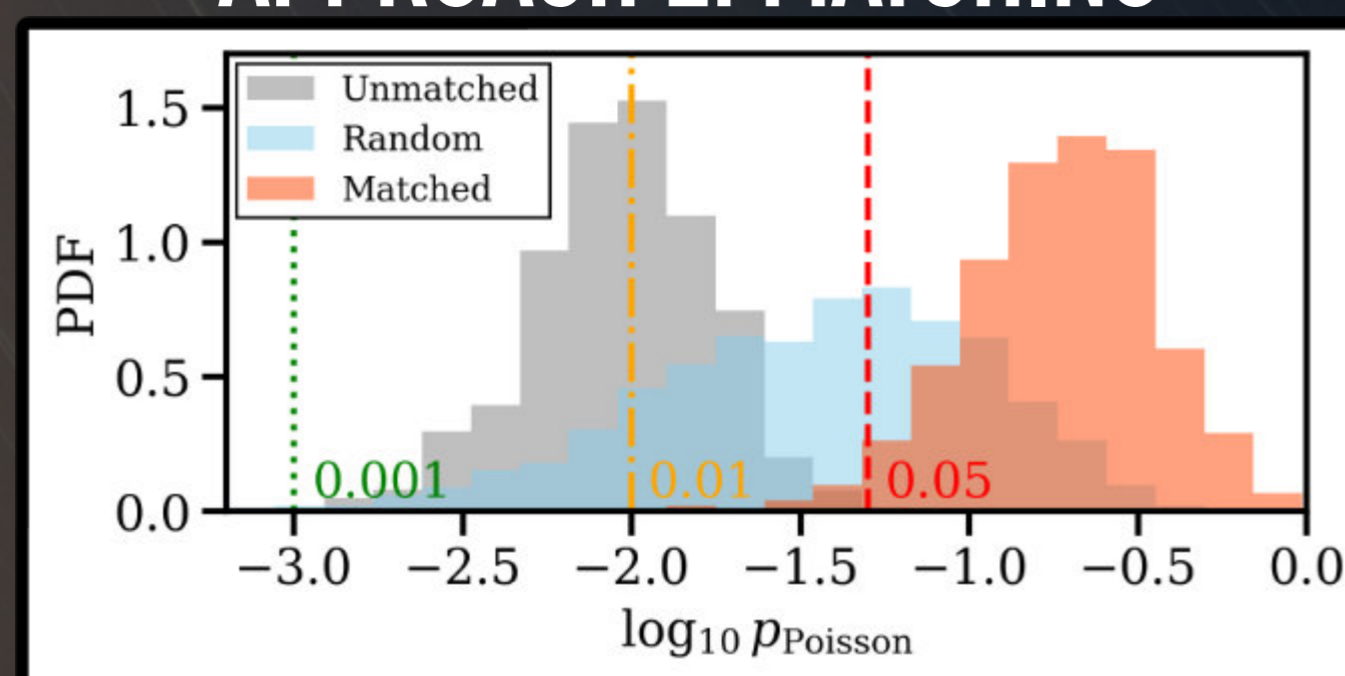
- We obtain **2265 FGK host stars** with full 6D *Gaia* astrometry from the NASA Exoplanet Archive and follow W20 in decomposing the sample based on each star's phase space density relative to the median in a 40 pc neighbourhood.
- We cross-match our sample with the SWEET-Cat (Santos et al. 2013) and Zhang et al. (2023) catalogues of **homogeneously derived stellar parameters** ($[Fe/H]$, T_{eff} , $\log g$) which we use for estimating isochronal ages with **isoclassify** (Huber et al. 2017).
- We then compare hot Jupiter occurrence between overdense and underdense environments while **controlling for host properties**.

HOST PROPERTIES



- In agreement with W20, we find hot Jupiters to be **more prevalent** around stars residing in phase-space overdensities.
- However, we also find these stars to be **systematically younger** (cf. Adibekyan et al. 2021) as well as more massive and metal-rich.

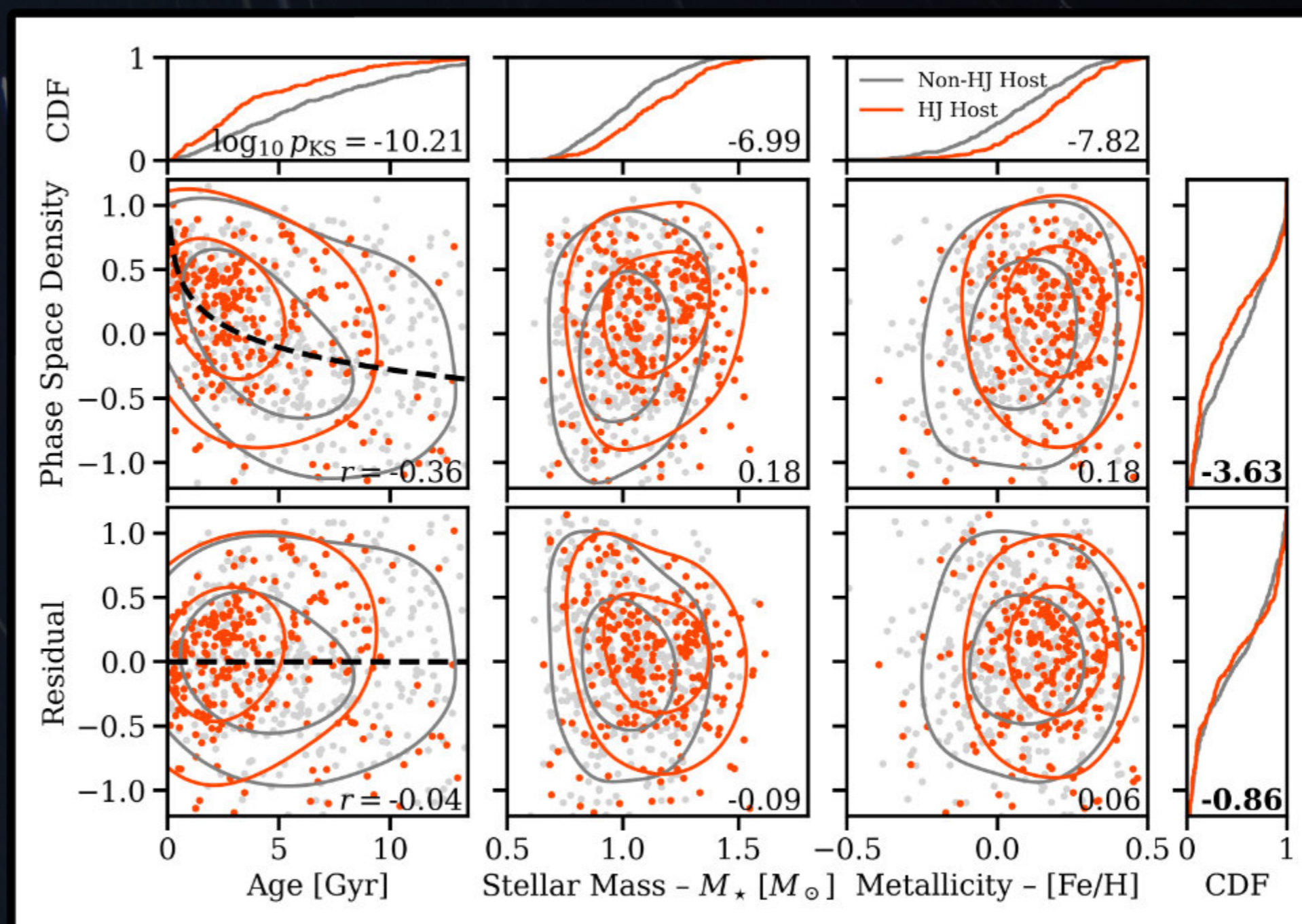
APPROACH 2: MATCHING



- To control for differences in host star properties, we match hosts in the overdensity and underdensity subsamples **like-for-like** based on their age, mass, and metallicity.
- After matching, the difference in hot Jupiter occurrence between the two subsamples is **no longer statistically significant**, as quantified by the Poisson means test.

RESULTS

APPROACH 1: DETRENDING



- As suggested by Mustill et al. (2022), the Mahalanobis phase space density is **anti-correlated with stellar age** (Pearson $r \sim -0.36$).
- After detrending this relationship (black dashed line), the phase space densities of **hot Jupiter hosts** are **indistinguishable** from other planet-hosting stars (Kolmogorov-Smirnov $p \sim 0.14$).

DISCUSSION

- Our results suggest that the trends in planetary system properties seen in different phase space environments likely reflect underlying **stellar demographic differences** rather than distinct formation or evolution mechanisms.
- This highlights the need for **multivariate control** of host parameters in comparative studies of exoplanet demographics.
- Our work pertains only to the use of the Mahalanobis phase space density as a proxy for stellar clustering and does not rule out other **potential environmental correlations**.