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Background

We develop a 6-parameter ($\ln A_{\rm p}$, $\ln \sigma_{\rm p}$, $\ln \mu_{\rm p}$, α, $\ln A_{\rm bd}$, β) parametric model that predicts the frequency and distribution of very low-mass companions, including a gas giants component and a brown dwarf component, as a function of orbital separation and stellar mass.

Fitting Framework

- Bayesian inference using the MultiNest [Feroz+, 2008, 2009, 2019] nested sampling algorithm.
- Model constrained by 51 literature point frequency measurements (RV, microlensing, imaging) (see Fig. B).
- We adopt the best-fit parameter based on the Maximum Likelihood Estimation (MLE) and use the evidence for model selection (Fig. A).

Results

- The Planet Companion Mass Ratio Distribution (CMRD) follows a raising power-law function: $dN/dq \propto q^{-1.29\pm0.08}$, while the brown dwarf CMRD has a positive power-law index: $dN/dq \propto q^{0.29\pm0.09}$.
- The peak orbital separation for planet companions is $\ln \mu = 1.30$ or $\sim$3.7 AU. For the brown dwarf component, we fix the separation distribution peaks based on stellar type: $\sim$27 AU for M dwarfs [Winters+ 2019], $\sim$50 AU for FGK stars [Raghavan+ 2010], and $\sim$522 AU for A stars [De Rosa+ 2014], scaled by a factor of 1.35 from [Duquennoy & Mayor 1991].
- The normalization amplitudes are: $\ln A_{\rm p} = -4.77$ for planets and $\ln A_{\rm bd} = -1.41$ for brown dwarfs.

Applications

- Predicted companion yields for ongoing direct imaging surveys, including: JWST M dwarf survey [Bogat+ 2025], SPHERE/H2 [Sartori+ 2025], JWST Sub-Jupiter Surveys [Carter+ 2023; Biller+ 2023], and METIS/ELT programs [Hinkley+ 2025].

Demographics of Low–Mass Companions From M Dwarfs to A Stars

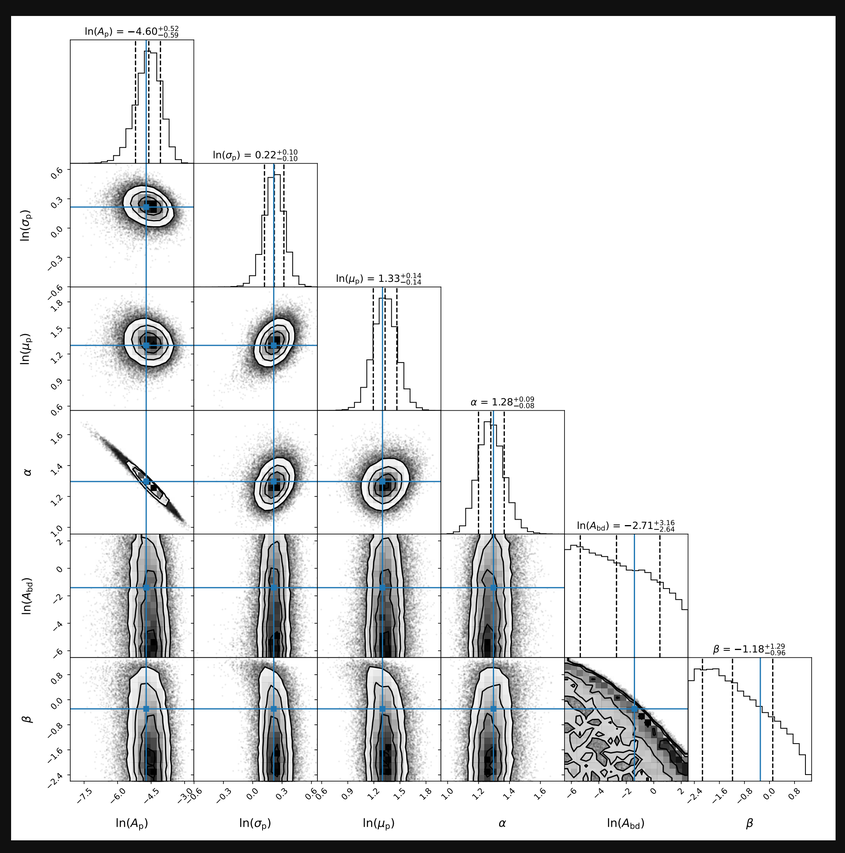

Fig. A: Posterior distributions.

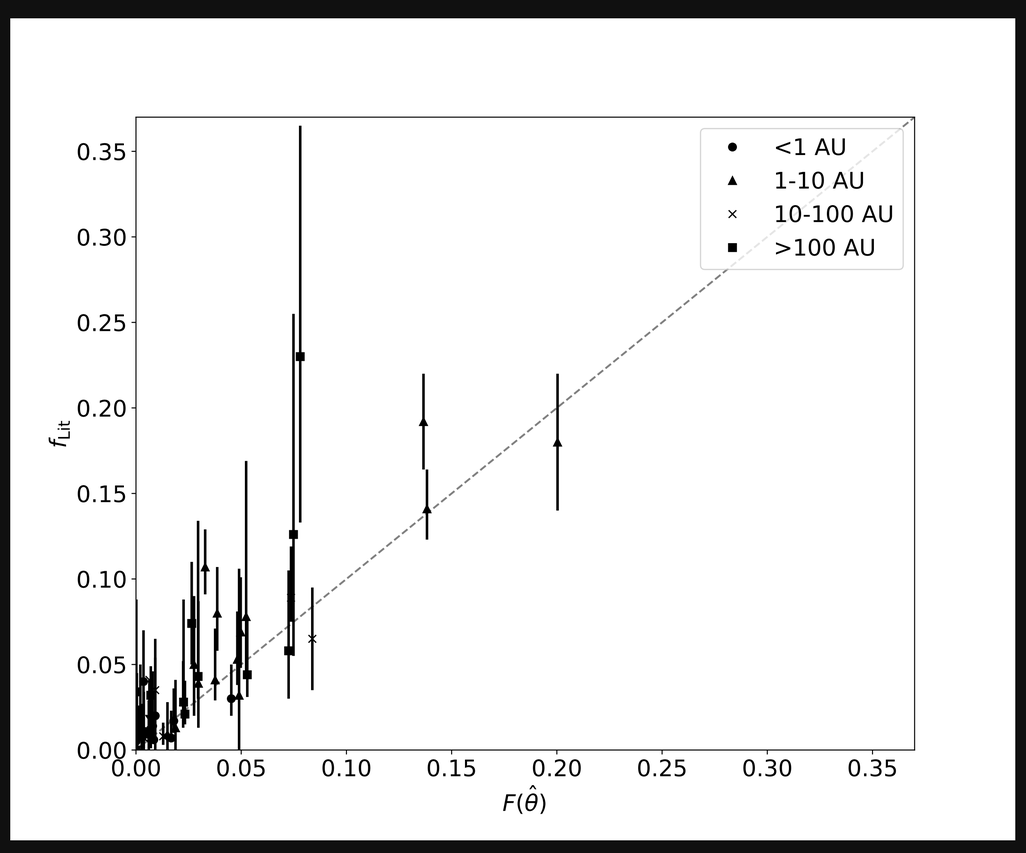

Fig. B: Model vs. observed frequencies.

Findings and Takeaways

- Gas giant planets and brown dwarfs follow different mass ratio distributions.
- Brown dwarfs likely represent the low-mass tail of the binary stellar companion population.
- Orbital separation differ significantly between M dwarfs ($\sim$1.65 AU) and A stars ($\sim$4.82 AU) with minimal overlap (1.26%) in distributions.
- Our model predicts exoplanet and brown dwarf occurrence rates across stellar types, supporting population studies and survey planning.

Meyer & Li, Calissendorf, Amara (2025)
Gas Giant and Brown Dwarf Companions: Two Populations in Mass Ratio and Orbital Distribution
Submitted to A&A.

Contact Me