Dynamically Constraining PDS 70 Planet Masses

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(Affiliations can be found at the bottom of the poster)

What is PDS 70?

PDS 70 is the only protoplanetary system with **multiple confirmed planet detections**. This makes it ideal for studying the processes of planetary formation.

How do we observe the planets?

PDS 70 b and c were some of the first planets to be observed through **direct imaging**[1,2]. We use the high angular resolution of the **VLT/GRAVITY** interferometer to produce precise relative astrometry.

How precise is GRAVITY?

The dual field mode of GRAVITY can achieve precision as low as **50μas**[3].

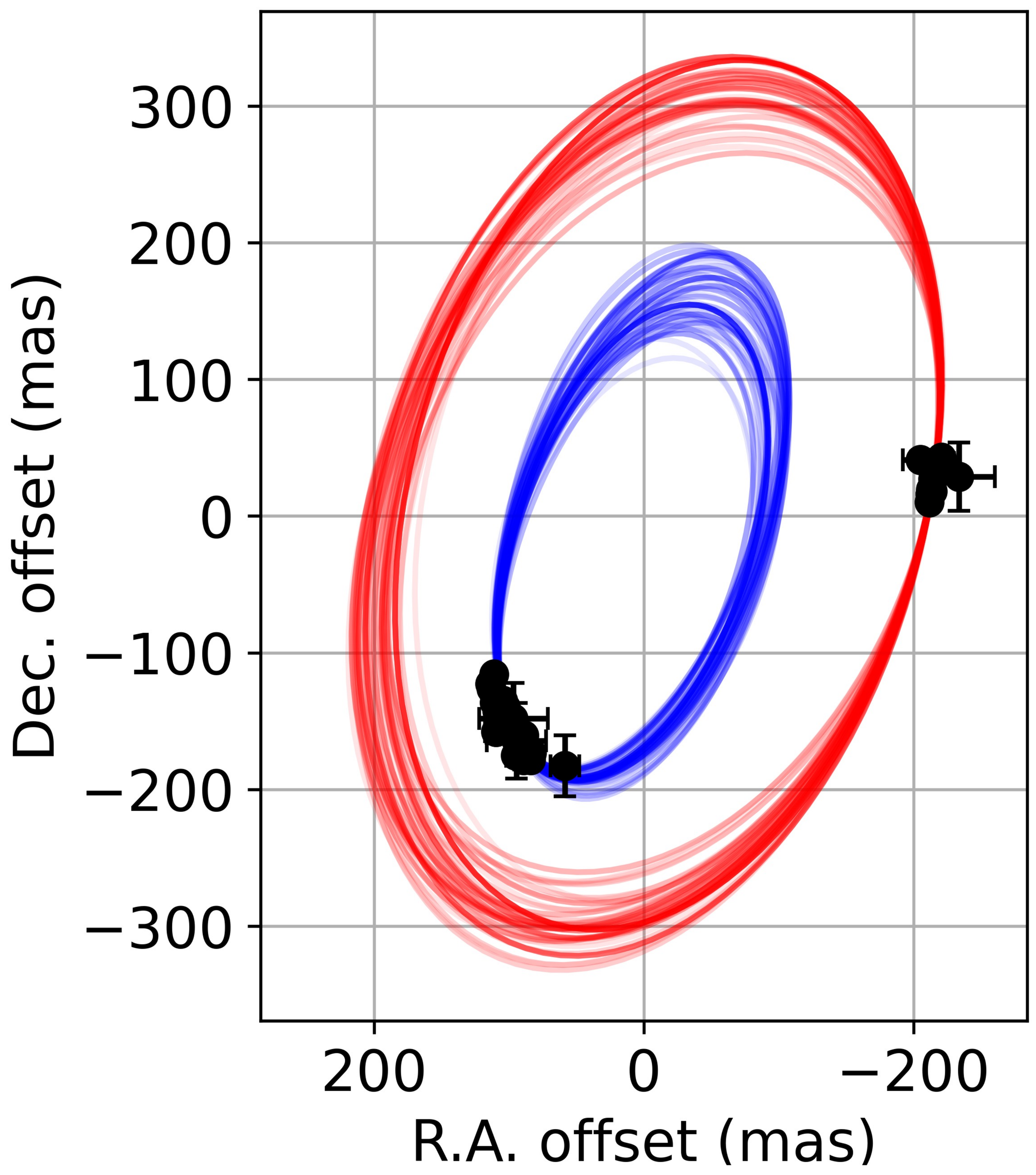

Figure 1: Sample orbits fit to astrometry data (black) for PDS 70 b (blue) and PDS 70 c (red). Astrometry is given relative to the star.

Orbital Parameters with MCMC

We use the Python MCMC sampling code `orbitize!`[4] to fit orbits to the astrometry. `orbitize!` uses the parallel-tempered affine-invariant sampler `ptemcee`[5].

Coplanarity vs Stability

In our MCMC models we assume either a coplanarity or stability prior to reduce the size of the parameter space:

- **Coplanarity** assumes that the inclination of the planet orbits are within 10 degrees of the disk
- **Stability** assumes the planet orbits do not cross

How do we fit planet masses?

Since the PDS 70 system has two planets we can use the **size of the planet-star interactions** to fit the planet masses[6]. However, the fraction of the orbit for which we have observed these planets is small, which makes obtaining precise mass estimates difficult.

N-Body Stability Analysis

For the models where a stability prior is added, we also perform n-body analysis to reduce the mass posterior:

1. Parameter sets from MCMC provide initial conditions
2. N-body code `REBOUND`[7] integrates backwards by the age of the PDS 70 system (8 Myr)
3. Parameter sets are rejected if the planets
   a) Crash OR
   b) Are ejected from the system

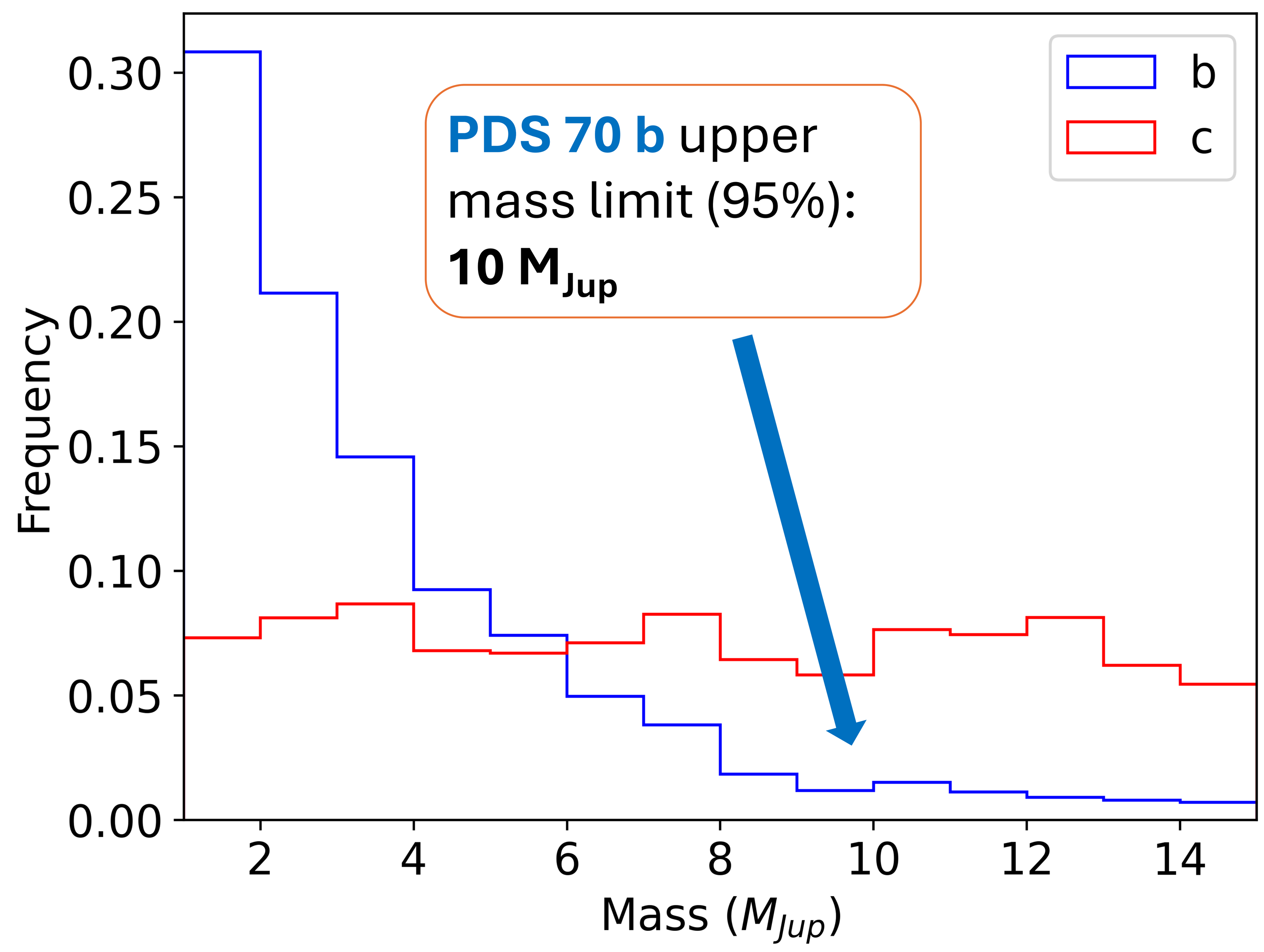

Figure 2: Posterior probability distribution for planet masses, assuming a stability prior and after n-body stability analysis.

References

1. Keppler et al, 2018
2. Haffert et al, 2019
3. GRAVITY Collaboration, 2020
4. Blunt et al, 2019
5. Vousden et al, 2016
6. Wang et al, 2021
7. Rein et al, 2012

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