A Single Large Boost in Planet Formation in the Milky Way's Past Reproduces Planet Occurrence Trend with Galactic Height

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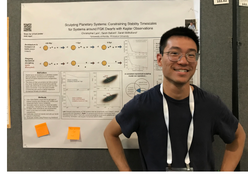

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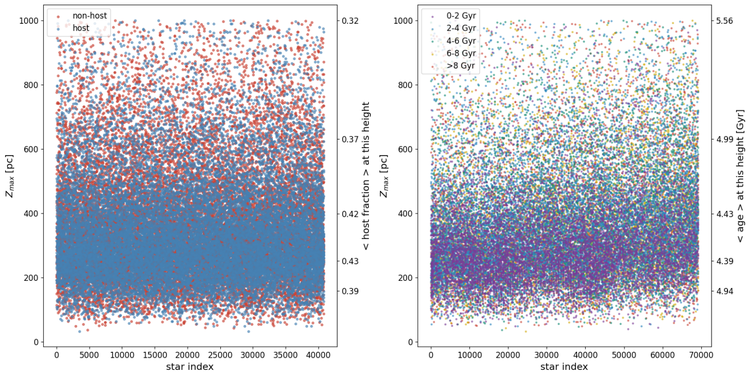
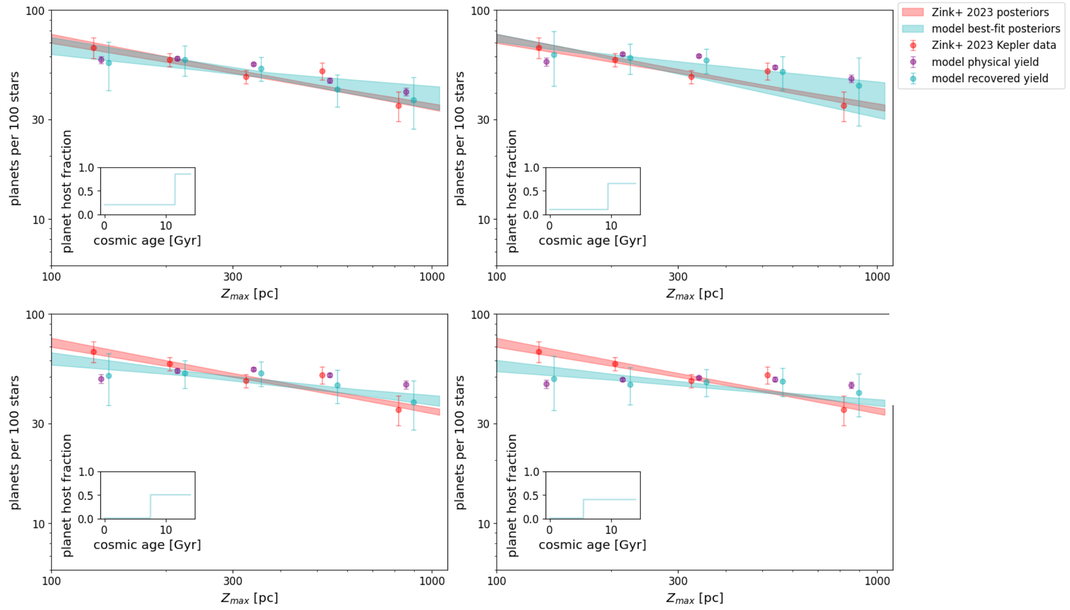
Motivation

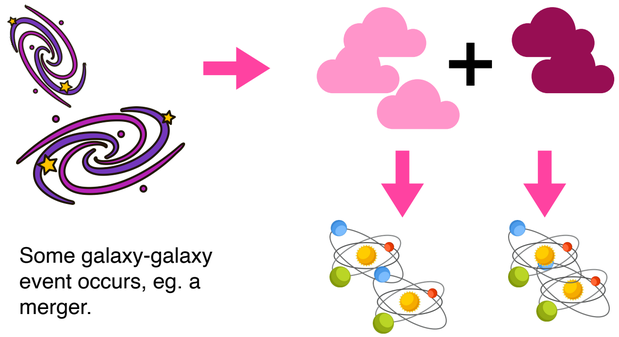
- Planetary system formation and evolution have until recently been studied as a closed process, independent of the system's galactic context.
- Internal dynamical sculpting and the ISM metallicity gradient are insufficient to fully explain the observed *Kepler* trend between planet occurrence and galactic scale height (Lam+ 2024; Zink+ 2023).
- We probe whether some event in the Milky Way's past could have increased planet formation by forward modeling step increases in the planet host fraction at different time thresholds.



Distribution of planet hosting stars (**left**) and stellar ages (**right**) for one fiducial model, for the Berger *Gaia-Kepler* cross-matched sample. As Z_{max} increases, average planet host fraction decreases and average age increases.



Planet occurrence versus Z_{max} for six different step function planet occurrence models, shown in insets. We consider only planets with period < 40 days and radius < 4 R⊕. All models are constrained to produce a present-day planet host fraction of 0.3 in order to maintain the correct normalization. **We find that some increase in planet host fraction must occur in order to match Zink+ 2023, and that this step increase must occur after the Milky Way was 7.5 Gyr old.**



Some galaxy-galaxy event occurs, eg. a merger.

Metal-poor gas is injected into the Milky Way.

More favorable planet formation conditions results in a larger planet-host to non-planet-host ratio, which naturally increases the overall planet occurrence rate.

Methods: `psps`

`psps (planetary system population synthesis)` is a package for forward modeling exoplanet demographics. For our purposes, the broad steps we followed were:

1. Starting with the Berger+ 2020a *Gaia-Kepler* cross-match, assign each system a probability of hosting a planetary system, based on the models depict

Results

1. Planet host fraction must increase at some point in the Milky Way's past in order to match the planet occurrence vs Z_{max} trend from Zink+ 2023. This could be a step or more gradual increase.
2. Step increase times prior to the Milky Way being 7.5 Gyr old cannot produce a match to Zink+ 2023. We cannot rule out any initializing timescales for the more gradual increase models.
3. The step increase times match some putative dynamical events in the Milky Way's past: the Virgo Radial Merger blah blah

Citations

Donlon 2019 ApJ 886 76.
Lam 2024 AJ 167 254.
Ruiz-Lara 2020 Nature 4 965.
Zink 2023 AJ 165 262.

Acknowledgments

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