Sculpting Planetary Systems: Constraining Stability Timescales for Systems around FGK Dwarfs with Kepler Observations

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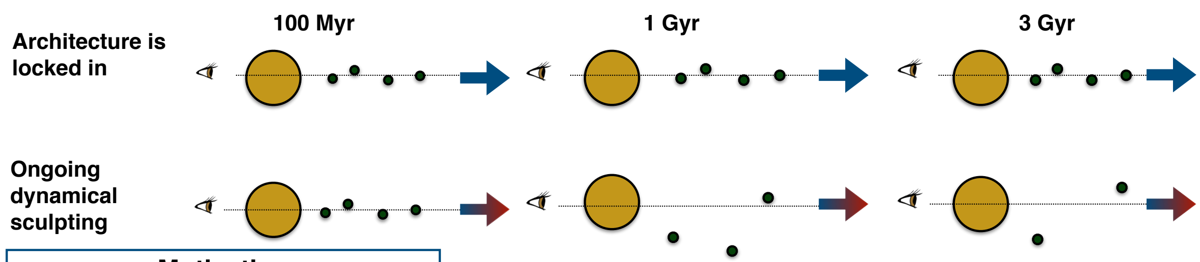
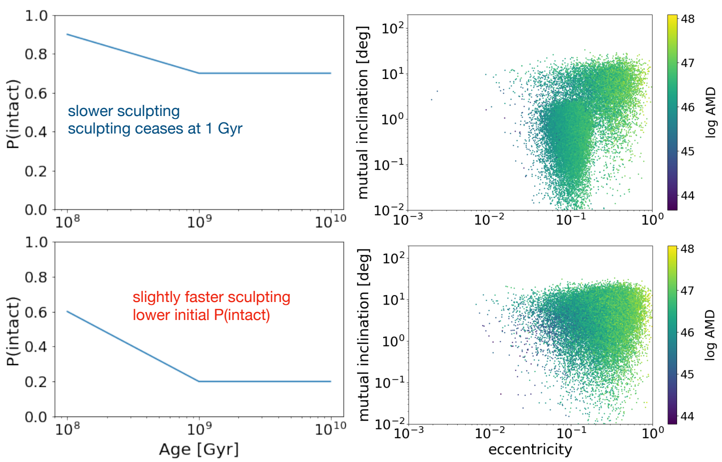


Motivation

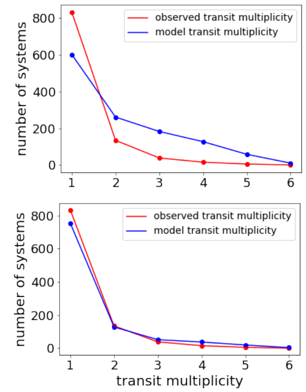
- *Kepler* gave us constraints on planetary system demographics, including transit multiplicity.
- Where do these observed transit multiplicities come from?
- The story of their provenance can tell us about the Solar System's dynamical history and the ease with which life on worlds around Sun-like stars can evolve. It can also give us better constraints with which to design expensive dynamical N-body simulations.

Methods

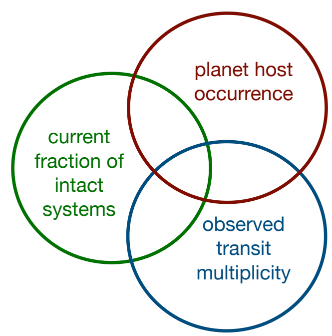
1. Use *Gaia-Kepler* crossmatch to get ages of planet-hosting stars (Berger et al. 2020b) and observed *Kepler* transit multiplicity
2. Simulate systems based on observed stellar properties, changing only the model, P(intact)
3. If intact, draw inclinations and eccentricities from a narrower and smaller distribution, respectively
4. Calculate observed transits (Fressin et al. 2013) and tally up model transit multiplicities
5. Evaluate models using Poisson log likelihood



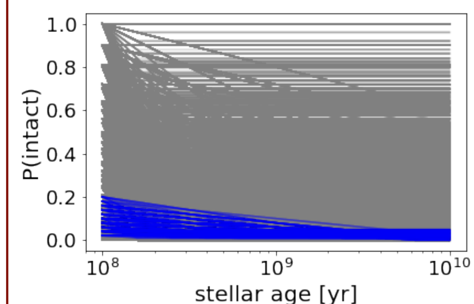
Dynamical sculpting can increase systems' eccentricities, inclinations, and angular momentum deficits (AMD; Millholland et al. 2021, He et al. 2020). Eccentricities are drawn from a combination of Van Eylen et al. (2018) and Limbach & Turner (2014); inclinations are drawn from Gaussians with spread of 2° if "intact" and 8° if "disrupted". Through sculpting, two populations of initially "intact" and "disrupted" systems can end up higher in AMD space.



Things to match to be a good model



Results and Discussion



Sculpting laws colored by whether they are strongly favored by the observed transit multiplicity and present-day fraction of intact systems (blue), favored only by the current intact fraction (green), or disfavored altogether (gray). P(intact) refers to the fraction of FGK systems that are dynamically cool.

- Models with fractions of planet-hosting stars between 10% and 40% are strongly favored.
- Models with initial fractions of dynamically cool systems over 20% are disfavored.

Example models:

- Favored: early period of rearrangement; frozen-in architecture before 1 Gyr
- Disfavored: all systems start intact and undergo sculpting over 10 Gyrs
- Disfavored: half of systems start intact; no sculpting occurs

Limitations on sample size and age errors for younger stars in the sample mean that we can more confidently comment on Gyr+ timescales than on timescales shorter than 1 Gyr.

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