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

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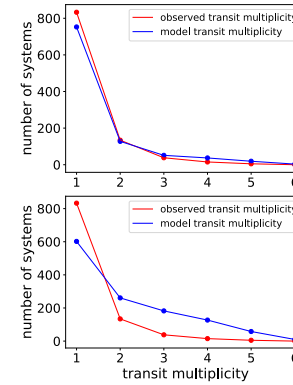
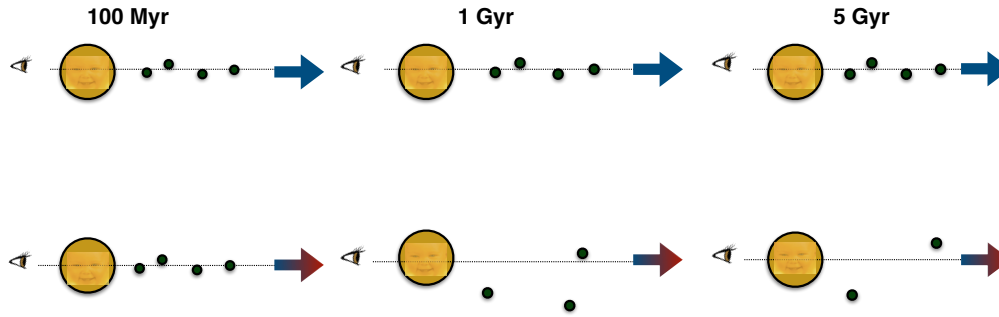
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Scan for virtual poster and repo!

Architecture is locked in at birth (stays intact)

Ongoing dynamical sculpting (gets disrupted)

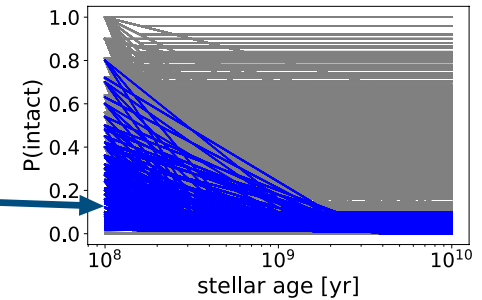


## Results and Discussion

- 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.
- 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.

### Example models:

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



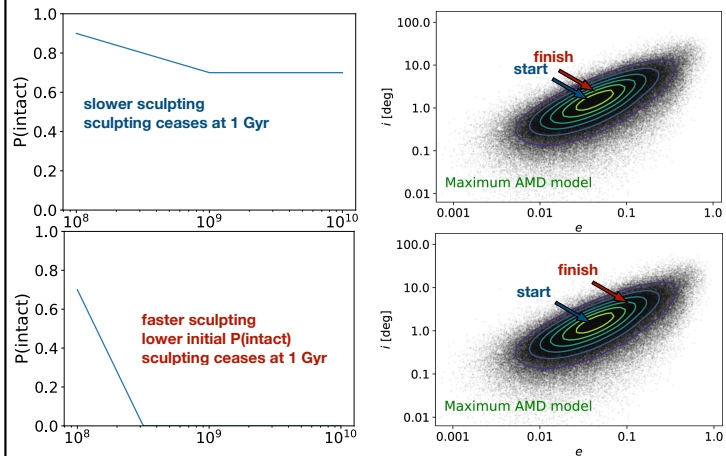
Sculpting laws colored by whether they are strongly favored by the observed transit multiplicity and present-day fraction of intact systems of ~8% (blue; Ballard 2019), or not (gray).

## 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.

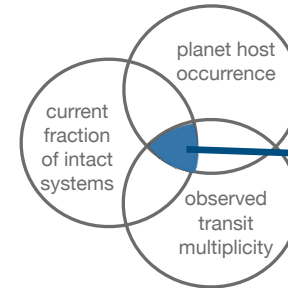
## Methods

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



**Left:**  $P(\text{intact})$  is the fraction of FGK systems that are dynamically cool ("intact"), versus dynamically hot ("disrupted"). **Right:** Eccentricity and inclination distribution from Millholland et al. (2021). Over time, dynamical sculpting would push systems up in eccentricity, inclination, and angular momentum deficit (AMD).

## A consistent dynamical sculpting model can reproduce...



## Acknowledgments

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## Citations

Ballard 2019 AJ 157 113.  
Berger et al 2020 AJ 160 108  
Millholland et al 2021 AJ 162 166