Constraints on Planetary Migration that Explain Structure in the Kuiper Belt

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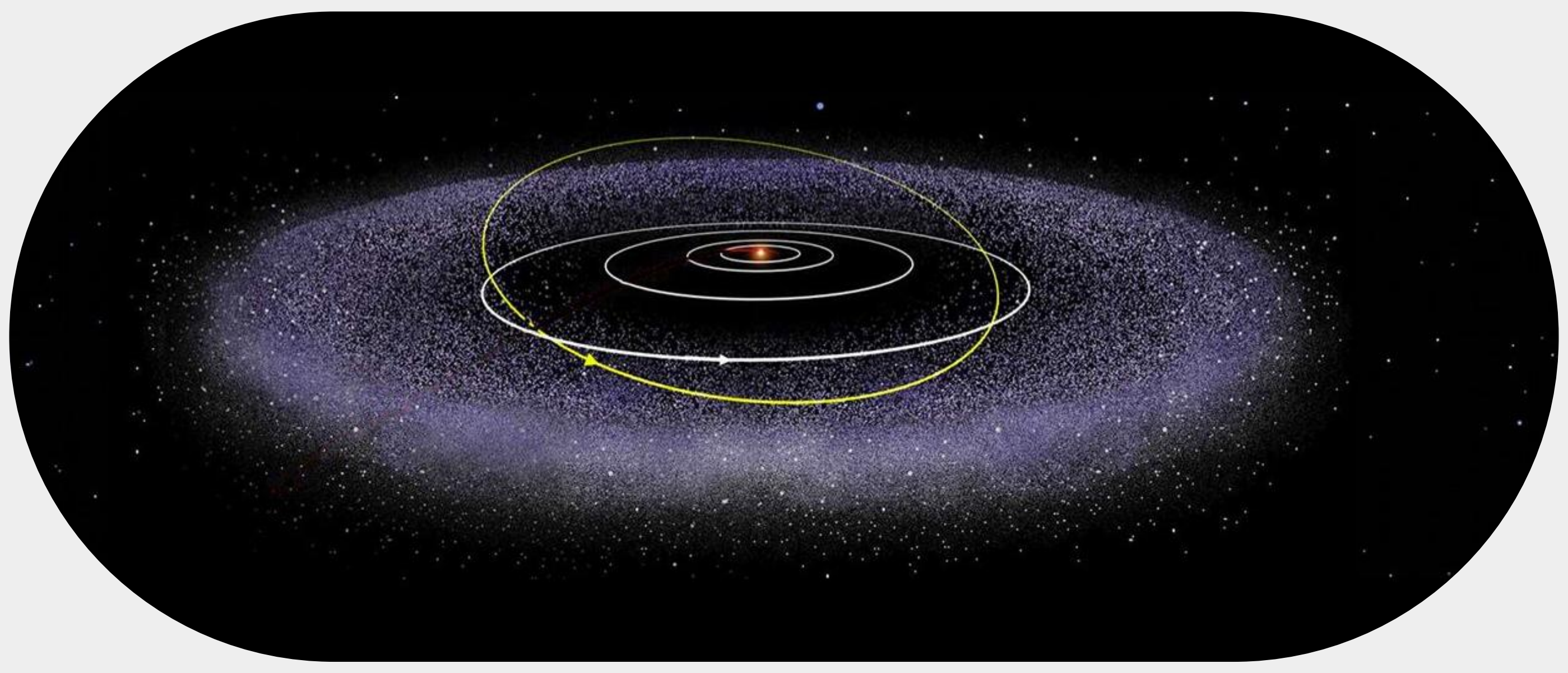
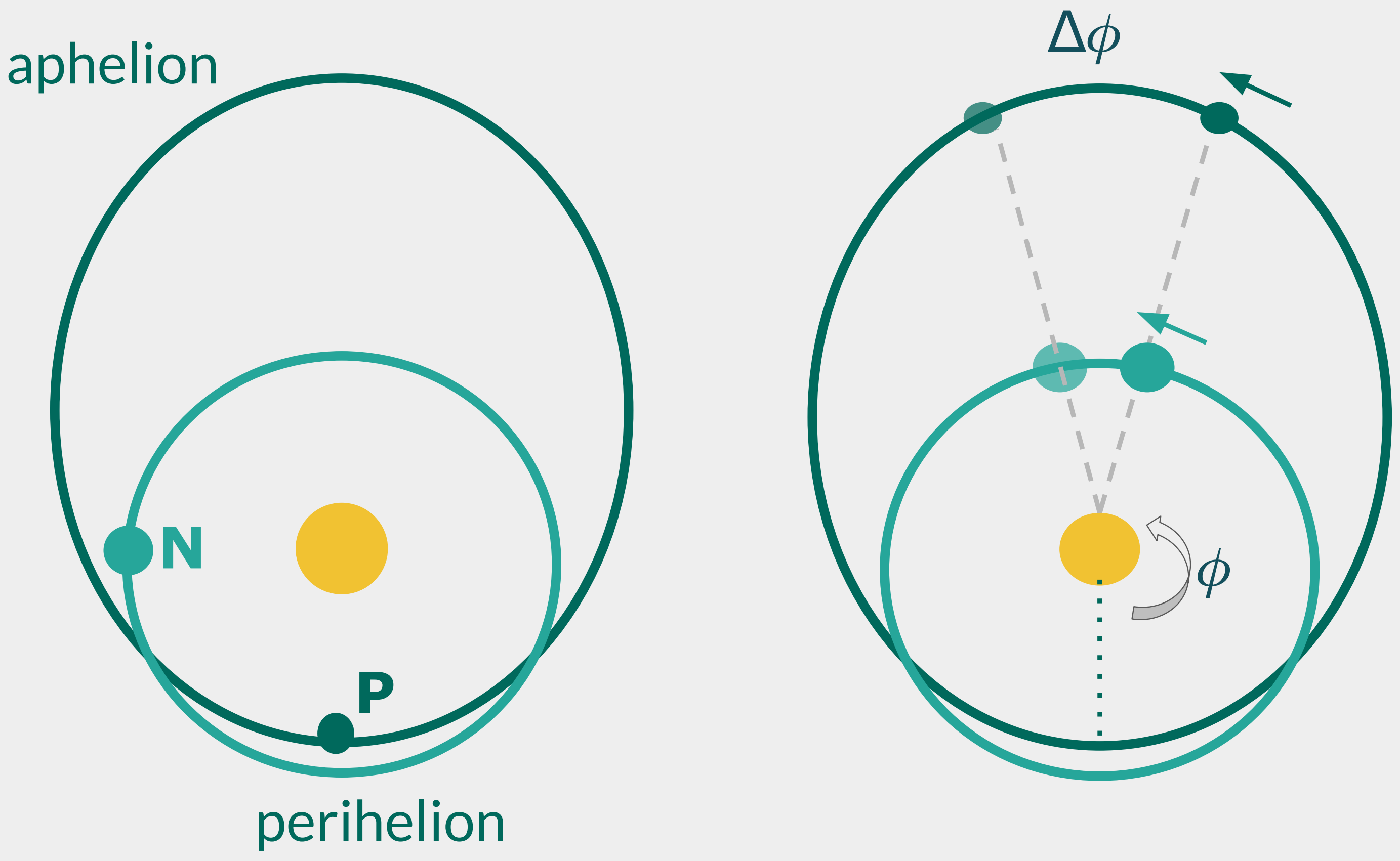
Introduction



The Kuiper Belt is the Solar System's (SS) debris disk, composed of icy objects left over after the SS formed. The existence of this debris disk, and the orbital structure in it informs our understanding of the evolution of the SS! In particular, the dynamical interactions between Neptune and KBOs significantly shapes the distribution of the Kuiper Belt. We can place constraints to get closer to answering "how did the planets get to where they are today?" and rule out certain migration scenarios. In this poster I present two projects that address two different methods of planetary instability/migration. This work is a preview of what we could accomplish once we get a well-characterized survey from Vera C. Rubin Observatory!!

Mean Motion Resonances (MMR), Resonant Angle & Libration Amplitude define objects in MMR

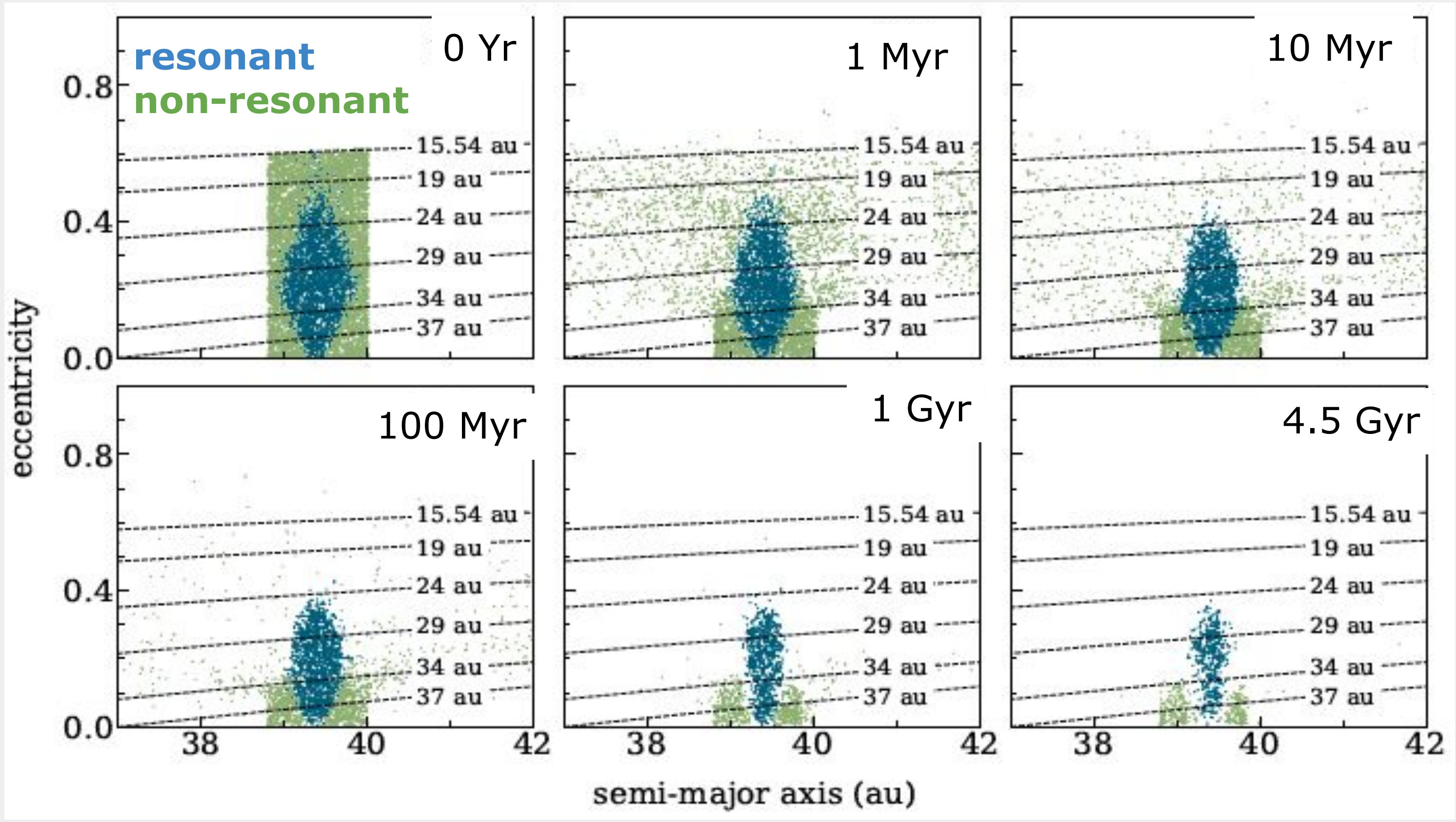


3:2 MMR

Can an upheaval (such as the Nice Model), followed by gravitational sculpting reproduce the orbital structure of the 3:2 MMR?

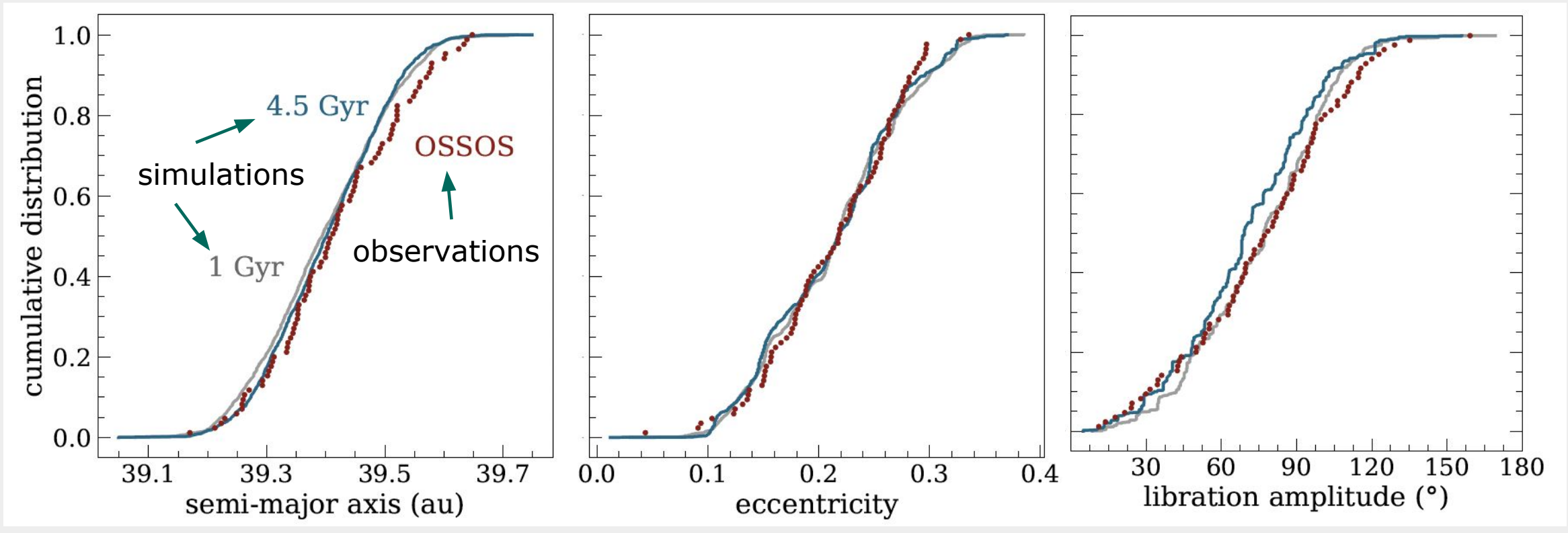
Our approach

- assume an upheaval already happened, and the giant planets have stabilized to their current orbital parameters
- fill phase space in semi major axis and eccentricity space around the 3:2 res, and then run REBOUND simulation for 4.5 Gyr



Balaji, incl Hermosillo Ruiz et. al. (in review)

Compare simulation results with observations by using the Kolmogorov-Smirnov (KS) Test



Results are **non-rejectable** if p >0.05

For 4.5 Gyr
a: p = 0.24
e: p = 0.43
$\Delta\phi$: p = 0.047

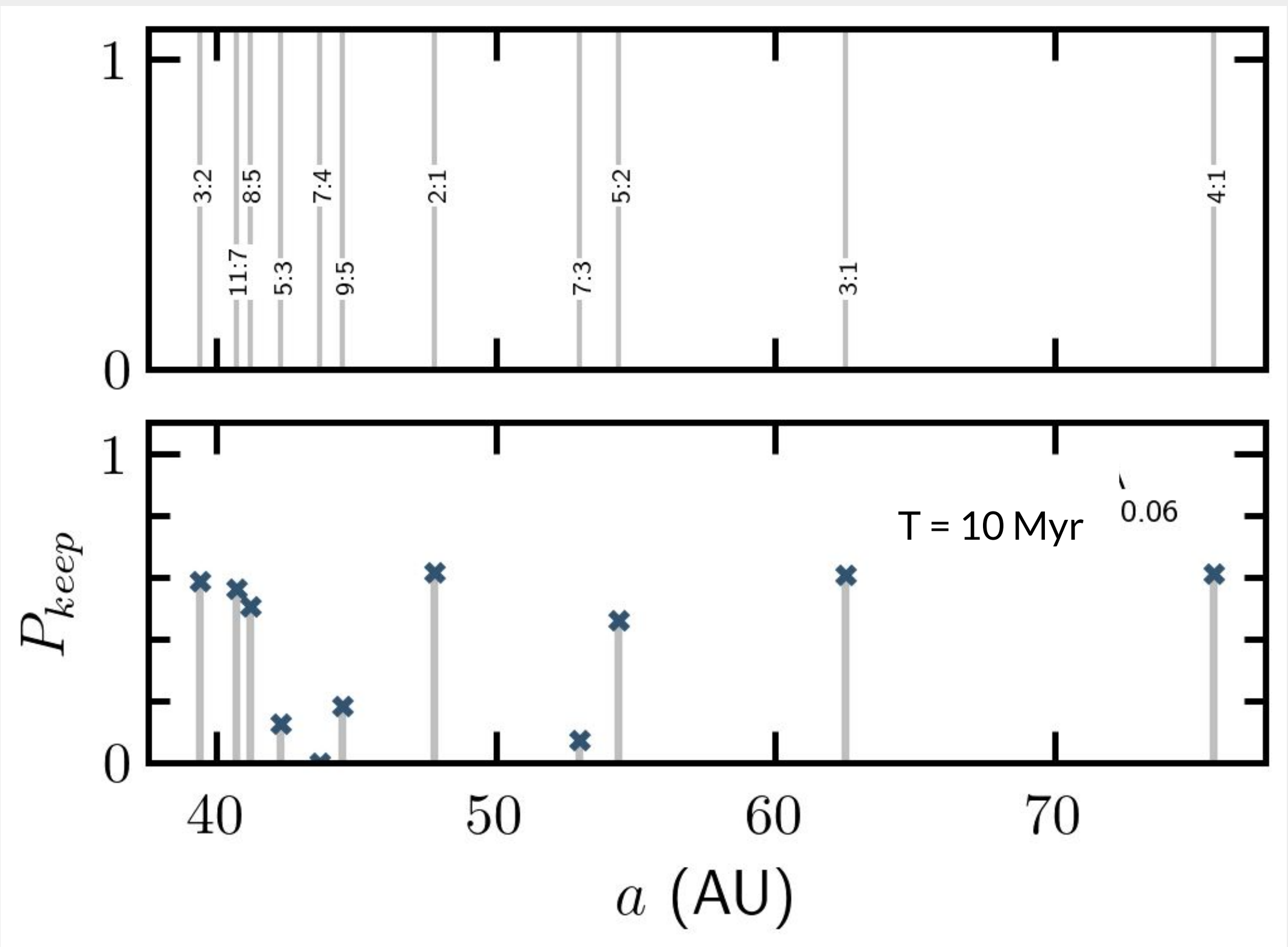
The KS test checks if you can reject that two samples are pulled from the same distribution. For 1 Gyr, the results are non-rejectable for all, but for 4.5 Gyr, the result is rejected for libration amplitude only. Stability sculpting does a good job at reproducing the structure of the 3:2 resonance!

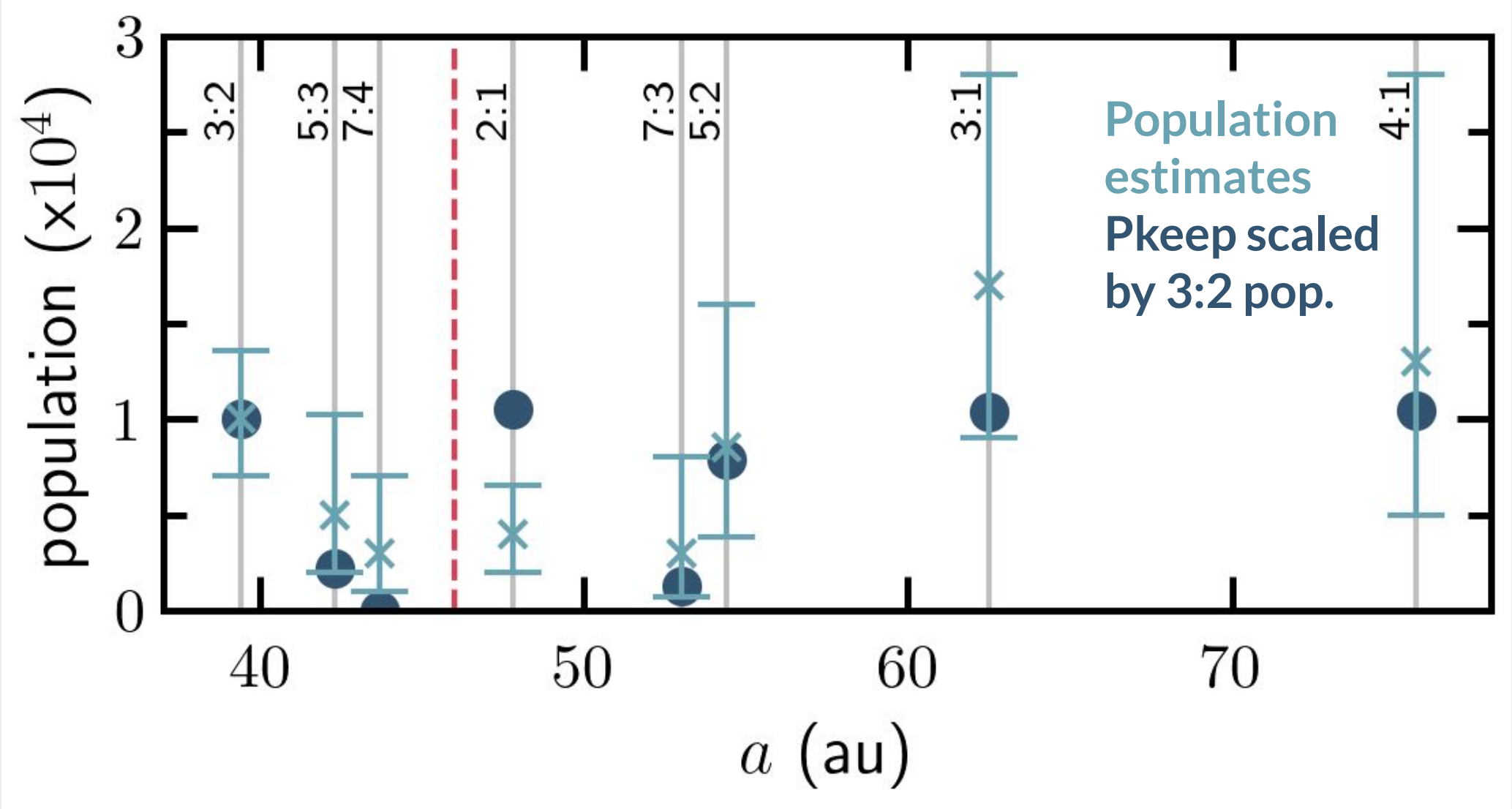
Stochastic Migration

How does the stochastic nature of planetesimal driven migration impact the retention fraction of objects in resonance over some migration timescale?

Planetesimal driven migration can be modeled as a **random walk** of the planet, where **large planetesimals produce the most stochasticity**. We use the analytical model in Murray-Clay & Chiang 2006 to find the **retention fractions** for several mean motion resonances.

We want to make constraints using the lowest retention fraction with an observed population since that will set the **size distribution of planetesimals** in the disk and a **maximum migration timescale** of Neptune (i.e. if Neptune migrates longer, then that weak resonance would lose all of its objects).





We apply these retention fractions to all resonances, assuming they all started with the same population as the 3:2. While that assumption is not right, we do see that our model still aligns with the estimated populations shown above.

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