Multi Planet Migration in Magnetospherically Sculpted Protoplanetary Disks

Tze Yeung Mathew Yu(1), Yasuhiro Hasegawa(2) & Brad Hansen(1)
1:UCLA 2:JetPropulsion Laboratory, California Institute of Technology

Background:

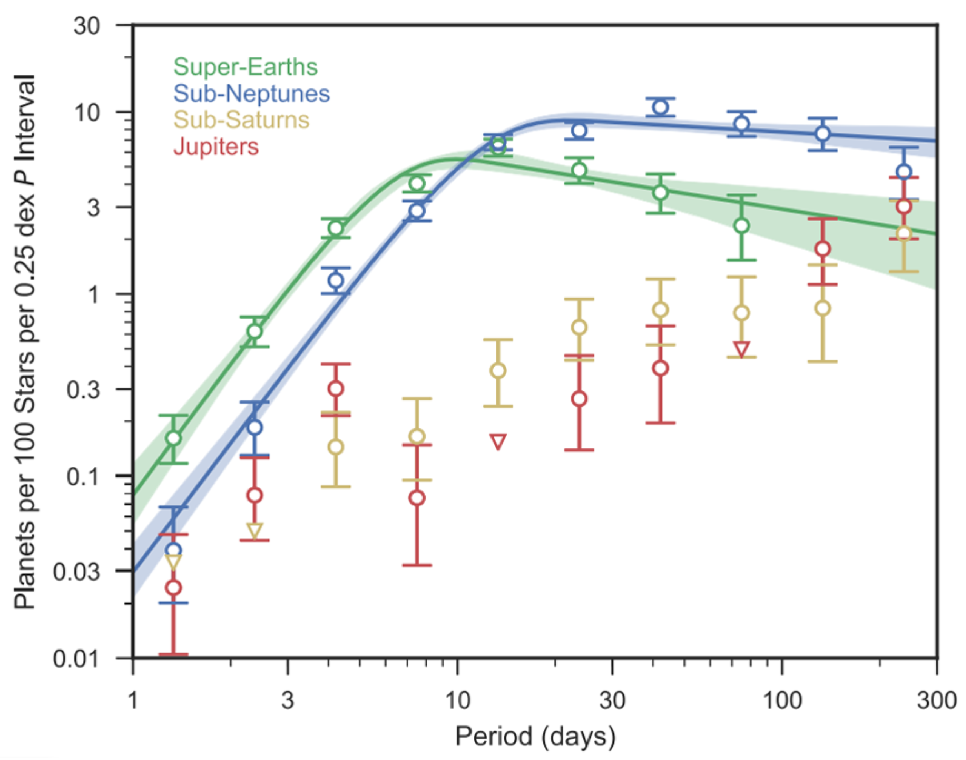

Figure 1:Super Earth Occurrence Drops off below 10 days (from CKS)

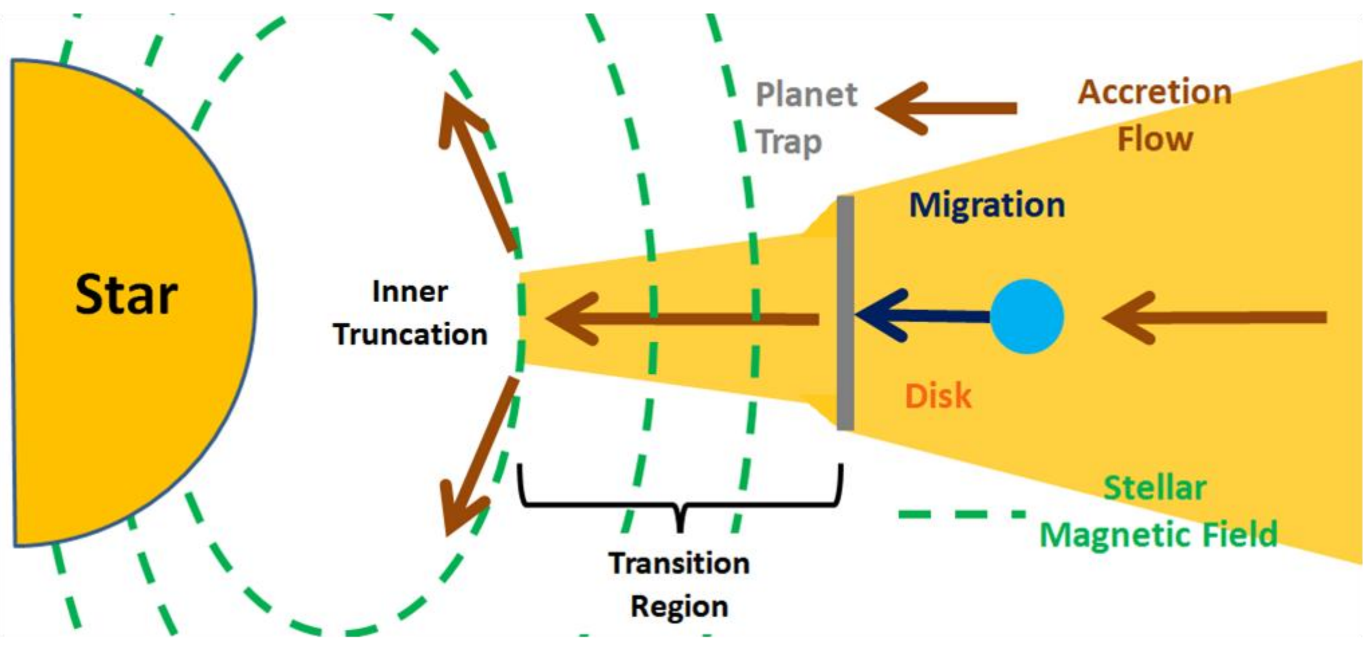

Figure 2:Our model seeks to use the stellar magnetic field's influence on the disk to set up a planet trap such that migrating planet would not reach the inner edge of the disk.

We present a physically motivated model for the manner in which a stellar magnetic field sculpts the inner edge of a protoplanetary disk, and examine the consequence for the migration and stopping of sub-Neptune and super-Earth planets. We seek to reproduce the drop off in both occurrence rates by enhancing existing models. The enhanced model avoid an all-or-nothing approach to stellar magnetic field's effect on the disk, which is not physical.

Model Detail:

•Magnetic Field threads through the inner disk forming an area called the transition region

•Magnetic Field enhances effective viscosity, which:

1)lowers the surface density

2)reverses migration torque

--> creating a planet trap exterior to truncation

•Include:

1)Disk evolution from decreasing accretion rate

2)Passive heating (host star)

3)Accretion heating

4)Disk magnetic profile accounting for diffusion

•Resulted planet trap stops planets within the super-Earth and Sub-Neptune masses

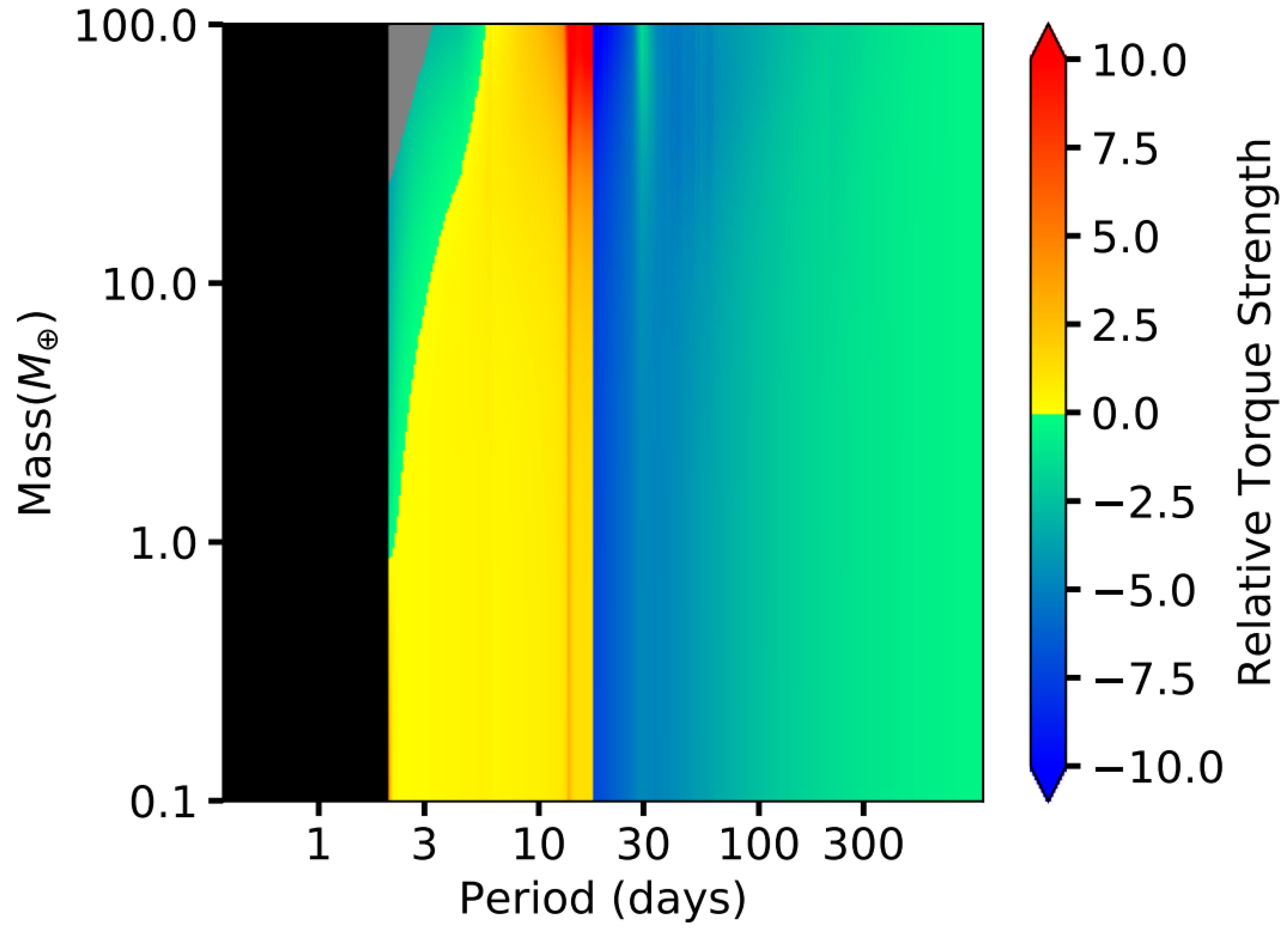

Figure 3: 0-eccentricity migration map shows that the planet trap is robust across a wide range of planet mass.

Ask about the dynamic evolutions!

Model and 1-planet paper

N-Body Simulations Result:

1-planet simulations

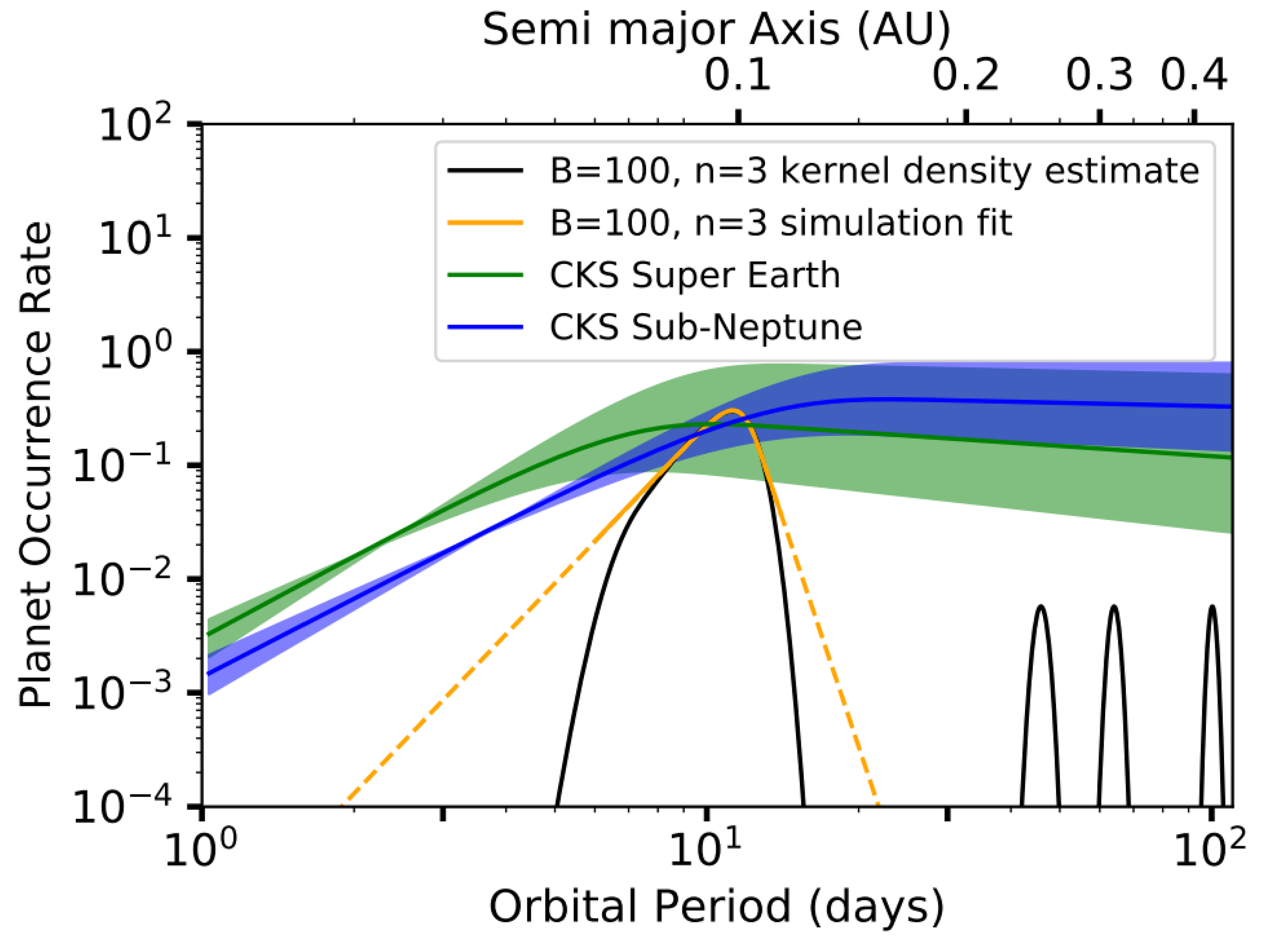

Figure 4: Comparing the kernel density estimation based on 100 single planet simulations of 100 G magnetic field with the CKS occurrence rate. The match is crude but expected for single planet.

2-planets simulations

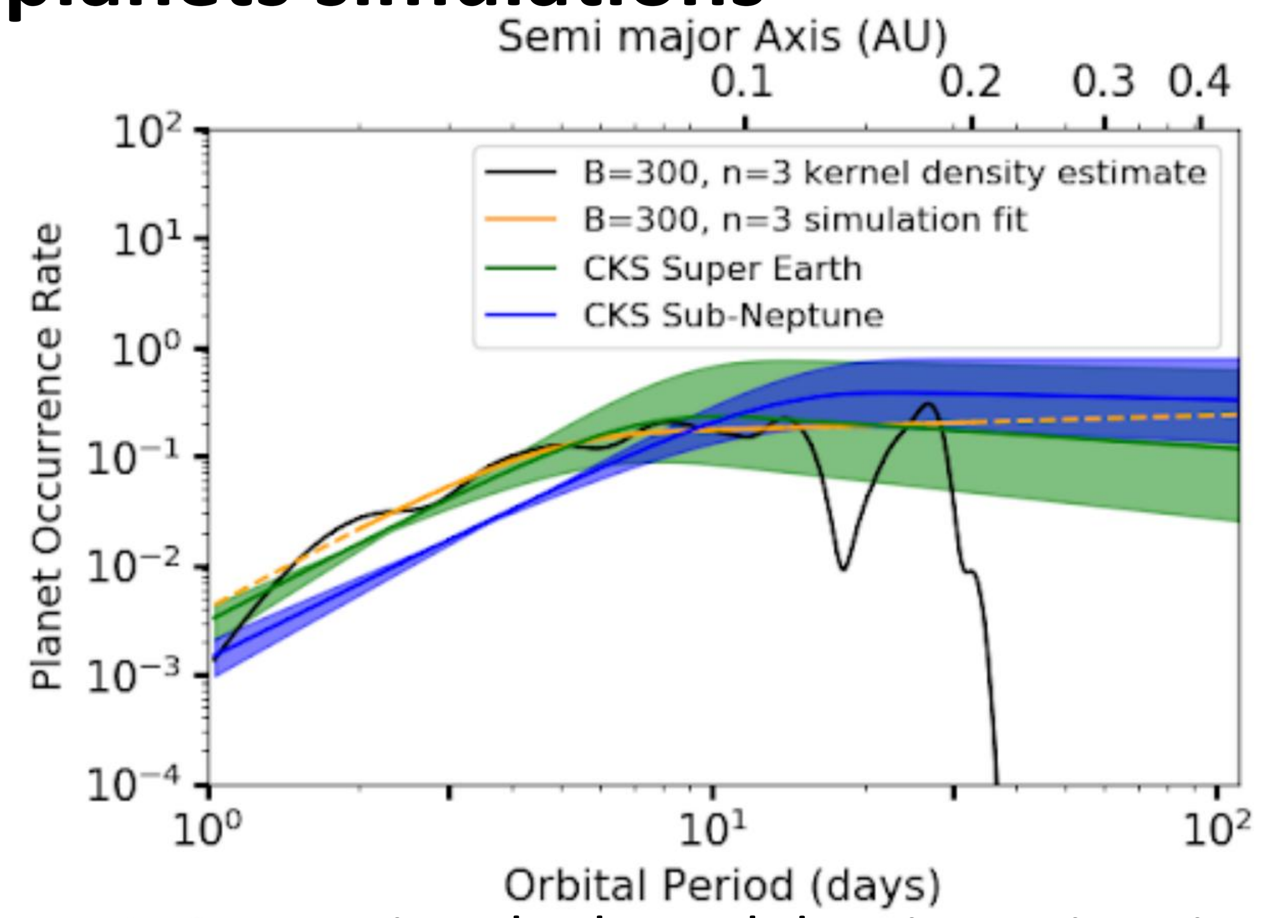

Figure 4: Comparing the kernel density estimation based on 100 double planets simulations of 300 G magnetic field with the CKS occurrence rate. The match is greatly improved. Now both the drop off below 10 days and the plateau beyond 10 days are represented, even though they are not exact matches with each others.

What's next?

•3 planets simulations (on-going)

•Generalization of 2-planet results

Reference:

Petigura E. A., et al., 2018, AJ, 155, 89
Yu, Hasegawa & Hansen, 2023, MNRAS,523, 3569Y
Yu, Hasegawa & Hansen (in prep)