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Bulletin of the AAS • Vol. 55, Issue 2 (AAS241 Abstracts)

Inside-Out Planet Formation: effect of planetesimal-disk interactions and finite formation time on oligarchic coagulation from a pebble ring

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Published on: Jan 31, 2023

URL: https://baas.aas.org/pub/2023n2i368p05

Inside-Out Planet Formation (IOPF) is a theory addressing the origin of Systems of Tightly-Packed Inner Planets (STIPs) via sequential in situ formation and growth of the planets. It predicts that a pebble ring is established at the pressure maximum associated with the dead zone inner boundary (DZIB) with an inner disc magnetorotational instability (MRI)-active region. The theory, in its simplest form, involves a single dominant planet forming from the pebble ring, which then opens a gap in the gas disk. Cai et. al (2022) investigated the feasibility of forming such a planet at the pressure maximum with an oligarchic collision model using N-body simulations considering only planet-star and planet-planet gravitational forces. In their simulations, a relatively massive secondary planet was always formed with properties inconsistent with the IOPF theory and observations. We build on their previous work investigating the effects of two planetesimal-disk interactions, an aerodynamic gas drag force and a planetary migration torque, on the evolution and resulting configuration of the simulated bodies. We port our simulations to the REBOUND N-body code (Rein et al. 2012) and implement additional forces in a model of the protoplanetary disk in IOPF based on Hu et. al (2016) and Mohanty et. al (2018). As in Cai et. al (2022), we model further mass growth via pebble accretion, but additionally we develop a mechanism to introduce planetesimals gradually during a formation period rather than all being present at initialization. We find that the drag force strongly damps planetesimal eccentricities leading to decreased collisional efficiency and the development of stable systems with 5 or more remaining planets. The migration torque concentrates the majority of the mass at a single orbital radius within about 1 Myr, but for the fiducial case investigated is not strong enough to form a single dominant planet within this timescale when the drag force is also considered. Depending on parameters, gradual formation can enhance the likelihood of forming a single dominant planet. We discuss the implications of these results for IOPF.