Formation of the Terrestrial Planets with LIPAD - including Dynamics, Accretion and Fragmentation

Kevin J. Walsh and Harold F. Levison (Southwest Research Institute)

We present simulations of the formation of the terrestrial planets from an annulus using a new Lagrangian code known as LIPAD (Levison, Duncan, and Thommes, 2012, AJ). LIPAD, which stands for 'Lagrangian Integrator for Planetary Accretion and Dynamics,' is a particle-based code that models the fragmentation, accretion and dynamical evolution of a large number of planetesimals through the entire growth process from km-sizes up to planets.

We report on simulations where initially the solids in the disk are planetesimals with radii varied between ~3, 30, or 300 km, and the disk mass was varied from one to a few minimum mass solar nebula in different simulations. The simulations were designed to examine the idea that some aspects of the terrestrial planets can be explained, particularly the Earth/Mars mass ratio, when they form from a truncated disk with an outer edge at 1.0 AU (Hansen 2009, Walsh et al. 2011). Therefore, we describe simulations that initially have planetesimals between 0.7--1.0 AU, and others that begin with material from 0.7--3.0 AU and were truncated at different times during the evolution of the disk by the migration of the Giant Planets.

Preliminary analysis shows that in all simulations planetesimals are depleted rapidly due to collisional fragmentation, and this effect is particularly dramatic in the those simulations with truncation caused by the Giant Planets. The mass distribution of the planets is not well matched for simulations starting as an annulus, and better matches are found for disks truncated at later times. We discuss other similarities and differences with previous models of terrestrial planet formation.