Gas/Solid Interactions in Gravitationally Unstable Protoplanetary Disks

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Astronomers and planetary scientists agree that terrestrial planets formed by the core accretion mechanism. The process is not so clear when it comes to gas giant planet formation: did planetary cores form first and attract gas to build their envelope, or did clumps of self-gravitating gas trap solids which eventually sunk to their centers? Evidence seems to indicate that the second possibility is at least as likely as the first. We plan to investigate this scenario using Gasoline (Wadsley et al. 2004) with the new addition of gas drag to the equations of motion. Our objective is to perform 3-D simulations of disks with both gas and solids, where the gas is self-gravitating and the solids respond to the local characteristics of the gas. We will study:

1. Differentiation of the solid component of the disk. We incorporate solids of three different sizes (mm, cm, m) of four different densities (water ice, silicates, graphite and iron) and investigate midplane settling and differential migration as a function of time, size, and composition.

2. Migration of solids toward local density peaks. The initial conditions of the gaseous disk will be such that it is unstable to the development of spiral arms, and thus induce the accumulation of solids along the spiral pattern. This could substantially shorten the process of forming planets by core accretion, whose classic disadvantage is the lengthy timescales it involves. Opacity transitions in and near the spirals due to growth of solids may also enhance this process.