APR11-2011-020081

Abstract for an Invited Paper
for the APR11 Meeting of
the American Physical Society

Planet Formation in Magnetized Accretion Disks

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Stars form by the flow of matter through an accretion disk. Inside these disks, solids particles suspended in the gas grow to form terrestrial planets and giant planet cores. I will review the physical processes of early planet growth, with an emphasis on the strong aerodynamic coupling between gas and dust (as well as larger solids). Turbulence in the gas disk is a crucial issue for these interactions. The magneto rotational instability (MRI) is the leading candidate to drive turbulent momentum transport in disks. I will briefly summarize the current status of MRI turbulence in weakly magnetized circumstellar disks. Then I will describe how MRI turbulence affects the formation of planets. By vigorously mixing small solids, turbulence generally tends to oppose the accumulation into planets. Yet somehow planets form. MRI turbulence has the tendency to support long-lived, axisymmetric zonal flows. These super- and sub-Keplerian flows surround a pressure maximum which efficiently accumulates centimeter to meter scale solids. These solids are further subject to a strong aerodynamic clumping mechanism driven by the streaming instability (Youdin & Goodman, 2005). Dense clumps of small solids can then collapse gravitationally into 100 km-scale solid planetesimals. Theories of early planet formation are recorded in the asteroid and Kuiper belts of our Solar System, the debris disks surrounding other stars and in magnetized meteorite fragments that fall to Earth.