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THE THREE-DIMENSIONAL BEHAVIOR OF SPIRAL SHOCKS IN PROTOPLANETARY DISKS

ABSTRACT: In this dissertation, I describe theoretical and numerical studies that address the three-dimensional behavior of spiral shocks in protoplanetary disks and the controversial topic of gas giant formation by disk instability. For this work, I discuss characteristics of gravitational instabilities (GIs) in bursting and asymptotic phase disks; outline a theory for the three-dimensional structure of spiral shocks, called shock bores, for isothermal and adiabatic gases; consider convection as a source of cooling for protoplanetary disks; investigate the effects of opacity on disk cooling; use multiple analyses to test for disk stability against fragmentation; test the sensitivity of GI behavior to radiation boundary conditions; measure shock strengths and frequencies in GI-bursting disks; evaluate temperature fluctuations in unstable disks; and investigate whether spiral shocks can form chondrules when GIs activate. The numerical methods developed for these studies are discussed, including a radiation transport routine that explicitly couples the low and high optical depth regimes and a routine that models ortho and parahydrogen. Finally, I explore the hypothesis that chondrule formation and the FU Ori phenomenon are driven by GI activation in dead zones.