Poster

Splinter Exoplanets

Hydrodynamics and Thermodynamics of super-Earth Planets' First Atmospheres

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In the core accretion paradigm of planet formation, gas giants form a massive atmosphere in a run-away gas accretion phase once their progenitors exceed a threshold mass: the critical core mass. On the one hand, the majority of observed exo-planets, being smaller and rock/ice-dominated, never crossed this line. On the other hand, these exo-planets have accreted substantial amounts of gas from the circumstellar disk during their embedded formation epoch.

We investigate the hydrodynamical and thermodynamical properties of proto-planetary atmospheres by direct numerical modeling of their formation epoch. Our studies cover one-dimensional (1D) spherically symmetric, two-dimensional (2D) axially symmetric, and three-dimensional (3D) hydrodynamical simulations with and without radiation transport. We check the feasibility of different numerical grid geometries (Cartesian vs. spherical), perform convergence studies, and scan the physical parameter space with respect to planet mass and optical depth of the surrounding.

In terms of hydrodynamic evolution, no clear boundary demarcates bound atmospheric gas from disk material in a 3D scenario in contrast to 1D and 2D computations. The atmospheres denote open systems where gas enters and leaves the Bondi sphere in both directions. In terms of thermodynamics, we compare the gravitational contraction of the forming atmospheres with its radiative cooling and advection of thermal energy, as well as the interplay of these processes. The coaction of radiative cooling of atmospheric gas and advection of atmospheric-disk gas prevents the proto-planets to undergo run-away gas accretion. Hence, this scenario provides a natural explanation for the preponderance of super-Earth like planets.