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Giant impact: an efficient mechanism for devolatilization of super-Earths

Mini-Neptunes and volatile-poor super-Earths coexist on adjacent obits in proximity to host stars such as Kepler-36 and Kepler-11. Several post-formation processes have been proposed for explaining the origin of the compositional diversity between neighboring planets: the mass loss via stellar XUV irradiation, degassing of accreted material, and in-situ accumulation of the disk gas. Close-in planets are also likely to experience giant impacts during the advanced stage of planet formation. This study examines the possibility of transforming volatile-rich super-Earths / mini-Neptunes into volatile-depleted super-Earths through giant impacts. We present the results of three-dimensional hydrodynamic simulations of giant impacts in the accretionary and disruptive regimes. Target planets are modeled with a three-layered structure composed of an iron core, silicate mantle and hydrogen/helium envelope. In the disruptive case, the giant impact can remove most of the H/He atmosphere immediately, while in the accretionary case, the planet is able to retain more than half of the original gaseous envelope. After the giant impact, a hot and inflated planet cools and contracts slowly. The extended atmosphere enhances the mass loss via both a Parker wind induced by thermal pressure and hydrodynamic escape driven by the stellar XUV irradiation. High-velocity impacts homogenize the refractory material in the planetary interior. Low-velocity collisions lead to a compositional gradient which suppresses the efficiency of heat transfer as the planetary interior undergoes double-diffusive convection.