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Modelling small body collisions and impact processes

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Abstract

The objects of the small body populations are a result of a billion-year-long collisional evolution of varying intensity. Their current properties provide important clues to their origin and history, and therefore represent a window to the early stages of the formation of the Solar System.

Most asteroids smaller than about 50 km in diameter are the result of a break-up of a larger parent body. They have been processed by sub-sequent collisions and their shapes, interior structure and spin state are determined to a large degree by the last major (global scale) impact event.

Although generally less frequent and less intensive, collisional processes - ranging from low-velocity mergers to catastrophic disruptions - have been proposed to also play an important role in the evolution of Kuiper Belt Objects and cometary nuclei.

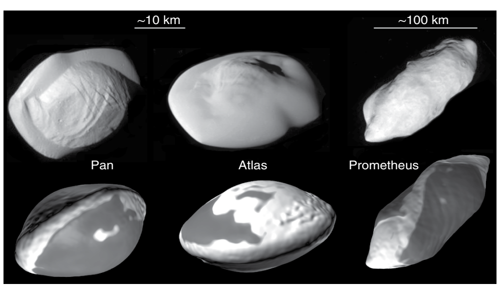

Figure 1: The small inner moons of Saturn as examples of collisionally formed objects (from Leleu et al., 2018, Nature Astronomy). Top: Cassini observations; bottom: results from simulations of collisional mergers.

Other small body populations such as the small inner moons of Saturn may also have formed and evolved through collisions (Figure 1).

Important questions are how much small bodies were processed by past collisions and to what extend they retained a record of processes that took place during the formation and early evolution of the Solar System. The degree of impact processing depends not only on the intensity of the bombardment, but also on the properties (density, porosity, strength, etc.) of the bodies involved.

As a complement to experimental and theoretical approaches, numerical modeling, using so-called “hydrocodes” or “shock-physics codes”, has become an important component to study small body collisions. Recent progress has allowed for the simulation of the entire process, the collisional disruption followed by the gravitational re-accumulation, and to compute the final shapes and structures of the objects resulting from such events. However, the realistic modeling of small body collisions is highly complex and the current models are still limited by a number of simplifications.

In this talk I will discuss the state-of-the-art models and the relevant physical processes that determine the fate of small bodies in collision regimes ranging from low-velocity mergers to catastrophic disruptions. The objects resulting from such events will be analysed in terms of their overall properties (e.g. shape and interior structure) and the degree of material processing (e.g. heating and compaction). Some results of recent studies performed in this this context will be presented.