

**FROM GIANT IMPACTS TO THE CATASTROPHIC DISRUPTIONS OF ASTEROIDS: INFLUENCE OF THE INTERNAL STRUCTURE ON THE OUTCOME AND ON THE RESULTING MATERIAL STATE.** P. Michel<sup>1</sup> and M. Jutzi<sup>2</sup>, <sup>1</sup>University of Nice-Sophia Antipolis, CNRS, Côte d'Azur Observatory, B.P. 4229, 06304 Nice Cedex 4, France. michel@oca.eu, <sup>2</sup>University of Bern, Physikalisches Institut, Sidlerstrasse 5, 3012 Bern, Switzerland. martin.jutzi@space.unibe.ch.

**Introduction:** The collisional process plays a major role in all phases of Solar System formation and evolution. The Moon is probably the outcome of a giant impact between the proto-Earth and a Mars-size planetesimal. Asteroid families are the products of the most energetic events in later phases. In recent years, we have been able for the first time to simulate the catastrophic disruption of large asteroids and to reproduce the properties of some asteroid families (e.g. [1], [2]). The fragmentation of the asteroid due to the impact of a projectile was computed as well as the subsequent mutual gravitational interaction of the generated fragments. The model of fragmentation included in our Smoothed Particle Hydrodynamics (SPH) code or hydrocode ([3]) was adapted to brittle materials with no porosity at micro-scales and was then limited to the study of asteroid families of S taxonomic type, believed to be composed of such material. Small bodies can also be composed of microporous material, as expected for dark (C) type asteroids, Kuiper Belt objects and comets, and we recently introduced a new model in our SPH impact code to account for microporosity.

**Giant impacts:** The formation of terrestrial planets is believed to have concluded with a period of giant impacts during 10 to 100 millions years. Numerical simulations [4] indicate that colliding Mars-size to lunar-size planetesimals do not systematically merge together. The smaller body rather escapes from the collision highly deformed, spun up, depressurized from equilibrium, stripped of its outer layers, or broken up into smaller pieces. Remnants of these so-called hit-and-run collisions are predicted to be common among remnant planet-forming populations, and thus to be relevant to asteroid formation and meteorite petrogenesis.

**Effect of Porosity:** A body containing microporosity (i.e. porosity on a scale much smaller than the numerical resolution) can be crushable, which will influence the collisional outcome. Various compaction models have been developed recently. We have extended our SPH impact code to include the effect of porosity at a sub-resolution scale by adapting

the so-called *P-alpha* model ([5]). A first validation at laboratory scale has been performed ([6]). Our next step has been to study this process at large scale and for the first time, to simulate the formation of asteroid families of dark taxonomic classes (e.g. C-type). We also investigated the influence of porosity on the thermodynamics of the impact process and on the attenuation rate of the stress wave within the target.

**Results and future work:** We will review the results of studies of giant impacts from [4], showing the effect on the physical state of the small bodies involved in the event. Then, numerical simulations of catastrophic disruptions of asteroids will be shown, indicating how the presence of porosity influences the outcome. Results from preliminary investigations of the range of pressure and internal energy that a small body can undergo during an impact as a function of its internal structure as well as physical processes such as the attenuation rate of the stress wave as a function of the distance from the impact point will then be exposed. Such information can be compared with the measurements on meteorites that have been extracted during such impact events. Future work will be done to improve our understanding of the impact process and its consequences on the materials that are involved. This will be done by means of numerical simulations and experiments, using targets covering a wide range of material properties that can represent small bodies in planetary system.

**References:** [1] Michel P. et al. (2001) *Science*, 294, 1696-1700. [2] Michel P. et al. (2003) *Nature*, 421, 608-611. [3] Benz W. and Asphaug A. (1994) *Icarus*, 107, 98-116. [4] Asphaug E. et al. (2006) *Nature*, 439, 155-159. [5] Jutzi M. et al. (2008) *Icarus*, 198, 242-255. [6] Jutzi M. et al. (2009) *Icarus*, 201, 802-813.

**Acknowledgments:** This work is supported by the French « Programme de Planétologie » (PNP), the French Program « Origine des Planètes et de la Vie » (OPV), and the cooperation program CNRS-JSPS 2009.