Granular media in the context of small bodies

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Granular materials of different particle sizes are present on the surface and the interior of several atmosphereless Solar System bodies. The presence of very fine particles on the surface of the Moon, the so-called regolith, was confirmed by the Apollo astronauts. From the polarimetric observations and phase angle curves, it is possible to indirectly infer the presence of fine particles on the surfaces of asteroids and planetary satellites. More recently, the visit of spacecraft to several asteroids and comets has provided us with close pictures of the surface, where particles of a wide size range from cm to hundreds of meters have been directly observed. The presence of even finer particles on the visited bodies can also be inferred from image analysis.

Solar System bodies smaller than a few hundred km may have a variety of internal structures: monolithic single bodies, objects with internal fractures, rubble piles maintained as a single object by self-gravity, etc. After the visit of the small asteroid Itokawa, it has been speculated that "some small asteroids appear to be clumps of gravel glued by a very weak gravity field" (Asphaug 2007). We still do not know the internal structure of these rubble piles and the size distribution of the interior constituents, but these clumps could have several million meter-sized boulders inside.

There are several pieces of evidence that many asteroids are agglomerates of small components, like:

- Rotation periods for small asteroids
- Tidal disruption of asteroids and comets when they enter the Roche's limit of a massive object
- The existence of crater chains like the ones observed in Ganymede
- Low density estimates (< 2 gr/cm^3) for many asteroids like Mathilde

It has been proposed that several typical processes of granular materials (such as: the size segregation of boulders on Itokawa, the displacement of boulders on Eros, the ejection of dust clouds after impacts) can explain some features observed on these bodies.

We review the numerical and experimental studies on granular materials with relevance to the understanding of the physical processes on the interior and the surfaces of minor bodies of the Solar System. In particular, we compare the different codes in use to perform numerical simulations of the physical evolution of these objects. We highlight results of these simulations. Some groups have been involved in laboratory experiments on granular material trying to reproduce the conditions in space: vacuum and low gravity. We describe the experimental set-ups and some results of these experiments. Some open problems and future line of work in this field will be presented.

References: Asphaug E. (2007), The Shifting Sands of Asteroids, Science, vol. 316, pp. 993–994.