Experiments on the Brazil-nut effect due to seismic shakings

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Size segregation processes have been identified as relevant when studying the behaviour of rocks and boulders on the surface and in the interior of a rubble-pile asteroid. The size segregation as a consequence of repeated shakings is also known as the Brazil-nut effect (BNE). These processes might be really important when studying rubble-pile -type asteroids, which may have suffered seisms as a consequence of repeated collisions; such as in the case of asteroid Itokawa.

Size segregation processes can be studied using laboratory experiments as well as computational models, the first case being the one initially considered in this work. Previous studies of the BNE were performed using a sinusoidal vertical or horizontal vibration of the containers. Since we are interested in the effects of repeated seismic shakes, we have used in our experiments a sequence of repeated knocks of the container. We built a resin and polycarbonate box, which is filled with marbles of different sizes. Vacuum up to 0.5 % of ambient pressure is established inside the box. The box is subjected to repeated free-falls from heights up to 1m, with impact velocities on the ground up to 4m/s. We have chosen these low velocities since they are comparable to the escape velocities of km-size asteroids; and they are on the order of the displacement velocities of surface material as a consequence of a small impact (far from the impact point; Tancredi et al. 2012).

We study the dependence of size segregation processes with the size rate among the spheres and the impact speed of the box. We observe that, when effectively occurs, size segregation mostly depends on the size rate of the particles and very little on the impact speed, even though this slight dependence has been recorded in our experiments.

The laboratory experiments have been also numerically simulated using the Discrete Element Method (DEM) package known as ESyS-particle. The results of the numerical simulations are compared to the experimental ones for a different set of physical parameters of the particles.

References: Granular physics in low-gravity environments using DEM (2012) G. Tancredi, A. Maciel, L. Heredia, P. Richeri, S. Nesmachnow; Monthly Notices of the Royal Astronomical Society, 420, 3368–3380.