ASTR630 Project (Koester): The Spherical Brazil Nut effect and Its Significance to Asteroids

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Abstract

It has long been observed that shaking a container of differently sized particles, mixed nuts e.g., will tend over time to bring the larger sized ones to the top, a phenomenon dubbed the Brazil Nut Effect. Given that a number of asteroids seem likely to be rubble piles of a mixture of different sized objects loosely held together by gravity (and possibly weak cohesive forces), given also the likelihood of an asteroid suffering multiple collisions over the course of its lifespan, it becomes interesting to investigate whether the resultant seismic shaking may lead to size sorting by this mechanism. Real asteroid interiors being complex to model and poorly understood, the authors simulate the behavior of a simpler, spherical, self-gravitating aggregate of 500 particles of radius 80 m and 500 of radius 40 m, density of 3 g cm^{-3}, under applied shaking of 6 different impact forces (translated into random velocities for each particle with v_{max} as a percentage of v_{esc} from the aggregate body as a whole). They generate 516 seismic events over 102 simulation days for each run in order to provide sufficiently prolonged shaking. They also investigate the results of seismic shaking with and without friction between each of the particle bodies. They find a minimum seismic threshold is needed to initiate size-sorting and that this can occur even in the (unrealistic) absence of friction. Further, they find that strong size sorting takes place nearest the surface, while the core of the simulated aggregates remains largely unsorted, even under shocks likely to disrupt the body surface. (Gravitational force would be weaker in the core; the effect would be much less pronounced. The authors do not think that the lack of sorting reflects a process that has yet to reach equilibrium.) Observational evidence at the level of detail necessary to confirm that the effect acts in nature is almost entirely lacking, unfortunately, but the very little that exists is suggestive.

One immediately wants to constrain the amounts of energy necessary to carry out this process under the various simulated runs the authors made, and calculating an ideal minimum (i.e., neglecting frictional or non-elastic collision losses) should be straightforward, using the masses and assigning randomized velocities within the v_{max} of each run. (It might be possible to obtain the initial datasets from the authors, alternatively.) Adding to this frictional losses might prove too difficult, but perhaps an idealized version could be attempted.