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Small scale impacts as trigger for an avalanche in a low gravity environment

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Abstract

The European Space Agency's Rosetta spacecraft was launched in 2004 and will rendezvous with comet 67P/Churyumov-Gerasimenko in 2014. On its route towards the comet, it flew by asteroid (21) Lutetia on 10 July 2010, with a closest approach distance of 3170 km. OSIRIS - the Optical, Spectroscopic, and Infrared Remote Imaging System on board Rosetta [1] - took 462 images of Lutetia, using 21 broad- and narrow-band filters covering a wavelength range from 240 to 1000 nm [2].

The surface of Lutetia is covered with a thick layer of regolith. On slopes of several craters this regolith layer collapsed in landslide like events. A possible trigger mechanism for these low-gravity avalanches is the impact of a small mm to cm-sized body.

We conducted an experiment where samples of different granular materials were tilted at different angles with respect to the vector of gravity. We accelerated a small mm-sized metal sphere to velocities up to 1.5 m/s and shot it into the sloped granular material. The impacts and any events triggered by the impact were recorded using a high-speed high-resolution camera.

The experiment was implemented at the center of applied space technology and microgravity (ZARM) vacuum drop tower in Bremen in August 2012. The experiment was placed in an evacuated cylinder and mounted on a centrifuge that was spun with varying rotation rates to accommodate the vacuum and low gravity present on the surfaces of asteroids.

A total of 20 experiments as described above were realized during 10 drops. The tilt angle and the magnitude of artificial gravity were varied for two different materials, a ground HED meteorite and the JSC MARS-1 Martian soil simulant. Additional ground-based experiments in 1g environment were conducted at a later time.

We analyzed the images using an image subtraction algorithm to track movement from one frame to the next. In subsequent steps we observed the behavior of the material on the surface as well as in deeper layers to characterize the effects of the impact with changing gravitational acceleration, impactor velocity and tilt angle of the material.

The preliminary analysis indicates that, after a shock, the motion in deeper layers of the material seems to subside at different speeds depending on both gravity and tilt angle of the box.

Additional simulations of this experiment will be conducted at a later time.

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References

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