Laboratory penetration experiments conducted at low effective gravity II

*Akiko Nakamura[1], Junpei Nakahata[2], Yuuya Nagaashi[1]

1. Graduate School of Science, Kobe University, 2. Faculty of Science, Kobe University

Laboratory measurements of the penetration depth of an impactor with a velocity of m/s in a granular layer under Earth's gravity were compiled to give an empirical relationship between drop height and penetration depth that is applicable for various granular materials (Uehara et al., 2013). There are limited data on the penetration depth under low gravity. In low-velocity (2–40 cm/s) impact experiments with a quartz sand target under low effective gravities (~0.2–1 m/s^2), the penetration depth was independent of the effective gravity (Murdoch et al., 2016).

To investigate the penetration of an impactor into granular material as an analogue of planetary regolith, we examined the low-velocity impact of a sphere into a granular layer at low effective gravity in the laboratory experiments. The target granular material was packed in a bucket. The bucket was fixed with two electromagnets; when the electromagnets were switched off, it dropped vertically downward, reducing the effective gravity, which was monitored by an accelerometer. In our previous set-up we used constant-force springs to hang the bucket and the effective gravity averaged 2.5 m/s^2 (Nakamura et al., 2019JpGU). In our new study, we used two linear shafts to guide the bucket. The impactor was a 16.7-mm-diameter glass sphere. A plastic straw with horizontal lines drawn on it was glued to the glass sphere. The penetration process of the glass sphere with the straw was imaged at 960 fps by a camera attached to the bucket. We used 1-mm-diameter glass spheres and 0.7-1 mm peach seed fragments as targets.

In this study, the effective gravity was lower than 0.09 m/s^2. The glass sphere collided with the granular target at a relative velocity of between 3 and 4.5 m/s. The final depth of the impactor roughly matched the expected value given by an analytic penetration model (Katsuragi and Durian, 2013).

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