Laboratory impact penetration experiments conducted at simulated reduced gravity

*中村 昭子[1]、森園 佳奈[2]、長足 友哉[1]
*Akiko Nakamura[1], Kana Morizono[2], Yuuya Nagaashi[1]

1. 神戸大学大学院理学研究科地球惑星科学専攻、2. 神戸大学理学部
1. Graduate School of Science, Kobe University, 2. Faculty of Science, Kobe University

Small bodies are covered with a layer of regolith made up of particles of various sizes. It is important to understand the interactions that occur with surface regolith when a spacecraft lands on or when a block secondarily collide with the regolith layer at low velocity. Penetration depth of an impactor in granular layer was investigated under Earth’s gravity and an empirical relationship between the drop height and penetration depth was shown to reproduce the experimental results for various granular materials (Uehara et al., 2013). Deceleration of spherical impactor in granular layer was experimentally and theoretically investigated and deceleration formulae were proposed (Katsuragi and Durian 2007, Nakamura et al., 2013; Katsuragi and Durian 2013). On the other hand, interactions of spheres with simulated regolith have been studied at reduced gravity and micro-gravity conditions (Murdoch et al., 2016; Brisset et al., 2018). However, more data of penetration depth of impactor are required to establish quantitative understanding of the penetration process in regolith under low gravity.

We conducted laboratory low-velocity impact experiments of a sphere into granular layer at reduced gravity. Impactor was a glass sphere with a diameter of 16.7 mm and granular layer consisted of glass beads with a diameter of 1 mm. The glass beads were packed in a bucket having a diameter of 15 cm and a depth of 15 cm. The bucket was hung with three constant load springs. The bucket was fixed with two electromagnets, and when the electromagnet was switched off, it dropped vertically downward with the gravity reduced. The simulated reduced gravity level was monitored by an accelerometer placed in a bucket and found to be on average 0.26 G. A plastic straw with horizontal line drawing was glued to the glass sphere. The glass sphere collided with the glass bead layer at a relative velocity between 2 and 4 ms^{-1}. The penetration process of the glass sphere with the straw was imaged at 240 fps by a camera attached to the bucket. The final depth of the glass sphere was found to be systematically deeper than the depth found in the experiment conducted at 1 G.

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