# Impact cratering experiments in microgravity environment

# Yasuhiko Takagi[1]; Sunao Hasegawa[2]; Hajime Yano[3]

[1] Aichi Toho University; [2] ISAS/JAXA; [3] Dept. of Planetary Sci., JAXA/ISAS

**Introduction:** The MUSES-C/Hayabusa mission found that Asteroid (25143) Itokawa is a rubble pile and some parts of the surface are covered by regolith or mm to cm size gravel layer [1, 2]. Although the number is limited, some craters were found on the regolith or gravel plain of Itokawa by Hayabusa [3]. These results reconfirmed that the understanding of impact cratering phenomena is important for studies of surface processes on small bodies. However, impact cratering experiments in microgravity environments were rare due to technical difficulties. Recently Colwell [4] performed some impact experiments into a dust-covered surface in a space shuttle payload. However, the impact velocities were very low ( less than 100 cm/sec). Only data available to the scaling law are data in Fig. 1 of Gault and Wedekind [5]. Impact cratering experiments in the microgravity environment are desired to elucidate process on small bodies and to make the best use of the wealth by asteroid explorations.

We performed impact cratering experiments in microgravity environments using a drop tower. The same facility and experimental devices were used in the performance tests of MUSES-C/Hayabusa sampling devices [2].

**Crater Formation Time:** The weakest point of drop tower experiments is the short duration time of microgravity condition. We checked the crater formation time first. All the video images of microgravity experiments showed that the crater formation ends within 0.1 sec. Any difference between the crater formation time in 1 G and microgravity environment is not observed. This result certified that the microgravity duration time of the facility, 4.5 sec, is enough long for impact cratering experiments in this case.

**Crater Final Diameter:** The result clearly showed that the diameters of craters formed in the microgravity environment coincide with those formed in the 1 G environment within the data scatter. These results indicate the crater formation in the present experiments is not controlled by the gravity.

On the other hand, the exponents between the impact energy and diameter are 1/3.5 - 1/4.0. These values are close to the value of gravity scaling, 1/4, rather than the value of strength scaling, 1/3. The exponents suggest that the diameter does not depend on the strength scaling either. It is possible that the phenomena are controlled by a new scaling term related to the kinetic friction between particles.

The present results both on the crater formation time and crater final diameter are different from those by Gault and Wedekind [5]. The reason is not clear, but may be the difference of amount of kinetic friction. Since the grain sizes of Ottawa quartz sands they used were much larger than those of the present experiment, the kinetic friction for each unit volume may be small.

**Conclusion:** We performed systematic impact cratering experiments in microgravity and vacuum environment with impact velocities larger than 100 m/sec and obtained data on diameter of crater formed in the environment. The experiments showed that the drop tower is an appropriate tool for studies of surface processes on small bodies. The result shows that the formation time and final diameter of crater are not controlled by the gravity.

**References:** [1] Fujiwara A. et al. (2006) Science, 312, 1330-1334. [2] Yano H. et al. (2006) Science, 312, 1350-1353. [3] Saito J. et al. (2006) Science, 312, 1341-1344. [4] Colwell J. E. (2003) Icarus, 164, 188-196. [5] Gault D. E. and Wedekind J. A. (1977) in Impact and Explosion Cratering, Pergamon, New York.

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