Effect of secondary collision and target texture on three-dimensional shape distribution

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3D shape distributions of regolith particles returned from the asteroid Itokawa by the Hayabusa mission and the moon by the Apollo and Luna missions have been measured [1,2]. Such 3D shape distributions reflect conditions of regolith particle formation and it is important to compare with those of fragments in laboratory impact experiments to discuss impact processes on the surfaces of Itokawa and the moon.
It has been proposed based on a laboratory experiment that the 3D shapes of impact fragments have characteristic distribution; the average axial ratios of the longest, intermediate and shortest lengths of fragments, *a* : *b* : *c* ,is 2:√2: 1. Although the ratios of individual fragments were widely distributed [3]. As this result was obtained only in a catastrophic disruption condition, Michikami et al. [4] carried out impact experiments under wide range of impact conditions from cratering to catastrophic disruption and found that the average three axial ratios is not 2:√2: :1 when the impact energy density is low (cratering conditions). However, the size of fragments examined (>4 mm) is bigger than that of Itokawa and Luna regolith particles (20-300 um). So, we measured the axial ratios of fragments obtained from the same experiments [4] with similar size to the regolith particles, and found that (1) the size distribution depends on the fragment size, (2) the average axial ratios are almost constant around 2:√2:1 irrespective of the impact energy density and (3) the distribution cannot be distinguished from that of Itokawa particles [5]. However, effects of secondary collision and target texture have not been evaluated.
In this study, additional experiments were made in order to elucidate the effect of secondary collision and target texture. Impact experiments were carried out with a two-stage light-gas gun at JAXA. We used basalt, dunite, ordinary chondrite (L4/5) and lead glass as targets and spherical nylon (7.14 mm in diameter) or alumina (1.00 mm) as projectiles. The impact velocity ranged from 1.60 to 7.0 km/s. Two types of impact fragments (30-600 um) were examined; one is fragments collected in aerogel, which were not suffered by secondary disruption, and the other is fragments collected from the surfaces of impact absorbers. The three axial lengths were measured using X-ray microtomography in SPring-8, and their 3D shape distributions were compared with each other and with those of Itokawa and Lunar regolith particles using Kolmogolov-Smilnov test.
It was found from the experiments that the 3D shape distributions and the average axial ratios of fragments collected from aerogel cannot be distinguished from those from the impact absorber surfaces. This indicates the fragments measured by Kadokawa et al. [5] were not influenced by secondary collision or secondary collision little affected the 3D shapes. It was also found that the 3D shape distributions of the experiments using basalt targets cannot by distinguished from those using dunite and ordinary chondrite targets, while they can be clearly distinguished from those using homogeneous lead glass target, which is largely different from basalt in textures. This suggests that experiments using basalt targets can simulate impact processes on the asteroids. The present results indicate that the results of Kadokawa et al. [5] is applicable to Itokawa and Luna particles; Itokawa particles can be formed by collisional destruction, but we cannot estimate their impact conditions from the 3D shape distribution while the values of the average axial ratios of Luna particles, which is closer to unity, suggests that they were affected by gardening in the regolith layer.

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