Impact condition of collisional disruption for differentiated bodies

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Achondrites (stony meteorites, stony-iron meteorites and iron meteorites) are considered to have been derived from differentiated bodies. For example, previous studies indicated that M-type asteroids were the origin of iron meteorites. Those asteroids are thought to have been a metallic core in the differentiated body and ejected from the parent body to space by collisional event. It could be possible that small icy satellites have a layered structure composed of porous snow mantle and ice core as a result of the thermal evolution. Therefore, it is reasonable to assume the presence of many differentiated bodies in the early solar system. The impact condition of collisional disruption for differentiated bodies is supposed to be different from that of homogenous bodies. So, the collisional experiment related to the differentiated bodies can provide the constraints on the formation processes of various asteroid (e.g. S-type, M-type and A-type) and collisional evolution of the asteroid belt. In this study, we determined the specific energy required for the collisional disruption of layered targets with a porous mantle-silicate core structure. The size distribution of impact fragments and these fragment velocities were measured.

Impact experiments were performed by using a two-stage light gas gun at Nagoya University. We used a spherical layered target: a glass ball (diameter 17mm) covered with a plaster layer. The target had a plaster layer with a different thickness (0, 2.10, 3.60 and 9.60mm). We observed the effect of that thickness on the collisional disruption. A nylon projectile was used and its mass is 7mg. The projectile was launched at about 3.5km/s. The collisional disruption process was observed by a high-speed digital video camera for the purpose of the measurements of the fragment speeds and their sizes.

Disruption type changed with the thickness of the plaster layer. The glass ball without the plaster layer was completely broken into small pieces. The target with 2.10mm plaster layer was also entirely disrupted. Both the plaster layer and the glass ball core were broken into small pieces. The plaster layer of the target with 3.60mm plaster layer was fractured and blown off from the core. The glass ball core was not broken, and a crater (diameter 3mm) was formed on the surface. The target with 9.60mm plaster layer was not broken so much and a crater (diameter 10mm) was formed on the plaster surface. The glass ball core was not damaged. Size distribution analyses of the targets indicated that the impact condition of collisional disruption for the target with layered structure could be determined by only the part of silicate core when the thickness of highly porous mantle was thinner than the size of the projectile.