EXPERIMENTAL STUDY ON COLLISIONAL DISRUPTION OF CORE-MANTLE BODIES

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In the accretion process of planetesimals, there could be a lot of bodies with heterogeneous internal structures by pressure sintering, melting and gravity differentiation. They might have a core-mantle structure such as silicate core-porous silicate mantle or metal core-rock mantle. Therefore, we should consider a collisional phenomenon not only of a homogenous body but also of a core-mantle body to study the planetary accretion process. However, we do not have few experimental data on the collisional disruption of a core-mantle body. So, we should investigate the collisional strength and the fragment velocity of core-mantle targets and clarify the differences of these physical processes between homogenous targets and core-mantle targets.

We used a two-stage light gas gun set in Nagoya University and studied the strengths and the fragment velocities for various core-mantle targets. The impact velocities (V_{i}) ranged from 1.5 to 4.6 km/s. The gypsum mantle-glass core targets were prepared for the spherical targets. The glass core was surrounded by the gypsum mantle. We changed the mantle thickness ($t_{\mathrm{m}}/d_{\mathrm{p}}$) and a ratio of the glass core mass to the total target mass (CMR) from 0 to 1. The density of glass and gypsum was 2.5 g/cm^3 and 1 g/cm^3, respectively. The collisional disruption of the core-mantle target was directly observed by high speed photography.

We investigated the relationships between the largest fragment mass and the energy density to determine the impact strength of targets. The core-mantle data having various $t_{\mathrm{m}}/d_{\mathrm{p}}$ and CMR spread between the basalt and gypsum data reported by previous studies. Therefore, we speculated that the behavior of core-mantle targets in collisional disruptions strongly depends on the key parameters, $t_{\mathrm{m}}/d_{\mathrm{p}}$ and CMR.

We compared the antipodal velocities (V_{ant}) normalized by impact velocities among core-mantle targets. As increasing the CMR and decreasing the $t_{\mathrm{m}}/d_{\mathrm{p}}$ at the same energy density, the $V_{\mathrm{ant}}/V_{\mathrm{i}}$ drastically increased. The shock wave going through the gypsum mantle attenuated very much because of the high porosity of the gypsum mantle. So, we obtain the larger $V_{\mathrm{ant}}/V_{\mathrm{i}}$ for the smaller $t_{\mathrm{m}}/d_{\mathrm{p}}$.

We suggest that the physical characteristics of core-mantle targets in collisional disruption depend on the decay rate of shock pressure, the $t_{\mathrm{m}}/d_{\mathrm{p}}$, and the kinetic energy of the projectile partitioned into the glass core.