In-situ observation of impact disruption of frozen clay using Flash X-ray

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We studied the dependence of physical properties of planetesimlas on the impact strength in the gravity regime, then we made laboratory impact experiments by using a Flash X-ray for frozen clay and porous gypsum simulating planetesimals in order to obtain the relationship between impact fragment masses and ejection velocities.

The impact strength of planetesimals is one of the most important physical properties to clarify the planetary accretion process and the formation process of proto-planets and asteroids. Thus, the impact strength in the strength regime applicable to planetary bodies smaller than 100 m has been mainly studied in laboratory experiments. However, the impact strength in the gravity regime applicable to planetary bodies larger than planetesimals has been studied only by numerical simulations, and their results are not consistent each other. Furthermore, recent numerical results conducted by Jutzi (2015) [1] showed us that the material properties such as friction, cohesion and porosity affected the impact strength in the gravity regime drastically. Then, we made laboratory impact experiments to elucidate the material dependence on the impact strength in the gravity regime.

In order to determine the impact strength in the gravity regime by the laboratory experiments, we should obtain the relationships between the impact fragment masses and the ejection velocities, and especially, the fragments ejected from the interior of the disrupted target must be observed to construct the velocity –mass relationship for all the fragments. Then, we introduced 3 set of a flash X-ray generator and imaging plates to take transmitted X-ray images of a target with 3 mm steel balls arranged in it. These steel balls were used as makers of the motion of impact fragments, and the time sequence of these balls were observed by using X-rays to analyze the local velocities of the target interior.

Impact experiments were conducted by using a polycarbonate projectile with the size of 7mm at the velocity of 1.5 –6.5 km/s, and the projectile was impacted on the spherical target with the size of 6 cm in the head-on collision. We used frozen clay targets with the tensile strength from 1 to 2 MPa and a porous gypsum target with the porosity of 47 %. All the targets were catastrophically disrupted into the largest fragment mass less than 0.1. As a result, we determined an upper limit of ejection velocities having a half mass of the target for each experiment, and we defined this upper velocity as a median velocity of V*. So, we studied how V* depended on the energy density, tensile strength and porosity, then we found that V* increases with the energy density, but it was almost independent on the tensile strength for the frozen clay. Furthermore, it was found for the porous gypsum target that the porosity drastically reduced V*. These new findings support the previous numerical results considering these material physical properties.

[1] Jutzi (2015) Planetary and Space Science, 107, 3–9.

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