Observation of catastrophic destruction of two different targets using X Ray photography

*Takumi Nagano[1], Masahiko Arakawa[1], Minami Yasui[1], masato nakamura[1], Fumiya Nagatomo[1]

1. Faculty of Science Kobe University

We studied the dependence of physical properties of planetesimals on the impact strength in the gravity regime, then we made laboratory impact experiments by using a Flash X-ray for porous gypsum and dry clay 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 with each other. Furthermore, recent numerical results conducted by Jutzi (2016) 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 sets of flash X-ray generators 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’ s interior.

Impact experiments were conducted by using a polycarbonate projectile with the size of 7mm at the velocity of 2 –5 km/s, and the projectile was impacted on a spherical target with the size of 6 cm in a head-on collision. We used porous gypsum targets with the porosity of 50% and the tensile strength from 1 to 2 MPa and dry clay targets with the porosity of 48 % and the tensile strength different from the porous gypsum. All the targets were catastrophically disrupted into the largest fragment mass less than 0.2. 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* increased with the energy density for both targets. Moreover, we found that it strongly depended on the target porosity when it was compared with the previous result for the frozen clay with the similar tensile strength but without porosity, the V* for porous gypsum reduced to be 1/3 for the frozen clay. The V* for the dry clay was almost similar to that for the porous gypsum, thus this might mean that the tensile strength does not affect the V* even for the porous target.

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