Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

PPS21-P25 Room:Convention Hall Time:May 22 17:15-18:30

Low-velocity impact experiments on equal-sized planetesimal collisions

KOMOTO, Yasunari[1*], YASUI, Minami[2], SHIMAKI, Yuri[3], ARAKAWA, Masahiko[1]

[1]Graduate School of Science, Kobe University, [2]Organization of Advanced Science and Technology, Kobe University, [3]Graduate School of Environmental Studies

Planets in the solar system have grown by mutual collisions among porous planetesimals. The Hayashi model suggested that many equal-sized planetesimals depending on the heliocentric distance were formed by the gravitational instability of dusts in the solar system. Moreover, it is expected that the collisional velocities among planetesimals were equal to or larger than the escape velocity and not only a head-on collision but also an oblique collision with various impact angles occurred. In this study, we conducted oblique impact experiments with low-impact velocity for samples simulating rocky and icy planetesimals and examined the effects of composition and impact angle on the impact strength and fragment velocity.

We prepared projectiles and targets of polycrystalline ice and porous gypsum with a porosity of 55 % simulating icy and rocky planetesimals, respectively. All samples have a spherical shape with a diameter of 30 mm. Impact experiments were conducted by an one-stage He-gas gun in Kobe University for gypsum samples and in the cold room of ILTS at -10^o C. The impact velocities (V$_i$) were 12.5-83.3 m/s for a head-on impact and 65-75 m/s for an oblique impact. The impact angle (l) changed every 15^o from 0 to 75^o. The target was set in the recovery box to measure the mass of each fragment. The collisional disruption of the projectile and the target was observed by a high-speed video camera at the frame rate of 3000-8000 frames s^{-1}. We measured the antipodal velocity (V$_a$), which was the fragment velocity ejected from the antipodal point of the impact point on both the projectile and the target to study the effect of oblique impacts on the average fragment velocity.

We found in the case of the head-on collision that the V$_a$ was almost consistent with the velocity of the center of mass (V$_g$). However, the Va was about 10-15 m/s smaller than the V$_g$ due to the crush of the target in the case of ice sample. Moreover, many finer fragments were ejected from the impact point in a direction perpendicular to the impact direction, and the fragment velocities became the maximum as same as the impact velocity. In the case of oblique impacts, the Va decreased with the increase of the l. The fragment velocity ejected from the impact point to the tangential direction of impact surface was about 1.5 times larger than the Vi due to jetting in the downstream while it was more than two times smaller than the Vi in the upstream. The relationship between the Va and the l could be written by V$_a$=20(cos l)$^{3.6}$ for the ice target of l=0-45^o, Va=7.7(cos l)$^{0.95}$ for that of l=45-75^o, and V$_a$=31(cos l)$^{1.3}$ for porous gypsum. We notice that in the cases of l=45-75^o, the power law index of cos l was almost 1 and the maximum fragment mass normalized to the original sample mass m$_l$/M$_p$ or $_t$ (=M) was about 0.5-1.0.

In the case of head-on impacts, the Q$*$ for ice was 89 J/kg at the mass ratio of projectile and target M$_p$/M$_t$ of 0.003-0.13 obtained by Arakawa et al. (1995) and Arakawa (1999), and the Q$*$ for porous gypsum was 446 J/kg at the M$_p$/M$_t$ of 0.027-0.56 obtained by Yasui and Arakawa (2011). In this study, the Q$*$ of ice and porous gypsum samples were almost consistent with those obtained by these previous works. In the case of oblique impacts, the ml increased with the l, and the relationship between the m$_l$/M and the l could be written by ml/M=0.044(cos l)$^{-1.4}$ for ice and m$_l$/M=0.44(cos l)$^{-0.62}$ for porous gypsum. Moreover, it is suggested that the normal component of impact velocity to the tangential surface at impact point (V$_i$ cos l) had the significant effect on the m$_l$/M so we reanalyzed the data by using the Q(cos l)^2. As a result, the results for head-on impacts were almost consistent with those for oblique impacts, that is, we succeeded to scale the effect of impact angle on the m$_l$/M.

Keywords: Oblique impact, Planetesimals, Porous body, Icy body