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Impact experiments of sintered snow sphere : implication for the collisional disruption of icy planetesimals in thermal evolution

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We can find a lot of icy bodies in the outer solar system, and we know that most of them with the size smaller than 100 km have a large porosity higher than 50 %. So, we studied the impact strength of small icy bodies by using a suitable analogue such as a sintered snowball.

Impact experiments of a snowball with the porosity of more than 50 % were conducted by using a one-stage He gas gun set in a cold room at the temperature of -10 to -20 C. Snowballs with the diameter of 60 mm were sintered for 1 hour to 1 month at the temperature from -10 to -20 C. This snowball was impacted by a projectile of snowball or ice cylinder at the velocity from 30 to 270 m/s. Impact disruption of snowball targets were observed by a high speed camera to analyze the velocity distributions of fragments. Recovered snow fragments were measured to study the mass distribution of the fragments and impact strength of sintered snow.

The static mechanical tests were conducted to measure the tensile strength of snow sintered for various periods. Then, we found that the snow tensile strength was changed with the sintering period according to the empirical equation of $Y_t=7.9*t^{0.15}$. The impact strength was also obtained by using the largest fragment mass recovered from the impact disruption. The relationship between the energy density (Q) and the largest fragment mass was derived for each sintered snowball, and we found that the snowball sintered for long period showed the larger strength and it had a good correlation with the static tensile strength shown by the empirical equation of $Q*=0.25*Y_t^{1.1}$. This result is almost the same equation as that was obtained for the snowball with the porosity of 40 %, which was studied previously.

High speed vide images were used to measure the antipodal velocity (Va) of the snowball target with the porosity of more than 50% and the relationship between Va and Q was compared to that of 40% snowball target. So, we found that the Va obtained for more porous snowball was 10 to 20 % higher than that of 40% snowball. It could be caused by the deeper penetration of the projectile into the snow target. The deep penetration might induce the drastic change of the shock wave propagation in the target such that the radiation point moved toward the antipodal point to enhance the high pressure at the antipodal point.