Crater formation on snow by snow impact

Masahiko Arakawa[1]

[1] Inst. Low Temp. Sci., Hokkaido Univ.

http://risu.lowtem.hokudai.ac.jp/~arak/

Recently, the surface image of the comet, Wild-2, was observed by the US spacecraft, Stardust. The surface is entirely covered with craters as usual in the other planets, but some of them have quite unusual topography, that is, the craters are characterized by the deeper depth and the steep slope of the edge. These craters are also found on the surfaces on the asteroids, so that their origin has been discussed with the porous structure of these small bodies. In this study, we studied the impact crater formed on the snow surface, which simulates the comet surface, by laboratory experiments. The scaling law for snow on snow impact is discussed to apply the laboratory result to natural scale.

A snow target was prepared to fill a cylindrical container (dai.=10cm, depth=5cm) with ice particles (~500microns). The ice particles were slightly tapped to enhance sitering among them. The resultant target had a porosity of about 45% and the expected compressive strength is about 1MPa in this porosity. A projectile is also snow with the porosity of about 35 %, which was pressed to decrease the porosity and to increase the strength. The expected compressive strength is twice as large as the target and it is necessary to endure ablation by gas flow for the acceleration. The impact experiment was conducted in a cold room (-10deg.) with a one stage He gas gun. This gun can launch a snow projectile (dai.=15mm, mass=1.6g) at the velocity from 3 to 65 m/s. After the impact, the target was recovered to measure the crater volume and the topography. The net mass change by the projectile sticking and cratering was observed by an electric balance. The projectile speeds and the cratering process were observed by a high-speed digital video camera at the frame speed of 2000 fps.

The projectiles were recovered without disruption at the impact velocities below 13 m/s and they did not rebound from the surface after impact: the restitution coefficient is almost 0, which means the projectile sticks on the surface to contribute the increase of the target mass. Beyond the velocity of 13 m/s, the crater with the polygonal shape was observed and the depth was always deeper than that formed by ice on ice impact at the same crater diameter.

The relationship between the crater volume (V) and the kinetic energy (Ek) is derived to be V = V0 Ek^0.65. The power law index of this relationship is more than two times smaller than that of ice on ice impact. The crater volume formed at the same Ek shows that snow crater is two orders of magnitude larger than ice crater. It is noticed that even if snow projectile was used for the projectile, snow crater was still quite larger than ice crater. According to the scaling law for crater formation, the power index of the above relationship is a good parameter to determine the physical mechanism controlling the crater size. When the crater size is limited by the snow strength, the index should be 1.2. This is rather larger than our result of 0.65. In the case that the size is limited by the gravity, the index should be 0.75, which is similar to our result. However, our snow sample exactly has strength to support itself against the gravity. Therefore, it is quit unclear why the derived power index is similar to the theoretical value for gravity regime rather than that for strength regime.