Crater shape and projectile trajectory in glazing impact on regolith

*Taisei Yamamoto[1], Akiko Nakamura[1]

1. Kobe University

Oblique impacts occur frequently from interplanetary space to the surface of celestial bodies. Therefore, several experiments have been conducted to simulate oblique impacts on regolith (e.g., Gault and Wedekind, 1978; Wright et al., 2020; Suo et al., 2023). The probability of oblique impacts by interplanetary bodies at impact angle i (angle from the tangent direction of the surface) is expressed as $dP=2\sin i\cos i\,di$(Shoemaker, 1961), and the probability of impacts occurring at impact angles of 10 degrees or less is ~3×10^{-2}, and that of impacts with an angle of 2 degrees or less is ~1×10^{-3}, meaning that there is a probability of about 1 in 1000 impacts. Not many experiments have been conducted on such glazing impacts.
Therefore, we conducted an experiment to clarify what kind of impact craters are formed by glazing impacts with an impact angle of less than 10 degrees, and how the impactors are ricocheted after the impact.

We conducted experiments using a gas gun with an impact velocity of a few hundred meters per second and an impact angle of less than 10 degrees to examine the crater shape. A high-speed camera was used to capture images of a 3 mm diameter nylon, glass, steel, and porous alumina projectile impacting a sand target with a grain size of ~0.65-0.80 mm, and the projectile’s velocity after ricochet was measured.

The crater shape becomes elongated along the direction of the projectile trajectory as the impact angle becomes smaller (e.g., Gault and Wedekind, 1978). Such a tendency was also observed in this experiment. The coefficient of restitution, the ratio of the velocity of the projectile after impact to the velocity before impact, was examined from images obtained with a high-speed camera. The coefficient of restitution for the horizontal component increased as the impact angle decreased. The relationship between impact angle and ricochet angle was compared with a previous study (impact on a sand target by a steel sphere at an impact velocity of 47 m/s (Soliman et al., 1976)) and generally agreed.
While the projectile is in contact with the sand, hydrodynamic drag and lift forces are thought to be acting on the projectile (Wright et al., 2020). The lift and drag coefficients derived from this phenomenological model are on the order of 10^{-1}, which is smaller than in previous studies (Wright et al., 2020). We will examine the effective projectile cross-section subject to drag, and conduct experiments with different target particle densities and shapes.

Keywords: impact, regolith, crater

