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VERIFICATION OF THE SCATTERING MECHANISM OF CELESTIAL SURFACE OBJECTS BY THRUSTER INJECTION

Abstract

This study experimentally investigated the cause and the scattering mechanism of the phenomenon in which a celestial surface object scattered by a thruster injection has a spacecraft direction component. The phenomenon was first observed by Hayabusa2. The asteroid explorer Hayabusa2 touched down on the asteroid Ryugu twice. During the touchdown of Hayabusa2, objects on the surface of the asteroid were scattered toward the vehicle. The possible causes of this phenomenon are that Hayabusa2 shot the projectile into the surface of the asteroid when it was sampling, and that Hayabusa2 fired the thruster when it left the surface. Ejector generation by projectile firing is a problem unique to Hayabusa2, but scattering of celestial surface objects by thruster firing may occur in all future missions including landing. If the scattering celestial surface objects hit or adhere to the spacecraft, it may interfere with the mission execution. Therefore, it is very important to understand the dispersal mechanism and behavior of objects on the surface of a celestial body by thrusters. This is because the impact of surface objects lifted by thrusters on a spacecraft will greatly degrade the engineering and physical performance required by the spacecraft, and thus the success or failure of the exploration mission itself will be greatly affected. There are three causes of ejecta scattered by thrusters. The first is that the thrusters are digging craters in the ground while the second is the effect of the original terrain. The third is that the thruster plumes from multiple thrusters collide with each other, creating an upward force. We conducted 1G and micro gravity experiments in which thrusters were fired onto a simulated soil whose interior was visualized through acrylic plates under vacuum in order to investigate the interaction between thruster plume and asteroidal regolith. Furthermore, we compared the experimental results with CFD calculations simulating the experimental environment to investigate the effect of the fluid injected from the thruster on the dispersal tendency. This research will enable us to understand the physical properties of surface objects

at the landing site of a spacecraft, and to constrain the design of sampling equipment that can collect more samples, which is expected to play an important role in the field of space exploration.