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DISPERSAL BEHAVIOR OF CELESTIAL SURFACE OBJECTS BY THRUSTER JET

Abstract

There is a problem when a spacecraft fires its thrusters at the surface of a celestial body, regolith on the surface of the celestial body is scattered vertically and adheres to the instruments onboard the spacecraft, such as cameras and ranging devices, degrading their performance. This problem was confirmed when the Japanese asteroid explorer Hayabusa2 touched down on the asteroid Ryugu. Hayabusa2 actually experienced problems with instrument performance degradation due to the adhesion of fine regolith on the ranging and observation instruments. Similar regolith scattering phenomena have also been observed on OSIRIS-REx and Sky Crane. It is necessary to clarify the regolith dispersal mechanism and direction of regolith dispersal by thruster injection in order to protect the spacecraft during landing and to ensure safe navigation and sufficient observation results. The authors investigated the regolith dispersal mechanism and direction by classifying the spacecraft into single-thruster and multiple-thruster types, and the target objects into gravitational and microgravity objects. An experiment was conducted in which multiple thrusters were injected into a sandbox under vacuum conditions, and the trajectories were obtained by image analysis. The trajectories of particles dispersing in the fluid field were calculated using a simple DEM-CFD program, which reads the results of numerical fluid dynamics calculations performed under the same conditions as the experiment as a field and tracks the regolith trajectories in the field. The results show that the primary dispersal direction of regolith follows the wall angle of the crater formed by the thruster jet. The crater shape depends on the injection pressure, regolith particle size, and gravity. In addition to the case of vertical thruster injection, the crater shape and dispersal tendency of the craters formed when the thruster is canted were newly clarified. In the case of multiple thrusters injected simultaneously, it was found that the regolith also changes the dispersal direction secondarily as the plumes collide with each other at the center and change the vertical direction of the main flow. The secondary change in regolith dispersal direction caused by the interference of multiple thrusters occurs

when the force exerted on the regolith by the plume main flow exceeds its inertia. Based on the new findings, the placement of spacecraft equipment that is less susceptible to the effects of scattered regolith is discussed.