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Sampling of Regolith on Asteroids Utilizing Electrostatic Force

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To achieve reliable and autonomous regolith sampling on asteroids, we have developed a unique sampler that utilizes the electrostatic force. When a rectangular high voltage is applied between parallel screen electrodes mounted at a lower end of a tube, the resultant electrostatic force acts on regolith particles in the vicinity of the electrodes. Some of the agitated particles are captured passing through the openings of the screen electrodes. In a microgravity environment such as the surface on the small asteroid Itokawa, the captured particles would be transported to a collection capsule located in the upper part of the tube due to their own inertia force, because the motion of particles is not affected by the negligible small gravitational force. The electrostatic sampler is very simple, has no mechanical drives, and does not need any complicated control, thus making it highly reliable. In addition, the sampler consumes extremely low power, and there is no risk for the contamination of impurities. To predict the performance of the sampler in the microgravity environment, we conducted a numerical calculation using the Distinct Element Method. The calculation results show a successful capturing of regolith, which include both conductive and insulative particles, in an air and the microgravity environment. Also, the sampler would perform much better in a vacuum than in the air. Moreover, samplings of some particles were experimentally carried out in a zero-G environment reproduced by the parabolic flight of an aircraft. It was demonstrated that a large amount of lunar regolith simulant, approximately 900 mg, was successfully collected without mechanical means. The collected regolith particles contained various diameters from 10 μm to 1 mm. Not only lunar regolith simulant, but also large particles, such as glass particles of 2 mm and rocks of 5 mm, could be also captured using our sampler in the microgravity environment. Our sampler is expected to be effective for future sample return missions, as not only stand-alone system but also both spare and support system for other sampling means. Because the sampler can be compactly designed, it can be easily equipped with the spacecraft without disturbing the operation of other sampling system. The sampler is compatible with other sampling systems, such as that employed on Hayabusa and Hayabusa-2, which shoot a bullet at the asteroid surface and raises a cloud of dust, because the electrostatic sampler can automatically capture floating particles without precise controls.