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Author: Ms. Maiko Yamakawa
The Graduate Universty for Advanced Studies (SOKENDAI), Japan

Mr. Kentaro Watanabe
Shizuoka University, Japan
Dr. Hiroumi Tani
Japan Aerospace Exploration Agency (JAXA), Japan
Dr. Yusuke Maru
Japan Aerospace Exploration Agency (JAXA), ISAS, Japan
Dr. Toshihiro Chujo
Tokyo Institute of Technology, Japan
Dr. Jun Matsumoto
Japan Aerospace Exploration Agency (JAXA), Japan
Dr. Hikaru Eguchi
Japan Aerospace Exploration Agency (JAXA), ISAS, Japan
Mr. Keisuke Michigami
Japan Aerospace Exploration Agency (JAXA), Japan
Mr. Taro Kawano
Japan Aerospace Exploration Agency (JAXA), Japan
Dr. Osamu Mori
Japan Aerospace Exploration Agency (JAXA), Japan
Prof. Hajime Yano
Japan Aerospace Exploration Agency (JAXA), Japan
Dr. Yuichi Tsuda
Japan Aerospace Exploration Agency (JAXA), Japan
Dr. Shingo Kameda
Rikkyo University, Japan
Prof. Shujiro Sawai
Japan Aerospace Exploration Agency (JAXA), Japan

SCATTERING MECHANISM OF SURFACE MATERIAL BY THRUSTING NEAR ASTEROID

Abstract

In the asteroid explorer Hayabusa2, phenomenon in which the surface material of the asteroid scattered vertically occurred when touching down. It is thought that this phenomenon is caused by thrusting of Hayabusa2 to escape from the asteroid Ryugu's surface.

In the future, if a large amount of ejecta sticks to the spacecraft when a mission including touchdown is planned, it may cause a mission failure. On the other hand, the mechanism by which the ejecta scattered in the vertical direction during the touchdown of Hayabusa2 has not been identified. Therefore, it is very important to understand the generating factor and movement of ejecta when thrusters are operated near asteroids.

Accordingly, the goal of this research is to ensure that a spacecraft always has the proper thrusting scheme by understanding the mechanism and movement trends of vertically erupting ejecta when performing a gas-ejecting maneuver near an asteroid. In addition, the appropriate spacecraft design theory for missions including touchdown will be established.

Two factors can be considered as a hypothesis of the mechanism in which the ejector flies in the vertical direction. The first hypothesis is that the sand on the surface is dug when the gas is ejected, and the second hypothesis is that the gas flows from multiple thrusters interfere with each other. To reproduce them experimentally, gas is ejected into a sandbox simulating the surface of an asteroid. In the experiment, each parameter considered to be related to how the ejecta flies is changed, and the sensitivity of each parameter to the phenomenon that the ejecta flies upward is evaluated. The parameters of the hypothesis that the effect of sand excavation is the cause include the particle properties such as density, size, and shape, gravity, and how hard the ground is relative to the ejection pressure. The parameters related to the hypothesis that the interference is caused by a plurality of jets include the arrangement of nozzles. Moreover, the shape of the nozzle is a parameter related to both theories. Furthermore, for an experiment performed by changing these parameters, the initial velocity and the trajectory of the ejecta are obtained. After that, a simulation program is created to compare the Hayabusa2 flight data with the experimental results. By using a simulation program to clarify the mechanism by which the ejecta scatters in the vertical direction, we discuss what ejection method and spacecraft design are good for future exploration.