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Author: Ms. Kristin Nichols
University of Colorado Boulder, United States

Prof. Daniel Scheeres
Colorado Center for Astrodynamics Research, University of Colorado, United States

DUST ENVIRONMENT MODELS FOR ASTEROID SURFACE OPERATIONS

Abstract

Small-body exploration missions are increasingly designed to interact with the target body, as the OSIRIS-REx and Hayabusa2 missions will. However, failures such as the anchoring problems associated with the bouncing Philae lander on comet 67P illustrate that proximity operations about small-bodies remains non-trivial. This motivates the development of small-body surface models which could be used by future exploration and utilization missions. Developing such models are not only critical to motivate exploration of a specific body, but also highlight the challenges encountered for operations in such environments. The primary forces acting on dust particles and regolith include the ambient gravitational force, cohesion due to van der Waals forces, and electrostatic forces (Scheeres et al. 2010). Dust levitation can only occur when an upward electrostatic force is able to overcome the forces of gravity and cohesion. Work by Hartzell and Scheeres (2011) showed that the electric fields required for such lofting of dust were unpractically large. However, recent work by Wang et al. (2016) experimentally showed that particle lofting could occur with much lower levels of electric field, primarily though the use of a new patched charge model, as opposed to the traditional shared charge model. As a part of this model, Wang also predicted and showed experimentally the existence of a particle-particle repulsive electrostatic force that is nearly two orders of magnitude greater than the traditional value given to represent the electrostatic force. These new models predict that dust levitation may be common at small bodies, motivating its detailed study. This paper develops and studies the levitation and transport of dust on small airless bodies using this new charging model. From proper analytical expression of the electrostatic force to simulation of the dynamics of a dust particle about an asteroid using initial conditions observed experimentally by Wang, this paper provides new insights and understanding into the dusty, charged environments around small-bodies. Such insights include predictions on what conditions lead to dust particle launching from the surface of a body and the subsequent motion of particles separated from the surface. Such results can be used by the Hayabusa2 and OSIRIS-REx missions to compare our current understanding of the dusty environment to that which is observed in nature, and give us a more complete understanding of how operations should be planned for missions to small-bodies.