SPACE EXPLORATION SYMPOSIUM (A3)
Small Bodies Missions and Technologies (5)

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INTERNAL ASTEROID COMPOSITION THROUGH DISTRIBUTED SENSING

Abstract

Small-body space missions and Earth-based observations have helped make important advances in asteroid characterization through remote sensing. Soon these missions will provide laboratories with physical samples. Fundamental questions remain, however, which affect our understanding of the formation and evolution of the solar system. These questions result in uncertain strategies for planetary protection and threat mitigation.

To date, little is known about the internal composition of asteroids. Numerical and experimental studies have examined various theories and these theories have been complemented by remote sensing and Earth-based radar imagery. Other mission concepts have been proposed for in-situ subsurface landers or impactors. For more reliable data in the exploration of remote bodies, it has been proven that in-situ measurements are necessary, but the accuracy and outcome of these methods are difficult to predict. This work proposes a small network of in-situ probes to study the interior of small bodies through radar mapping.

Unfortunately the electrostatic properties of an asteroids surface yield potentially hazardous environments due to dust levitation occurring near any lander. Previous missions and experiments dating from the Apollo program have studied the redistribution of regolith on the surface due to these electrostatic charging cycles. However, to date, little to no measurements have been obtained regarding the electrostatic surface properties of asteroids, which may or may not be coupled with interior mass distribution. These properties are necessary to understand when carrying out reliable in-situ and sample return operations.

In this mission concept, we primarily seek to map the interior of an asteroid through radio transmission tomography, and secondarily seek to analyze the surface charge by studying the local electric field. Other secondary objectives are to measure in-situ parameters such as gravitational, magnetic, and thermal properties. For better characterization, the probes are to be launched from a mothership at different orbital positions to land at pre-determined strategic locations that will minimize the internal asteroid uncertainty (as given by possible singular configurations). A possibly larger secondary lander will be able to carry out more complex operations while receiving data from the probes, and transmitting to the mothership. A larger lander may also be mobile, allowing for a more accurate map of the interior to be gathered from changing sensor configurations while in-situ measurements are being obtained.

In this paper, we discuss candidate designs of the probes and the larger lander through the mission analysis of orbit to surface. We show that although asteroids have an inherently challenging environment, the proposed distributed sensing can more reliably answer fundamental questions on the nature of small bodies, while remaining relatively simple to implement.