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What's Inside a Rubble Pile Asteroid? DISCUS - a Tomographic Twin Radar Cubesat to Find Out

Jakob Deller(1,*), Patrick Bambach(1), Esa Vilenius(1), Sampsa Pursianen(2), Mika Takala(2), Hans Martin Braun(3), Harald Lentz(3), Manfred Wittig(4)

(1) Max Planck Institute for Solar System Research (Justus-von-Liebig-Weg 3, D-37077 Göttingen),
(2) Tampere University of Technology
(3) RST Radar Systemtechnik GmbH
(4) MEW-Aerospace UG, Hameln, Germany
(*Email:deller@mps.mpg.de)

Abstract

DISCUS, the Deep Interior Scanning CubeSat, is a mission concept based on a penetrating step frequency radar to resolve the interior structure of a rubble pile asteroid using computed tomography.

A big fraction of asteroids with d>240 m are suspected to be loose piles of rocks and boulders bound together mainly by gravity and weak cohesion. Still, to date the size and distribution of voids and monolith inside these "rubble-piles" are not known. To perform a full tomographic interior reconstruction a bistatic CubeSat configuration has been investigated by TU Tampere, Radar System Technology (RST) and the Max Planck Institute for Solar System Research (MPS). The concept is based on two 6U CubeSats, both carrying an identical 1U sized stepped frequency radar. As stepped frequency radars can be built compact, require less power and generate less data volume compared to other radar applications they are well-suited for small sat platforms.

In 2017 the Concurrent Design Facility of ESA/ESTEC conducted two studies relevant for DISCUS. In the Small Planetary Probes (SPP) study DISCUS served as a reference payload for a piggyback mission to a NEA or a main belt asteroid. The M-ARGO study investigated a stand-alone mission to a NEA, with a DISCUS sized instrument. Based on the spacecraft design of SPP and M-ARGO we could prove the instrument requirements as feasible and evaluate our science case from the orbits and mission duration that have been identified by the studies.

Using inversion methods developed for medical tomography the data would allow to reconstruct the large scale interior structure of a small body. Simulations have shown that the measurement principle and the inversion method are robust enough to allow full reconstruction of the interior even if the orbits do not cover the entire surface of the asteroid.

The measurement results of the mission will help to gain a better understanding of asteroids and the formation mechanisms of the solar system. In addition, the findings will increase the predictability of asteroid impact consequences on earth and improve future concepts of asteroid deflection.