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The Main-belt Asteroid and NEO Tour with Imaging and Spectroscopy (MANTIS)

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Abstract

The Main-belt Asteroid and NEO Tour with Imaging and Spectroscopy, proposed to the 2019 Discovery mission competition offered by NASA, is a flyby grand tour encountering 14 asteroids covering a wide range of types and masses, and obtaining remote sensing and in-situ data with a powerful multi-instrument payload.

1. Introduction and Motivation

The asteroids preserve information from the earliest times in solar system history, with compositions in the population reflecting the material in the solar nebula that experienced a wide range of temperatures. Today they experience ongoing processes, some of which are shared with larger bodies but some of which are unique to their size regime. They are critical to humanity's future as potential threats, resource sites, and targets for human visitation. However, over 25 years since the first spacecraft encounters with asteroids, they remain poorly understood and seldom visited.

A flyby tour of asteroids is an effective means of quickly sampling many members of this population of objects, providing discovery science on a large number of small worlds in the inner solar system and also returning data that is complementary and contextual to past, present, and future missions. While the overwhelming numbers of small bodies makes the prospects of visiting a representative sample of asteroids daunting, recent work suggests that the vast majority of objects in the asteroid belt may be derived from a small number of 100-km-scale parent bodies [1, 2], which then collisionally evolved to created today's population. Focusing on family members makes it possible to effectively visit the objects responsible for most of the impactors in the inner solar system and the meteorites that fall to Earth, and providing ground truth for extensive observations conducted from Earth.

2. Targets

The MANTIS tour, as noted, visits 14 asteroids. The largest of these is 50 Virginia, an 85-km Ch-class asteroid that is consistent with an intact planetesimal in the "born big" scenario [1]. The smallest is the Mars Trojan 2011 UB256 which is ~300 m in diameter. Other objects of especially notable individual interest are the multiple system 1993 QO and a member of the Gersuind family, whose members tend to be in the unusual L spectral class [2].

In addition to these objects of particular interest, the MANTIS tour is designed to focus on members of asteroid families. The trajectory goes past members of eight known collisional families (including objects already mentioned) of different spectral classes and in different parts of the asteroid belt. This allows robust comparisons of surface properties and active processes among objects within families, between families thought to have similar compositions, and between families with dissimilar compositions. It also provides for a test of the homogeneity of family members via remote sensing, how objects change between their original parent bodies and arrival at Earth as meteorites, and how representative family members are of their parent bodies.

3. Payload

MANTIS has a payload of four instruments, allowing comprehensive characterization of the objects it encounters. These instruments include a powerful narrow-angle camera similar to that onboard the New

Horizons spacecraft and planned for inclusion on the Double Asteroid Redirection Test (DART) and Lucy spacecraft, a near-infrared imaging spectrometer similar to the CRISM instrument onboard the Mars Reconnaissance Orbiter, a mass spectrometer analyzing microsamples shed by asteroids and interplanetary dust particles encountered during cruise, and a mid-infrared camera measuring thermal emission and built by colleagues in the United Kingdom.

4. Summary

The mission we present, the Main-belt Asteroid and NEO Tour with Imaging and Spectroscopy (MANTIS), explores the diversity of asteroids to understand our solar system's past history, its present processes, and future opportunities and hazards. The MANTIS tour visits 14 unexplored asteroids, including an intact planetesimal, a Mars Trojan asteroid, a low-albedo multiple-asteroid system, and members of 8 collisional families. MANTIS addresses many of NASA's highest priorities as laid out in its 2014 Science Plan and provides additional benefit to the Planetary Defense and Human Exploration communities via a low-risk, cost-effective tour of the inner asteroid belt. MANTIS would revolutionize our understanding of asteroids through its state-of-the-art payload of complementary instruments: A powerful infrared imaging spectrometer and narrow angle camera, both with recent flight heritage, an innovative dust analyzer operating during and between asteroid encounters, and a capable mid-IR imager to help. MANTIS obtains datasets at each target that can be readily intercompared with one another, effectively doubling the current sample of asteroids visited by spacecraft.

We will discuss the MANTIS concept as proposed to the 2019 Discovery competition.

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