IAF SPACE EXPLORATION SYMPOSIUM (A3)
Small Bodies Missions and Technologies (Part 2) (4B)

Author: Dr. Justin Atchison
The John Hopkins University Applied Physics Laboratory, United States, justin.atchison@jhuapl.edu

Mr. Clint Apland
The John Hopkins University Applied Physics Laboratory, United States, clint.apland@jhuapl.edu
Mr. Mark Bryant
The John Hopkins University Applied Physics Laboratory, United States, mark.bryant@jhuapl.edu
Mr. Kyle Candela
The John Hopkins University Applied Physics Laboratory, United States, kyle.candela@jhuapl.edu
Mr. Ken Harclerode
The John Hopkins University Applied Physics Laboratory, United States, ken.harclerode@jhuapl.edu
Mr. Calvin Kee
The John Hopkins University Applied Physics Laboratory, United States, lake.kee@jhuapl.edu
Dr. Ryan Mitch
The John Hopkins University Applied Physics Laboratory, United States, ryan.mitch@jhuapl.edu
Dr. Andrew Rivkin
The John Hopkins University Applied Physics Laboratory, United States, Andrew.Rivkin@jhuapl.edu
Mr. Jake Wortman
The John Hopkins University Applied Physics Laboratory, United States, jake.wortman@jhuapl.edu
Dr. Erwan Mazarico
NASA Goddard Space Flight Center Greenbelt MD 20771, United States, erwan.m.mazarico@nasa.gov

AN INSTRUMENT PROTOTYPE FOR OPTICAL GRAVIMETRY DURING ASTEROID FLYBYS

Abstract

Optical gravimetry (OpGrav) is a method for estimating the mass of asteroids using observations from a spacecraft to a set of deployed test-masses. In this concept, a host spacecraft releases a group of small white spheres prior to an asteroid flyby. The spheres, which act as test-masses, are deployed such that they pass very near to the small body (1-10 km) and their trajectories are measurably perturbed. A spacecraft-mounted camera determines the relative right ascension and declination angle of each test-mass before and after the flyby. These measurements are then processed on the ground and used to estimate the small body's mass. The relative measurements have the advantage a high signal-to-noise ratio and high resolution, owing to the short ranges between the host spacecraft, the test-masses, and the small body.

Previous studies suggest roughly an order of magnitude improvement in accuracy or asteroid accessibility (how small an asteroid one can measure) over Earth-based Doppler-only mass estimation. Accurate mass determination drives asteroid density and porosity estimation. These are important parameters for inferring the asteroid's interior structure (homogeneous solid body vs. rubble pile), its formation and evolution, its expected response to planetary defense methods, and its potential for resource utilization.

We have designed, implemented, and fabricated a prototype instrument for this concept called the Small-body In-situ Multi-probe Mass Estimation Experiment (SIMMEE). This prototype provides a basis for inputs into the simulations, grounding the models with physical values. The primary design driver for the instrument is a need for accurate deployment parameters to enable flybys of very small asteroids. A

long mechanism life is also a consideration. The mechanisms are designed for five years of flight prior to operation.

The instrument consists of a dispenser, a set of four collapsible test-mass spheres called probes, and four pairs of sabots to house the probes. The dispenser contains the sabots and probes, which are shielded prior to operation with a frangibolt actuated door. The sabots are deployed using independent compression springs that provide roughly 3 m/s of separation velocity within 0.3 degrees of a nominal deployment vector. A set of two LED emitters and photodiodes measure the exit velocity and timing to 1 mm/s and 0.1 ms accuracy respectively.

This paper presents the current SIMMEE instrument prototype design and testing. This includes size, mass, and power accommodation requirements. We present the remaining development schedule in preparation for potential flight opportunities on future planetary science missions.