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Small Bodies Missions and Technologies (Part 1) (4A)

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OPTICAL GRAVIMETRY FOR PLANETARY DEFENSE FLYBY RECONNAISSANCE MISSIONS

Abstract

In a planetary defense scenario, it is critical to accurately determine the threatening asteroid's mass and density. These parameters inform which mitigation options are possible and how to scale them appropriately. However, the mass of asteroids is challenging, if not impossible, to accurately determine from distant observations. Consequently, if an asteroid were threatening Earth, the first step is to send a reconnaissance mission to obtain estimates of the small body's mass, size, shape, and density prior to designing a mitigation response.

A rendezvous mission provides the most accurate estimates of these critical parameters, but they require long time-scales and often infeasibly high delta-v capabilities. Alternatively, a flyby mission can reach the asteroid faster since it does not require the spacecraft to match the asteroid's orbit. However, flyby missions offer a much more limited opportunity to observe the target. For all but the largest asteroids, typical radiometric-based tracking techniques cannot determine the asteroid's mass to relevant accuracy from a flyby. In this paper, we evaluate an approach to solve this problem and achieve useful mass determination from an asteroid flyby mission. This would offer a solution to the planetary defense knowledge gap between identifying a potential threat and designing a suitable response.

In this paper, we evaluate a technique for estimating the mass of an asteroid during a spacecraft flyby, optical gravimetry (OpGrav), in the context of planetary defense. As a reference scenario, we use the 2019 Planetary Defense Conference hypothetical asteroid impact exercise. This reference scenario provides the full context for orbit geometries and knowledge timelines. OpGrav works by deploying and tracking a set of small test masses prior to the asteroid flyby. The test masses pass very close to the small body and are imaged by the host spacecraft using a high-resolution camera. The low flyby distance deflects the test masses, despite the small mass of the asteroid. In previous analyses, this approach has been shown to offer an order of magnitude better mass estimates during a flyby than traditional techniques.