IAF SYMPOSIUM ON PLANETARY DEFENSE AND NEAR-EARTH OBJECTS (E10)
Informing Planetary Defense (2)

Author: Dr. Björn Grieger
European Space Agency (ESA/ESAC), Spain, bjoern.grieger@ext.esa.int

Dr. Michael Küppers
European Space Agency (ESA), Spain, michael.kueppers@sciops.esa.int

DETERMINING DIMORPHOS' MASS FROM THE WOBBLE OF DIDYMOS

Abstract

In order to demonstrate of the feasibility of the deflection of an Earth threatening asteroid, the DART mission impacted Dimorphos, the asteroid moonlet of Didymos, on 26 September 2022. For the assessment of the efficiency of the momentum transfer, the mass of Dimorphos needs to be known.

Around October 2026, the Hera mission will reach the Didymos binary system and inspect closely its properties and the consequences of the DART impact. Images taken by the Asteroid Framing Cameras aboard Hera will make it possible to measure the wobble of Didymos introduced by its common orbiting with Dimorphos around the barycenter of the binary system. This will enable the estimation of Dimorphos' mass.

In 2016, we discussed the expected accuracy of such a mass reconstruction under different assumptions (EGU2016-12296). So far, we had skiped the process of actually defining landmarks and measuring their pixel positions in images. We just assume landmark positions in the body fixed frame randomly distributed over the surface of Didymos. The available measurements are then inertially referenced directions from the spacecraft to the landmarks at different times (images).

In the reconstruction process, we assume that we do not know anything about the true landmark positions, the spacecraft trajectory, and the orientation of Didymos. Image by image, we estimate the pose (position and attitude) of the asteroid relative to the spacecraft. Through many iterations over all images, the landmark positions in the body fixed frame are optimized. Because the attitude of the spacecraft is known, this provides the trajectory of the spacecraft relative to Didymos. The trajectory reconstructed in this way is falsified in the sense that it comprises the wobble of Didymos around its common barycenter with Dimorphos.

In a second step, we filter the wobble out of the spacecraft trajectory and estimate its size. Here, we assume that the orbit of Dimorphos is known, so we know the period of the wobble and its direction at all times.

So far, each time point had been treated separately. With the additional assumption of a continuous asteroid rotation and its appropriate modeling, the accuracy of the mass estimation can be improved. Moreover, with the new data from the DART mission and the matured design of the Hera mission, we are now able to refine the predictions and prepare in more detail the strategy for the reconstruction of the mass of Dimorphos.