

The Double Asteroid Redirection Test in the AIDA Project

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The Asteroid Impact & Deflection Assessment (AIDA) mission will be the first space experiment to demonstrate asteroid impact hazard mitigation by using a kinetic impactor. AIDA is a joint ESA-NASA cooperative project, that includes the ESA Asteroid Impact Mission (AIM) rendezvous mission and the NASA Double Asteroid Redirection Test (DART) mission. The AIDA target is the near-Earth binary asteroid 65803 Didymos, which will make an unusually close approach to Earth in October, 2022. The ~300-kg DART spacecraft is designed to impact the Didymos secondary at 7 km/s and demonstrate the ability to modify its trajectory through momentum transfer. DART and AIM are currently Phase A studies supported by NASA and ESA respectively.

The primary goals of AIDA are (1) perform a full-scale demonstration of the spacecraft kinetic impact technique for deflection of an asteroid, by targeting an object larger than ~100 m and large enough to qualify as a Potentially Hazardous Asteroid; (2) measure the resulting asteroid deflection, by targeting the secondary member of a binary NEO and measuring the period change of the binary orbit; (3) understand the hyper-velocity collision effects on an asteroid, including the long-term dynamics of impact ejecta; and validate models for momentum transfer in asteroid impacts, based on measured physical properties of the asteroid surface and sub-surface. The primary DART objectives are to demonstrate a hyper-velocity impact on the Didymos moon and to determine the resulting deflection from ground-based observatories. The DART impact on the Didymos secondary will cause a measurable change in the orbital period of the binary. Supporting Earth-based optical and radar observations and numerical simulation studies are an integral part of the DART mission.

The baseline DART mission launches in December, 2020 to impact the Didymos secondary in September, 2022. There are multiple launch opportunities for DART leading to impact around the 2022 Didymos close approach to Earth. The AIM spacecraft will be launched in Dec. 2020 and arrive at Didymos in spring, 2022, several months before the DART impact. AIM will characterize the Didymos binary system by means of remote sensing and in-situ instruments both before and after the DART impact. The asteroid deflection will be measured to higher accuracy, and additional results of the DART impact, like the impact crater, will be studied in great detail by the AIM mission. The combined DART and AIM missions will provide the first measurements of momentum transfer efficiency β from hyper-velocity kinetic impact at full scale on an asteroid, where the impact conditions of the projectile are known, and physical properties and internal structures of the target asteroid are also characterized.

The DART impact on the Didymos secondary is predicted to cause a ~4.4 minute change in the binary orbit period, assuming $\beta=1$, and is expected to be observable within a few days. The predicted β would be in the range 1.1 to 1.3 for a porous target material based on a variety of numerical and analytical methods, but may be much larger if the target is non-porous. The DART kinetic impact is predicted to make a crater of ~6 to ~17 meters diameter, depending on target physical properties, but will also release a large volume of particulate ejecta that may be directly observable from Earth or even resolvable as a coma or an ejecta tail by ground-based telescopes.