EPSC Abstracts
Vol. 10, EPSC2015-123, 2015
European Planetary Science Congress 2015

Asteroid Impact and Deflection Assessment (AIDA) mission: science investigation of a binary system and mitigation test

P. Michel (1), A.F. Cheng (2), M. Küppers (3) for the AIDA Team
(1) Lagrange Laboratory, University of Nice, CNRS, Côte d'Azur Observatory, France, (2) JHU/APL, Maryland, USA, (3) ESA-ESAC, Madrid, Spain (michelp@oca.eu / Fax: +33-4-92003121)

Abstract

The Asteroid Impact & Deflection Assessment (AIDA) mission will be the first space experiment to investigate a binary near-Earth asteroid (NEA) and to demonstrate asteroid impact hazard mitigation by using a kinetic impactor. AIDA is a joint ESA-NASA cooperative project, which includes the ESA Asteroid Impact Mission (AIM) rendezvous spacecraft and the NASA Double Asteroid Redirection Test (DART) mission. The primary goals of AIDA are (i) to investigate the binary NEA (65803) Didymos, (ii) to test our ability to impact its moon by an hypervelocity projectile in 2022 and (iii) to measure and characterize the impact deflection both from space with AIM and from ground based observatories.

1. Introduction

AIDA is a joint ESA-NASA cooperative project, which includes the ESA Asteroid Impact Mission (AIM) rendezvous spacecraft and the NASA Double Asteroid Redirection Test (DART) mission. The AIM study entered Phase A/B1 at ESA in early 2015 and will proceed through summer 2016. The DART study entered NASA Phase A in late spring 2015 and will also proceed through summer 2016. The critical decisions on AIM and DART to proceed to the next phases at ESA and NASA will be made at roughly the same time (second half 2016).

The target of AIDA is the binary NEA (65803) Didymos, with the deflection experiment to occur in October, 2022. The DART impact on the secondary member of the binary at ~6 km/s will alter the binary orbit period, which can be measured by Earth-based observatories. The AIM spacecraft will be launched in 2020 and arrive at Didymos in spring 2022. AIM will characterize the Didymos binary system by means of remote sensing and in-situ instruments and monitor results of the DART impact.

AIDA addresses issues that interest a large variety of communities, such as communities of researchers and engineers working on impact physics, planetary defense, seismology, geophysics (surface and internal properties), dynamics, mineralogy and resources, spectral and physical properties of small bodies, low-gravity environments and human exploration.

2. AIM: science return

AIM [1] is a rendezvous mission that focuses on the monitoring aspects i.e., the capability to determine in-situ the key properties of Didymos' satellite used as the target of the deflection test. AIM will also give access to the detailed conditions of the DART impact and its outcome, allowing for the first time to get a complete picture of such an event, a better interpretation of the deflection measurement and a possibility to compare with numerical modeling predictions. Baseline payloads for AIM include the following remote sensing and in-situ instruments: a Visual Imaging System, a lander (based on DLR MASCOT heritage), a thermal infrared imager, a high frequency (decimeter-wave) radar, and a low frequency (60 MHz) radar, to measure Didymos surface and sub-surface physical properties and to study internal structures. AIM also includes an optical communication demonstration that can be used as a laser altimeter and CubeSat payloads.

AIM has several objectives. First, AIM will characterize for the first time the secondary of a binary asteroid, allowing us to better understand the formation and properties of these systems that represent 15% of the NEA population. Second, AIM will demonstrate the technologies required by a simple monitoring spacecraft as well as establishing the suitability of binary asteroids as candidates for future explorations and asteroid deflection tests. Finally AIM will demonstrate, on the minimum expression of a deep-space mission, technologies related to autonomous navigation, optical communication, on-board resources management and close proximity operations.

AIM is not meant to be a purely scientific mission but rather a technology demonstration. However, AIM will improve drastically our scientific knowledge on small asteroids, in very relevant areas of Solar System science, such as asteroid geophysics, granular mechanics, impact processes, and thermal effects/properties.

The characterization of Didymos' satellite by AIM will provide precious knowledge on the physical/compositional properties of at least a component of a near-Earth-Asteroid (NEA). Physical and compositional properties of small bodies provide crucial information on the dynamical and collisional history of our Solar System. In addition, the formation mechanism of small binaries is still a matter of debate, although several scenarios have been proposed to explain their existence. In particular, rotational disruption of an NEA, assumed to be an aggregate, as a result of spin-up above the fission threshold due to the YORP effect (a thermal effect which can slowly increase or decrease the rotation rate of irregular objects) has been shown to be a mechanism that can produce binary asteroids with properties that are consistent with those observed. These properties include the oblate spheroidal shape of the primary, the size ratio of the primary to the secondary and the circular equatorial secondary orbit [2]. Other fission scenarios have been proposed which imply different physical properties of the binary and its progenitor [3]. Binary formation scenarios therefore place constraints on, and implications for the internal structure of these objects.

Small asteroids undergo substantial physical evolutions, and yet the geophysics and mechanics of these processes are still a mystery. AIM will allow us to address fundamental questions, such as: what are the subsurface and internal structures of asteroid's satellites and how does an asteroid's surface relate to its subsurface? What are the geophysical processes that drive binary asteroid formation? What are the strength and thermal properties of a small asteroid's surface? What is the cohesion within an aggregate in micro-gravity? What are the physical properties of the regolith covering asteroid surfaces and how does it react dynamically to external processes, such as the landing of a surface package and/or an impact?

3. DART: science return

The primary goals of DART [4] are (i) to demonstrate a hypervelocity spacecraft impact on a small near-Earth asteroid (NEA) and (ii) to measure and understand the deflection caused by the impact. The DART mission includes ground-based optical and radar-observing campaigns of Didymos both before and after the kinetic impact experiment, as well as modeling and simulation programs. DART has the further objective to learn how to mitigate an asteroid threat by kinetic impact and to develop and validate models for momentum transfer in asteroid impacts. AIM will further make detailed measurements of the DART impact and its outcome.

6. Summary and Conclusions

The DART and AIM missions, comprising AIDA, will return fundamental new information on a binary system, on its mechanical response, on the impact cratering process, and consequently on the collisional evolution of asteroids with implications for planetary defense, human spaceflight, and Solar System science. AIDA mission studies involve various scientific activities regarding binary dynamics and impact modeling, asteroid geophysics, observations. AIDA will be the first fully documented impact experiment at real asteroid scale, allowing numerical codes to be tested and used for similar and other scientific applications at those scales.

Acknowledgements

We are happy to acknowledge the support of ESA for the AIM studies and of NASA for the DART studies.

References

[1] Küppers, M., Carnelli, I., Galvez, A., Mellab, K., Michel, P. and the AIM team: The Asteroid Impact Mission (AIM), EPSC 2015, abstract.

[2] Walsh, K., Richardson, D.C., and Michel, P: Rotational breakup as the origin of small binary asteroids, Nature, Vol. 454, pp. 188-191, 2008.

[3] Jacobson, S.A and Scheeres, D.J: Dynamics of rotationally fissioned asteroids: Source of observed small asteroid systems, Icarus, Vol. 214, pp. 161-178, 2011.

[4] Cheng, A.F., Michel, P. for the AIDA team: Asteroid Impact and Deflection Assessment mission: the Double Asteroid Redirection Test (DART), EPSC 2015, abstract.