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Ejecta evolutions and fates from the AIDA impact on the secondary of the binary asteroid Didymos: a NEOShield-2 project contribution

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Abstract

The Asteroid Impact & Delfection Assessment mission is a project composed of two components: the European (ESA) Asteroid Impact Mission (AIM) and the USA (NASA) Double Asteroid Redirection Test (DART) mission. The objectives of AIDA are: (1) to perform a test of asteroid deflection using DART, and (2) with AIM, to investigate the binary near-Earth asteroid Didymos, in particular its secondary and target of DART, called hereafter Didymoon, and to observe the impact outcome of DART using both the main spacecraft and a Cubesat [1]. In order to determine the safest position for the AIM spacecraft to observe the DART impact and to better understand the evolutions and fate of ejecta produced by such an impact, we have developed a model that computes the evolutions of ejecta in the Didymos system, including the gravitational perturbations of the system, the solar radiation pressure, and the solar tides [2]. We have then performed a study showing how the ejecta evolutions and fate depend on the launching speed and location on Didymoon.

1. Introduction

One of the purposes of the Asteroid Impact & Deflection Assessment (AIDA) space project is to understand the post-dynamics of the ejecta cloud produced by a hypervelocity impact on the secondary of the binary near-Earth asteroid (65803) Didymos. In a preliminary work also supported by the NEOShield-2 project funded by the European Commission (H2020 program), a two-stage method to track the motion of arbitrary individual ejected particles was developed and applied to a full-scale simulation of the ejecta cloud in the Didymos system [2]. In a second work, using this method, we have then performed systematic simulations over a wide parameter space, and the results reveal several global features of the ejecta fate distribution. In particular, a grid search of launching sites of ejecta was defined over the globe of Didymoon, and considering a wide range of possible ejection speeds, we determined the dependency of ejecta fate on launching sites and speeds. This range allows us to track all the complex cases that include different types of dynamical fates, such as a collision with one of the binary components or the escape from the region of influence of the system.

2. Results

25 groups of simulations in total were performed to sweep the parameter space and to analyse the dependencies of the ejecta fate on (λ, ϕ) and v_l, where λ and ϕ denote the longitude and latitude of the launching site, respectively, and v_l is the ejecta launching speed, which is supposed to follow the purely normal direction of the launching site. We then performed simulations of two-month long evolutions of the tracer particles. This time is supposed to be long enough for the interest of AIDA, and to enable a complete observation, i.e. most tracer particles may have either impacted a binary component, escaped the system or entered a period of relatively stable motion within the simulated time. We first consider a large size of ejecta, in order to neglect the solar radiation pressure and first check the role of purely gravitational perturbations.

Our results reveal the detailed proportions of the ejecta that are either orbiting, escaping or re-accreting on the primary/secondary before the final simulation time, as a function of the ejection speed and launching site, which allows us to explore the global characteristics of the ejecta dynamical fates (Fig. 1; [3]). Two major mechanisms are found to be working broadly during the post-ejection evolution of the ejecta cloud: 1) ejecta on mean-motion resonance orbits with Didymoon produce long-term quasi-periodic re-accretion peaks over at least a couple of weeks after the projectile impact, 2) ejecta on non-resonant orbits produce a rapid re-accretion peak that is not recurrent; this is because ejecta on such orbits that do not experience a collision during their first encounter with a binary component leave the system. The slingshot effect occurs in both mechanisms, which is a source of chaotic motion as ejecta with similar initial conditions can then have very different fates. Moreover, a vacuum of ejecta is noticed to emerge around the mid-latitude zone of the celestial sphere in a period posterior to the impact.

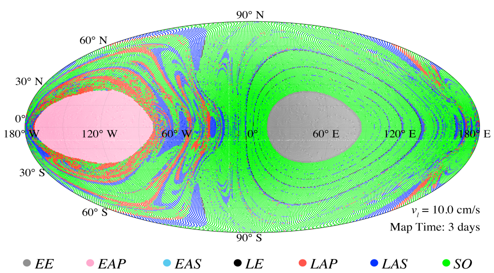

Figure 1: Dynamical fate of ejecta from Didymoon's surface. The solar radiation pressure is neglected. The example map shows the distribution of the 7 types of dynamical fates pictured against the launching sites of the sampled particles, each for a unique ejection speed of 10.0 cm/s. The primary of Didymos is in the direction of the left of the image. The different colors correspond to the 7 different fates: Early Escape (EE), Early Accretion on the Primary (EAP) or Secondary (EAS), Late Escape (LE), Late Accretion on the Primary (LAP) or Secondary (LAS), Surviving Orbit (SO).

We then performed full-scale simulations of the ejecta cloud released from 6 hypothetical impact sites and assuming two types of material of the subsurface, combining a power-law size distribution and a scaling-law crater ejection model. Results of these simulations, as well as the role of the solar radiation pressure, the re-impact speeds of the ejecta that fall back on the primary or secondary and other results of this extensive investigation will be shown at the conference. Our model can be applied to other binary or individual asteroids and impact scenarios.

Acknowledgments

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References

[1] Michel, P., et al.: AIM-D^2: Asteroid Impact Mission – Deflection Demonstration to the binary asteroid Didymos. Advances in Space Research, submitted, 2017.

[2] Yu, Y., Michel, P., Schwartz, S.R., Nadu, S.P., Benner L.: Ejecta Cloud from the AIDA Space Project Kinetic Impact on the Secondary of a Binary Asteroid: I. Mechanical Environment and Dynamical Model. Icarus, Vol. 282, pp. 313-325, 2017.

[3] Yu, Y., Michel, P.: Ejecta Cloud from AIDA Impact on the Secondary of a Binary Asteroid: II. Fates and Evolutionary Dependencies. Icarus, in preparation, 2017.