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ORBITAL DEPENDENCIES OF EJECTA FROM THE DART IMPACT ON THE SECONDARY OF 65803 DIDYMOS

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ABSTRACT

We study the orbital dependency of debris produced by a kinetic impact on the secondary of a binary asteroid system. In a preliminary work supported by the NEOShield-2 project of the European Commission in its program Horizon 2020, we developed a two-stage method to track the motion of arbitrary individual ejected particles. This method was mainly applied to assess the potential hazard posed by the ejecta produced by the impact on the secondary of the binary asteroid 65803 Didymos to the Asteroid Impact Mission (AIM) spacecraft in the framework of the AIDA deflection test mission. We then extended this numerical model to explore the general post-impact dynamics of the ejecta cloud in Didymos system, this time focusing on the possible fates of the orbits of the ejected material. Our analysis relies on a classification of the orbits as a function of the ejecta fates, e.g. a collision with

one of the binary components or the escape from the region of influence of the system. A grid search was performed using a range of ejection speed from the secondary's surface v_l=4.0~55 cm·s^{-1}. This range allows us to track all the complex cases that include different types of dynamical fates. For each specified v_l value, ~100,000 sampled particles were assigned to cover the entire globe of the moonlet of Didymos, which provided a hierarchical systematic sweep over the considered ranges of ejection speeds and launching sites. The results reveal the detailed proportions of the ejecta that are either orbiting, escaping or re-accreting on the primary/secondary at the termination time, as a function of the ejection speed, which allows us to explore the global characteristics of the ejecta's dynamical fates. 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 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 as 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.

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