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NEO Characterization

Energy Dissipation in Didymos Prior to Hera's Arrival

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ABSTRACT

Near-Earth binary asteroids usually consist of a large, rapidly rotating primary in a mutual orbit with a smaller secondary [1]. These systems undergo energy dissipation processes, primarily through tidal dissipation, which tends to rapidly reduce the secondary's spin rate to synchronous with the orbit rate, particularly for close-orbiting systems [2]. Understanding the process of energy dissipation is necessary for the study of the lifecycle of near-Earth binary asteroids, which consist of at least 15% of all near-Earth objects [3]. Binary asteroids play an important role in planetary defense, both due to their ubiquity among NEOs and their direct application through missions like DART [4], so a comprehensive understanding of these systems' lifecycle is important.

The DART impact offers an unprecedented opportunity to study energy dissipation in the Didymos binary asteroid system. The DART impact on Dimorphos, the secondary of Didymos, added an appreciable level of eccentricity to the mutual orbit, inducing libration in the secondary about the synchronous spin rate. Hera, which is planned to arrive at Didymos in 2026 to characterize the impact effects, will have the opportunity to study the dynamical state of the Didymos system [5]. The libration amplitude and eccentricity may have evolved since the impact due to dissiation, and this difference is a function of the tidal parameters in the Didymos system [6]. Hera's characterization of the post-impact Didymos depends on an understanding of the system's evolution in the years since the impact. To maximize the return from both DART and Hera, we

cannot ignore the process of relaxation of the system via energy dissipation between these missions. Specifically, neglecting energy dissipation could lead to underestimating the effects of the DART impact. Furthermore, this provides an unprecedented opportunity to constrain the tidal parameters of Didymos, something never done before for a small body.

We will present our analysis of the possible energy dissipation within Didymos after the DART impact but before Hera's arrival. With constraints on the Didymos system, particularly the shape of Dimorphos and change in velocity caused by the impact, we can test a wide range of possible tidal parameters to explore how energy dissipation may manifest upon Hera's arrival. As a function of the tidal parameters, we will present possible values of eccentricity and libration amplitude for the system. Depending on what Hera observes upon its arrival, we can constrain the rate of energy dissipation in the binary system. Furthermore, a fast enough dissipation rate may be directly observable by Hera during its time at Didymos.

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