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Ongoing and Upcoming Mission Highlights (DART)

THE EFFECT OF DIDYMOS INTERNAL STRUCTURE ON THE DYNAMICS

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ABSTRACT

On 26th September, 2022, the DART spacecraft intentionally impacted on Dimorphos, the secondary member of the Didymos system, successfully demonstrating the first planetary defense test in space [1]. The images captured by the DRACO camera [1] and LICIACube [2] have provided an initial understanding of the local topography of both Didymos and Dimorphos. Thus, a preliminary estimation of both asteroids' shape models is now available [1]. In this work, we examine the hypothesis regarding the internal structure of Didymos by comparing several rubble-pile models (multi-polyhedron, SPH, and PKDGRAV) to estimate the dynamical properties due to

variations in internal structure and grain density. Figure 1 shows how uncertainties in Didymos' bulk density affect its dynamical properties (e.g., equilibrium points).

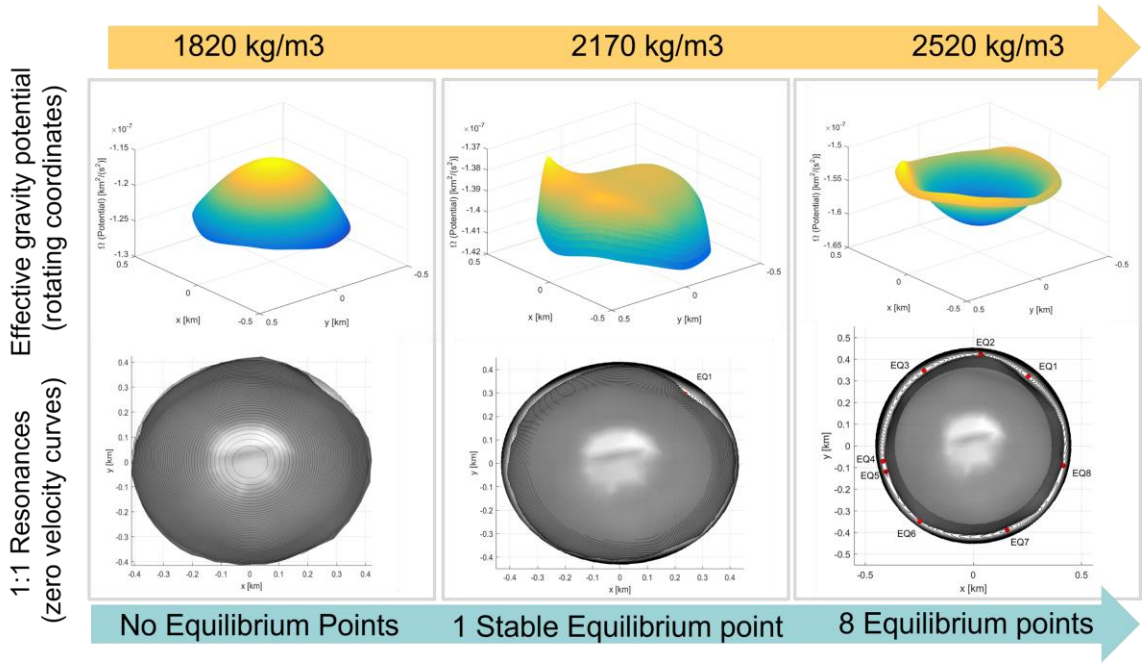

Figure 1 - The effect of the bulk density on dynamical objects (e.g., equilibrium points and 1:1 resonances). The first row of figures shows the effective gravity potential of Didymos where the gradient represent the intensity of the potential. The second row of figures show the zero velocity curves, curves where the velocity of a particle is null, and the existing equilibrium points.

To cross-compare different internal structure models, a sphere-cluster based gravity model (SPH-Mascon) is used. This method provides a semi-analytical expression of the linearised equations around the asteroids' equilibrium points [4] and an easy method for searching families of periodic orbits around them. The SPH-Mascon gravity model can retrieve the same dynamical objects (e.g., equilibrium points) of the polyhedron gravity model when a uniform bulk density is assumed but faster. The dynamics are solved for a rotating asteroid-fixed frame with angular velocity equivalent to the asteroid spin. The SPH-Mascon gravity model has the advantage of providing the same particle mesh distribution for both impact models and astrodynamics, providing an opportunity for a direct link of the two. In this work, the generalised methodology derived by Soldini et al. [3] for asteroid Ryugu [4] is used to study the dynamics around Equilibrium Points (EPs) of Didymos [5]. At the core of our study, a comparison among different initial conditions for the rubble-pile models is performed by evaluating dynamical properties and global gravity information as Stokes coefficients. The evaluation of the dynamical properties of Didymos constrains the assumption made for the internal structure and provides a direct comparison of models. Moreover, this study provides a database of expected gravity estimates that is beneficial for the inverse problem of estimation of the asteroid internal properties from Hera's gravity measurements during the Juventas CubeSat radio science campaign.

References: [1] Terik et al, (2022) Nature (under review) [2] Dotto et al, (2022) Nature (under review) [3] Soldini et al, (2019) PSS, (2020) 180. [4] Watanabe et al. (2019) Science, 364, 268–272. [5] Michel et al., (2018) Adv. Space Res., 62, 2261- 2272

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