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THE EFFECT OF NEAs INTERNAL STRUCTURE ON PARTICLE DYNAMICS: A WAY TO SEARCH FOR STABLE ORBITS AROUND ASTEROID DIDYMOS

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ABSTRACT

A sphere cluster (SPH-Mas) based gravity model allows a semi-analytic expression of the linearised equations around irregular-shaped celestial bodies Equilibrium Points (EPs) [1] and an easy method for searching families of periodic orbits around them. The SPH-Mas model can retrieve the same dynamical objects of the shape model when the spheres share a uniform density distribution as shown in Fig. 1 for the asteroid Didymos.

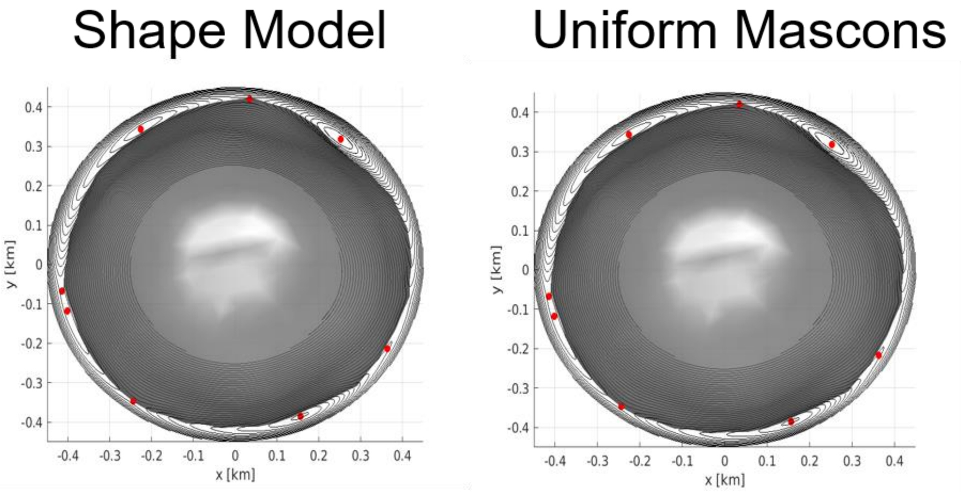


Figure 1 - Equilibrium points (red dots) for Didymos: comparison between shape model and Mascons with uniform density.

In Fig. 1, the SPH-Mas model and the sphere model can both retrieve 8 equilibrium points (4 stables and 4 unstable) for Didymos. The dynamics are solved for a rotating asteroid-fixed frame of angular velocity equivalent to the asteroid spin axis.

The SPH-Mas model has the advantage to define the same particles mesh distribution for both astrophysical and astrodynamics tools [2]. Figure 2 highlights how the density distribution of an asteroid affects both numerical simulations for impact dynamics [3] and orbital dynamics [1]. In this work, we apply the generalised methodology derived by Soldini et al. [1] for Ryugu [4] to study the dynamics around (EPs) of Didymos [5]. To the core of our study, we aim to gain a general insight on the dynamics around Didymos in term of stable and unstable orbits for studying the dynamics of ejecta particles.

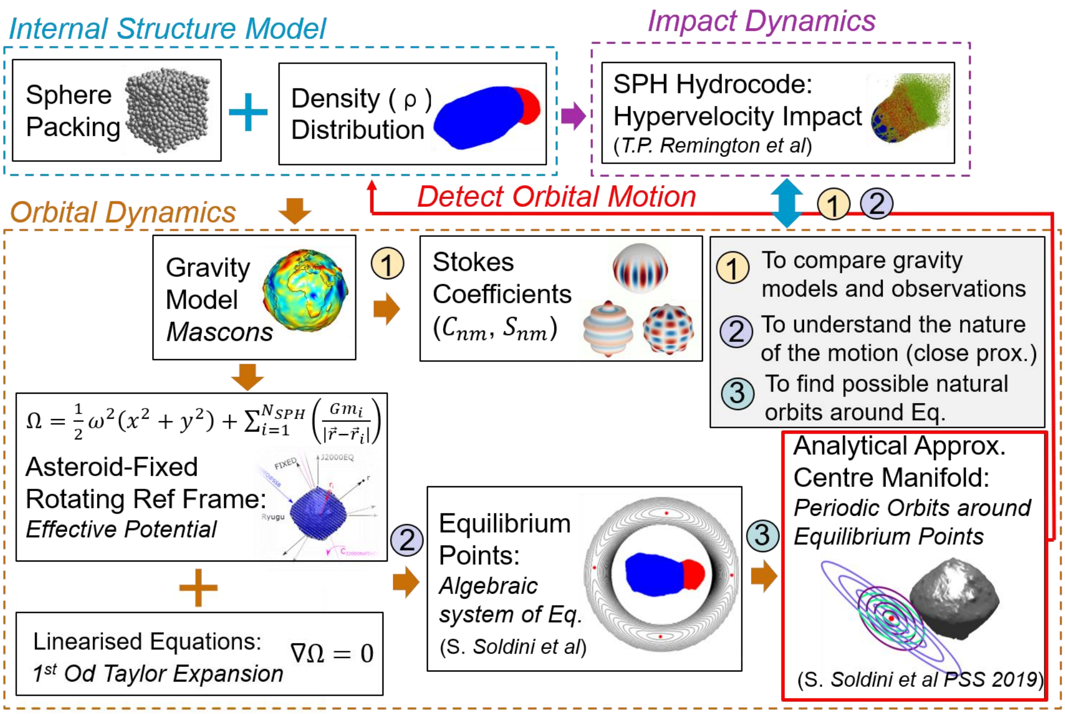
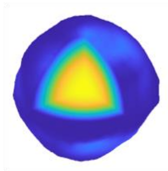
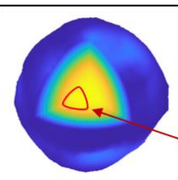
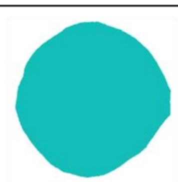


Figure 2 - Overview of the method to compute periodic orbits around irregular asteroids through a semi-analytic approach based on SPH-Masc gravity [2].

Table 1 shows an example of internal density distribution for Didymos including (a) homogeneous radial distribution, (b) homogeneous radial distribution and voids and (c) uniform distribution for a direct comparison with the shape model. We explore the evolution of the EPs and their periodic orbits as a function of the internal asteroid composition and period of rotation. A preliminary analysis on the effect of the solar radiation pressure acceleration is also considered for different area-to-mass ratio of ejecta particles.

Table 1 - Internal density distribution model for Didymos.

Didymos (*Mass* = *5.53185x*10^{11} $[kg]$, T = 2.26 $[h]$)			
Sphere Packing		Density $[kg/m^3]$	
Number	Uniform	Model	Value
6.643879x10^6 (Yu Yang et al, CMDA 2019)		Homogeneous radial distribution	$1179.65 \div 3100.00$
6.592038x10^6		Homogeneous radial distribution + Void	
6.643879x10^6		Uniform	2139.8266

References: [1] Soldini et al., (2019) PSS, (2020) 180. [2] Soldini et al., (2020) EPSC2020. [3] Melosh et al., (2013) Science, 340,1552–1555. [4] Watanabe et al., (2019) Science, 364, 268–272. [5] Michel et al., (2018) Adv. Space Res., 62, 2261-2272

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Comments:

This contribution should be included into the DART-Hera missions' session.

(Alternative session, Time slot, Oral or Poster, Etc…)