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Tidal stress and failure in the moon of binary asteroid systems: Application to asteroid (65803) Didymos

Laurent Sophal Pou (1), Raphael F. Garcia (1), David Mimoun (1), Naomi Murdoch (1), and Ozgur Karatekin (2)
(1) ISAE Supaero, DEOS / SSPA, Toulouse, France (l.pou@isae.fr), (2) Royal Observatory of Belgium

Rocky remnants left over from the early formation of the Solar System, asteroids are a target of choice for planetary science since much about the history of planetary formation and small body evolution processes can be learnt by studying them. Here we consider the case of the binary asteroid (65803) Didymos, the target of several mission proposals e.g., AIM [1] and DART [2]. A mission to Didymos would be a great opportunity for in-situ geophysical investigation, providing information on the surface and interior of asteroids. Such studies would improve our knowledge of binary asteroid formation and subsequent evolution of asteroids, thus of the history of the Solar System.

As Didymos is a binary asteroid [3] with the main 800-meter diameter asteroid named Didymain and a 150-meter sized moon named Didymoon, both are subject to tidal stress. Recent investigations suggest that Didymoon is tidally locked and moves in a retrograde motion around Didymain along an elliptic orbit with a 0.03 eccentricity at most. In the case of an eccentric orbit, the tidal stress varies periodically and may be strong enough to cause tidal quakes on Didymoon at some points of the orbit. For this study, we modelled Didymoon as a spherical, layered body with different internal structures: a homogeneous model, and two models with a 1-meter and 10-meter regolith layer on top of a stronger internal core.

Simulations show that, for a cohesionless body with an internal friction angle of 30°, tidal stress is strong enough to cause failure at the surface of Didymoon. A maximal stress is reached around the poles and for a mean anomaly of 90°. These results would mean that if tidal quakes occur on Didymoon, then they are likely to happen at these locations. An extension of these results to an ellipsoidal model of Didymoon is also presented for comparison with the spherical case and for application to other bodies.

[1]: P. Michel et al., Science case for the asteroid impact mission (aim): A component of the asteroid impact and deflection assessment (aida) mission, Advances in Space Research 57 (12) (2016) 2529 – 2547. doi:http://dx.doi.org/10.1016/j.asr.2016.03.031.
[2]: A. F. Cheng et al., Asteroid Impact & Deflection Assessment mission: Kinetic impactor, Planetary and Space Science 121 (2016) 27–35. doi:10.1016/j.pss.2015.12.004.
[3]:"AIM-A Team", ASTEROID IMPACT MISSION: DIDYMOS REFERENCE MODEL v10, ESA document reference: AD3-AIMA.