Geophysical Research Abstracts
Vol. 20, EGU2018-4755, 2018
EGU General Assembly 2018

Determination of the gravitational potential and tidal stress of asteroids using the finite element method

Laurent Sophal Pou (1), Raphaël 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, Brussels, Belgium

Because they are elementary bricks of planets during the early formation of the Solar System, asteroids have been main targets of numerous space missions such as NEAR Shoemaker [1] and Hayabusa [2], and still are with missions OSIRIS-REX [3] and Hayabusa 2 [4] arriving at their targets this year. However, little is still known about the internal structure and morphology, as only a few observables are available from Earth such as radar measurements, or gravity field measurements done by spacecraft during rendezvous missions. Here, the present work aims at determining the gravitational potentials of asteroids using the finite element method in order to compare them with the in-situ gravity field measurements but also in order to study tidal displacement and stress and thus analyse the possibility of in-situ passive seismic experiments at their surface.

First studies of tidal deformation of simplistic spherical asteroids [5] showed that local material failure might happen at the surface of a binary asteroid, and as a consequence that tidal quakes might occur, thus possibly allowing a passive seismic experiment. Yet, asteroids are often highly irregular with complex internal structures, displaying inhomogeneities, voids and porosity [6]. For these reasons, a specific tool had to be developed for studying them. Our choice was a finite element method code in C++, motivated by the freedom in discretization, mesh refining, shapes and allowing the study of local stress for failure. The theory used is an elastic deformation for a self gravitating body like in Dahlen and Tromp 1998 [7] but without spherical symmetry.

Validation of the gravitational potential from the simulations has been done for simple objects, such as inhomogeneous spheres and triaxial ellipsoids, matching well the theoretical results. The tidal calculations were also validated on the Earth tides due to the Moon. The results of this code applied to Eros for comparison with the gravity field data is presented, together with an application on the Mars moon Phobos for passive seismic experiment possibility.

[1] A. F. Cheng et al (1997), Journal of Geophysical Research 102, 23695-23708.

[2] A. Fujiwara et al. (2006), Science 312, 1330.

[3] D. S. Lauretta et al. (2012), 43rd Lunar and Planetary Science Conference.

[4] Y. Tsuda et al. (2013), Acta Astronautica 91, 356-362

[5] P. Michel et al. (2015), University of Arizona Press.

[6] N. Murdoch et al. (2017), Planetary and Space Science 144, 89-105.

[7] Dahlen and Tromp (1998), Princeton University Press.