EPSC Abstracts
Vol. 9, EPSC2014-569-1, 2014
European Planetary Science Congress 2014

Effects of the tidal mass redistribution on the rotation of an anelastic celestial body. Application to the Earth

T. Baenas (1), **J.M. Ferrándiz** (1), A. Escapa (2,1) and J. Getino (3)
(1) University of Alicante, Spain (jm.ferrandiz@ua.es / Fax: +34-965-909707) (2) University of León, Spain (3) University of Valladolid, Spain

Abstract

The gravitational interaction with external bodies perturbs the rotational motion of a given celestial body and induces deformations as well. In most cases the celestial body can be considered to have a simplified structure, e.g. be rigid or made up of a few layers like the so-called Poincaré model consisting of a rigid mantle and a liquid core, among diverse models composed of solid and liquid layers. The explanation of different phenomena (e. g., [2]), as well as the demand of high accurate solutions, requires to consider the elastic or in-, an-elastic behavior of the solid layers. It entails a yielding of those layers under the action of the external forces and the rotation of the body itself, causing a time dependent redistribution of masses that is usually expressed in terms of Love numbers.

A detailed analytical study of this problem is presented here by assuming that the celestial body is a fast rotator, continuing in this way previous works of the authors [4] [5] [6].

The approach follows the Hamiltonian formalism: the problem is expressed in Andoyer variables (e. g., [13], [1]) and then approximate analytical asymptotic solutions are derived by means of Hori's perturbation method ([12]). This methodology has been used successfully in other studies of the rotation of celestial bodies, like the Earth, Moon or Mercury, as well as in rigid or non-rigid cases and simple or multilayered models (e. g., [8], [9], [10], [11], [3]).

By doing so, we compute the evolution of the figure axis of the body (precession and nutation). Apart from the simplest case in which the body response is fully elastic and the Love numbers are thus independent on the forcing frequency, special attention is paid to most realistic hypothesis in which deviations from elasticity and dissipations are allowed and the Love numbers become frequency dependent and complex. Applications are made to the case of the Earth precession and nutation, showing that this effect cannot be disregarded at the present level of accuracy [7].

Acknowledgements

This work has been partially supported by the Spanish government under grants AYA2010-22039-C02-01 and AYA2010-22039-C02-02 from Ministerio de Economía y Competitividad (MINECO), Universidad de Alicante project GRE11-08, and Generalitat Valenciana project GV/2014/072.

References

[1] Efroimsky, M. and Escapa, A.: The theory of canonical perturbations applied to attitude dynamics and to the Earth rotation. Osculating and nonosculating Andoyer variables, Celest. Mech. Dyn. Astron. Vol. 98, pp. 251–283, 2009

[2] Efroimsky, M. and Makarov, V.: Tidal Friction and Tidal Lagging. Applicability Limitations of a Popular Formula for the Tidal Torque, Astrophys. J., Vol. 764:26, 2013

[3] Escapa, A.: Corrections stemming from the non–osculating character of the Andoyer variables used in the description of rotation of the elastic Earth Celest. Mech. Dyn. Astron. Vol. 110, pp. 99-–142, 2011

[4] Escapa, A., Getino, J. and Ferrándiz, J. M.: On the effect of the redistribution tidal potential on the rotation of the non-rigid Earth: discrepancies and clarifications. Capitaine, N. (Ed.), Proceedings of the Journées 2004 "Systèmes de Référence Spatio-Temporels", Observatoire de Paris, pp. 70–73, 2005

[5] Ferrándiz, J. M., Navarro, J. F., Escapa, A., Getino, J. and Baenas, T.: Influence of the mantle elasticity on the precessional motion of a two–layer Earth model, In: Lemaître, A. (ed) The rotation of celestial bodies, Press. Universitaires de Namur, pp. 9–14, 2007

[6] Ferrándiz, J. M., Baenas, T. and Escapa, A.: Effect of the potential due to lunisolar deformations on the

Earth precession, EGU General Assembly 2012, Vienna, Austria, Geophysical Research Abstracts 14, EGU2012–6175, 2012

[7] Ferrándiz, J. M. and Gross, R.S.: The New IAU/IAG Joint Working Group on Theory of Earth Rotation, IAG Symp Vol. 143 (accepted 2014).

[8] Getino, J. and Ferrándiz, J. M.: On the effect of the mantle elasticity on the Earth's rotation, Celest. Mech. Dyn. Astron. Vol. 61, pp. 117–180, 1995

[9] Getino, J. and Ferrándiz, J. M.: A Hamiltonian approach to dissipative phenomena between the Earth's mantle and core, and effects on free nutations, Geophys. J. Int. Vol. 130, pp. 326–334, 1997

[10] Getino, J. and Ferrándiz, J. M.: Effects of dissipation and a liquid core on forced nutations in Hamiltonian theory, Geophys. J. Int. Vol. 142, pp. 703–715, 2000

[11] Getino, J. and Ferrándiz, J. M.: Forced nutations of a two-layer Earth model, Mon. Not. R. Astron. Soc. Vol. 322, pp. 785–799, 2001

[12] Hori, G.: Theory of General Perturbation with Unspecified Canonical Variable, Publ. Astron. Soc. Jpn. Vol. 18, pp. 287–296, 1966

[13] Kinoshita, H.: Theory of the rotation of the rigid Earth, Celest. Mech. Dyn. Astron. Vol. 15, pp. 277–326, 1977