EPSC Abstracts
Vol. 11, EPSC2017-735, 2017
European Planetary Science Congress 2017

Global ice flow on Europa

Y. Ashkenazy (1), R. Sayag (1), and E. Tziperman (2)
(1) Department of Solar Energy and Environmental Physics, The Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Midreshet Ben-Gurion, 84990, Israel, (2) Dept of Earth and Planetary Sciences and School of Engineering and Applied Sciences, Harvard University, 20 Oxford Street, Cambridge, Massachusetts 02138, USA. (ashkena@bgu.ac.il)

Abstract

Europa is one of the most probable places in the solar system to find extra-terrestrial life [1], motivating the study of its deep (∼100 km) ocean [2] and its thick (many kilometers) icy shell [2]. Recently, the Hubble telescope discovered water vapor plumes over Europa's southern pole region [3], strengthening the evidence for an underlying ocean. The observed chaos terrain patterns on Europa's surface [4] were interpreted, among other mechanisms, as a signature of vertical convective motions within the ice [5]. Horizontal gradients of ice thickness [6] are expected due to the large equator-to-pole gradient of surface ice temperature, and can drive a global horizontal ice flow; yet the dynamics of such a flow and its observable implications were not studied.

Here we present the first global ice flow model for Europa, composed of a soft flowing ice under a rigid cold external ice crust, under the influence of tidal heating and coupled to a global underlying ocean. We show that Europa's ice can indeed flow meridionally due to pressure gradients associated with anomalies in the ice thickness of up to a few kms. Observable gradients of ice thickness are reduced both by ice flow and due to ocean heat transport when included. The ice thickness and meridional flow direction depend on whether the ice is convecting or not, and multiple equilibria are found in some parameter regimes.

Future missions to Europa such as the *JUICE* of ESA and *Europa*, *Clipper* of NASA are expected to measure the ice thickness and surface temperature, which can be used together with our global ice model to deduce whether Europa's icy shell is convecting, to estimate the effectiveness of ocean heat transport, and more.

References

[1] Hand, K., Chyba, C., Priscu, J., Carlson, R., and Nealson, K.: Astrobiology and the potential for life on Europa, Europa, University of Arizona Press, Tucson, pp. 589–629, 2009.

[2] Pappalardo, R. T. *et al.*: Geological evidence for solid-state convection in Europa's ice shell, Nature, Vol. 391, pp. 365–368,1998.

[3] Sparks, W. *et al.*: Probing for evidence of plumes on europa with hst/stis, The Astrophysical Journal, Vol. 829, pp. 121, 2016.

[4] Pappalardo, R. *et al.*: Does Europa have a subsurface ocean? Evaluation of the geological evidence, J. Geophys. Res., Vol. 104, pp. 24015–24055, 1999.

[5] Collins, G. C., Head, J. W. I., Pappalardo, R. T., and Spaun, N. A.: Evaluation of models for the formation of chaotic terrain on Europa, J. Geophys. Res., Vol. 105, pp. 1709–1716, 2000.

[6] Ojakangas, G. W. and Stevenson, D. J.: Thermal state of an ice shell on Europa, Icarus, Vol. 81, pp. 220–241, 1989.