Geophysical Research Abstracts
Vol. 15, EGU2013-4310, 2013
EGU General Assembly 2013

Titan's interior from its rotation axis orientation and its Love number

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The tidal Love number k_2 of Titan has been recently estimated from Cassini flybys radio-tracking and is consistent with the presence of a global ocean in Titan's interior, located between two ice layers (Iess et al. 2012), in accordance with prediction from interior and evolutionary models for Titan. Previously, the orientation of the rotation axis of Titan has been measured on the basis of radar images from Cassini (Stiles et al. 2008). Titan's obliquity, is about 0.3. The measured orientation is more consistent with the presence of a global internal liquid ocean than with an entirely solid Titan (Baland et al. 2011).

The global topography data of Titan seem to indicate some departure from the hydrostatic shape expected for a synchronous satellite under the influence of its rotation and the static tides raised by the central planet (Zebker et al. 2009). This may be explained by a differential tidal heating in the ice shell which flattens the poles (Nimmo and Bills 2010). A surface more flattened than expected implies compensation in depth to explain the measured gravity coefficients C_{20} and C_{22} of Iess et al. (2012). Here, all layers are assumed to have a tri-axial ellipsoid shape, but with polar and equatorial flattenings that differ from the hydrostatic expected ones. We assess the influence of this non-hydrostatic shape on the conclusions of Baland et al. (2011), which developped a Cassini state model for the orientation of the rotation axis of a synchronous satellite having an internal liquid layer.

We assess the possibility to constrain Titan's interior (and particularly the structure of the water/ice layer) from both the rotation axis orientation and the Love number. We consider a range of internal structure models consistent with the mean density and the mean radius of Titan, and made of a shell, an ocean, a mantle, and a core, from the surface to the center, with various possible compositions (e.g. ammonia mixed with water for the ocean). The internal structure models consistent with the measured orientation of the rotation axis and Love number still have to be examined with respect to other constrains, such as the shell thickness estimation derived from electric-field measurement of the Huyges probe (Béghin et al. 2012) and the expected temperature profile of the water/ice layer. For instance, a thin shell would imply a rather thick ocean, based on water (or water/ammonia) phase diagram.