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Obliquity and non-hydrostaticity: Constraining the interior of Titan

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Abstract

The orientation of the rotation axis of Titan has been measured on the basis of Cassini radar images [5, 6]. It has been shown that this orientation is more consistent with the presence of an internal global liquid ocean beneath an ice shell than with an entirely solid Titan [1].

The global topography data 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, although the possibility of Titan being in hydrostatic equilibrium cannot be ruled out [7].

We investigate how the non-hydrostaticity may influence the obliquity solution. Then, we derive interior models which are compatible with the observed orientation as well as gravity and a non-hydrostatic shape deduced from the solution of [7].

1. The rotation axis orientation and the presence of an ocean

The orientation of the rotation axis of Titan can be characterized by the obliquity ε which is the angle between the rotation axis and the normal to the orbital plane. Giving the actual knowledge on the orientation of the orbital plane, the measurement of Stiles et al. [5, 6] led to the following estimation: $\varepsilon_{meas} = 0.32° \pm 0.02°$[1].

For an entirely solid Titan, the obliquity ε sould be $0.12°$ and it has been shown that some internal structure models of Titan with an internal global ocean, and consistent with the mass and the mean moment of inertia constraints, have an obliquity in agreement with the estimated ε_{meas} [1].

2. Non-hydrostaticity

Given the observed topography of Titan [7], it was proposed that the ice shell of Titan may depart from the hydrostatic equilibrium because of the differential tidal heating which could flatten the poles (lateral shell thickness variations) [4] (see also [3], this conference).

Therefore, we assess the effect of non-hydrostatic shell and ocean flattenings on the obliquity compared to the hydrostatic solution. In that frame, the internal structure models for wich we compute the obliquity do not need to satisfy the mean moment of inertia I given by [2] and computed with Radau's equation, as long as they satisfied the measured gravity coefficients C_{20} and C_{22}.

3. Constraining the interior

The internal structure models matching the observed obliquity (candidate-models) are not necessarily realistic given the expected temperature profile and composition of the materials of Titan.

For instance, the thickness of the shell and of the ocean required to match the obliquity may not be consistent with the water (or water/ammonia) phase diagram. Finding which of the candidate-models are realistic may help to provide constraints on the interior of Titan and on the composition of its layers.

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