Constraining Ceres' interior from its Rotational Motion

Nicolas Rambaux (IMCCE), Julie Castillo-Rogez (JPL), Véronique Dehant (ROB), Petr Kuchynka (IMCCE, JPL)

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Context. Ceres is the most massive body of the asteroid belt and contains about 25 wt.% (weight percent) of water. Understanding its thermal evolution and assessing its current state are major goals of the Dawn Mission. Constraints on internal structure can be inferred from various observations. Especially, detailed knowledge of the rotational motion can help constrain the mass distribution inside the body, which in turn can lead to information on its geophysical history. Aims. We investigate the signature of the interior on the rotational motion of Ceres and discuss possible future measurements performed by the spacecraft Dawn that will help to constrain Ceres' internal structure. Methods. We compute the polar motion, precession-nutation, and length-of-day variations. We estimate the amplitudes of the rigid and non-rigid response for these various motions for models of Ceres interior constrained by recent shape data and surface properties. Results. As a general result, the amplitudes of oscillations in the rotation appear to be small, and their determination from spaceborne techniques will be challenging. For example, the amplitudes of the semi-annual and annual nutations are around ~364 and ~140 milli-arcseconds, and they show little variation within the parametric space of interior models envisioned for Ceres. This, combined with the very long-period of the precession motion, requires very precise measurements. We also estimate the timescale for Ceres' orientation to relax to a generalized Cassini State, and we find that the tidal dissipation within that object was probably too small to drive any significant damping of its obliquity since formation. However, combining the shape and gravity observations by Dawn offers the prospect to identify departures of non-hydrostaticity at the global and regional scale, which will be instrumental in constraining Ceres' past and current thermal state. We also discuss the existence of a possible Chandler mode in the rotational motion of Ceres, whose potential excitation by endogenic and/or exogenic processes may help detect the presence of liquid reservoirs within the asteroid.

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