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Equilibrium Obliquity of Mercury: Effect of the inner core and the pericenter

M. Yseboodt[1], R.-M. Baland[2 1], T. Van Hoolst[1], A. Rivoldini[1]
[1] Royal Observatory of Belgium, Brussels, Belgium (m.yseboodt@oma.be),
[2] Université catholique de Louvain, Earth and Life Institute, Louvain-la-Neuve, Belgium

1. The Cassini state

Mercury's spin axis has been shown to occupy the Cassini state 1 (Margot et al. 2007, 2012). In this equilibrium state, the orbit normal, the spin axis and the normal to the Laplace plane remain coplanar, precessing all together with a very long period of about 300 000 years. The obliquity stays constant with time.

Up to now, the Cassini state and the corresponding equilibrium obliquity have only been investigated for a planet with a solid layer and a fluid core. In this study, we investigate the effect of an ellipsoidal inner core and the precession of the pericenter on the equilibrium obliquity.

2. Ellipsoidal Inner Core

We consider a planet with 3 layers: a solid mantle (including the crust), a fluid outer core and a solid inner core. The interior models are constrained by the mass, the radius, the gravity field coefficients and the observed libration amplitude. Different assumptions are used to compute the equatorial and polar flattening of each layer (see Yseboodt et al. 2013).

Using a method similar to Baland et al. (2012), we investigate the effect of a non spherical inner core on the equilibrium obliquity. Since the orbital plane is precessing about the Laplace plane, we express the motion of the spin axis in a frame based on the Laplace plane.

We take into account the following torques on each layer: the solar gravitational torque on the layers, the pressure torque on the mantle and the inner core, and the gravitational torque between the mantle and the inner core. We also add dissipative viscous torques.

3. Precession of the pericenter

The longitude of the pericenter ω of Mercury around the Sun has a slow precessional motion of about 127 000 years. In order to compute the motion of the spin axis, the solar gravitational torque has to be averaged over the fast motions like the anomaly of Mercury. The pericenter precession is not a fast angle, therefore we keep the terms depending on the argument of the pericenter and evaluate the effect of this motion on the equilibrium obliquity.

References

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