EPSC Abstracts,
Vol. 4, EPSC2009-218, 2009
European Planetary Science Congress,

Mercury's interior from forced librations

M. Yseboodt, T. Van Hoolst, V. Dehant

Royal Observatory of Belgium, avenue Circulaire 3, 1180 Uccle, Belgium (marie.yseboodt@oma.be)

Mercury is in a resonant state in which two revolution periods are equal to three rotation periods. This resonant state leads to librations in longitude whose periods are harmonics of the orbital period (88 days, 44d, 29d, etc). These librations are due to the gravitational torque of the Sun on the permanent flattening of the planet. The amplitude of the 88day libration is proportional to the moment of inertia ratio $(B-A)/C_m$ where A, B are the moments of inertia of the planet and C_m is the moment of inertia of the silicate shell.

The rotation of Mercury can be estimated by using radar measurement from the Earth or by using future data from the MESSENGER and BepiColombo spacecraft. The range of $(B-A)/C_m$ values has already been deduced from the Earth-based rotation data [1].

Additionally to these main librations, Mercury also experiences planetary forced librations ([2] or [3]), due to the perturbations on the orbital motion of Mercury induced by the other planets. These librations have a longer period, mainly between 2 and 15 years and amplitudes up to 40 arcseconds. The main librations are due to Jupiter and Venus, with periods of 11.86 years and 5.66 years, respectively.

Given an interior structure model for Mercury, amplitudes of the forced long period librations can be obtained using a numerical integration of a set of differential equations describing the librational motion of the mantle [3]. Alternatively, the amplitudes have been determined in an analytical study based on a Hamiltonian approach and Lie transforms [4].

The effect of the planetary perturbations is amplified by the resonance with the free libration. The amplitudes of the librations with periods close to the free libration period (about 12 years) will be most amplified while most librations will have a negligible amplitude. We develop a theoretical model that can predict the amplitudes and the phases of the long period forced librations based on the planetary perturbations on some orbital element combination. The model is a generalization of the harmonic oscillator model given in Peale et al [2] for the 11.86 year libration due to Jupiter. The librations are damped by core-mantle interactions and tidal dissipation and are periodically forced by the planetary perturbations. We develop an equation linking the long period libration amplitudes and the moment of inertia ratio $(B-A)/C_m$.

When interpreting the rotation state of Mercury from future spacecraft data, these long period librations should be included. Additionally, the $(B-A)/C_m$ ratio may be determined from the phases and amplitudes of the long period librations in addition to that of the 88 day libration.

References

[1] Margot et al, *Large longitude libration of Mercury reveals a molten core*, Science 316, 2007.

[2] Peale, Yseboodt and Margot, *Long-period forcing of Mercury's libration in longitude*, Icarus 187, 2007.

[3] Peale, Margot and Yseboodt, *Resonant forcing of Mercury's libration in longitude*, Icarus 199, 2009.

[4] Dufey, Lemaitre and Rambaux, *Planetary perturbations on Mercury's libration in longitude*, Celest. Mech. Dyn. Astr. 101, 2008.