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The influence of an inner core and tides on Mercury's longitudinal libration

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The rotation speed of Mercury is not constant but shows small periodic variations. These longitudinal librations are due to the torque exerted by the sun on the aspherical shape of Mercury. Observation of the main libration at 88 days has already shown that Mercury's core is (at least partially) liquid (Margot et al. 2007) but improved estimates of the rotation and gravity field will moreover allow constraining the mantle density and the size, density, and composition of the core. However, in order to be able to make accurate inferences on the interior structure of Mercury, all relevant effects on the libration have to be known more precisely than the observational precision. Here we investigate the influence of tides on the librations of Mercury, which have up to now not been accurately quantified. We moreover rediscuss and modify previous analyses of the effect of a solid inner core on Mercury's libration. Numerical results are presented for a wide range of recent models of the interior structure of Mercury. The effect of tides is shown to be below the (future) observational precision of about 10 m. The presence of an inner core modifies the libration of the silicate shell (mantle + crust) because the inner core can rotate differentially with respect to the silicate shell and the librations of the shell and inner core are coupled through gravitational and pressure torques. The existence of an inner core decreases the libration amplitude by an observable amount for inner core radii larger than about 1500 km and lengthens the free libration period by up to more than 25%. Because of this large effect, a future determination of the free libration period would hold the potential of yielding important information on the inner core of Mercury.