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Slichter modes of Mercury: period and possible observation

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Abstract

We study the period of the Slichter mode (vibrational mode of the inner core of a planet) of Mercury in relation to its interior structure and assess the possibility to observe this mode with the probes MESSENGER and BepiColombo.

1. Introduction

The high mean density of Mercury compared to the other terrestrial planets is thought to imply that the core of Mercury is relatively much larger than the core of the other terrestrial planets of the solar system. Observations of periodic changes in Mercury's spin rate have shown that at least the outer part of Mercury's core is liquid [4] and the global magnetic field (observed by Mariner 10 in 1974 and confirmed by MESSENGER [1]), if due to a hydrodynamo, can be considered as evidence of the presence of a growing inner core. Thanks to its possibly larger inner core (due to its larger core), the Slichter modes of Mercury could be easier to detect than the Slichter modes of the Earth.

2. Slichter mode period

Using the equation of conservation of momentum of the planet and the Newton's second law for the inner core, Grinfeld and Wisdom [2] have developed a methodology for the determination of the period of the polar Slichter modes of a planetary interior consisting of three homogeneous layers. We generalized this approach to models with an arbitrary but finite number of layers.

We constructed a large set of interior structure models of Mercury and calculated Slichter mode period of Mercury for these models. Periods obtained ranges from a few hours to more than hundred hours with increasing inner core size. Periods depend mainly on the size of the inner core (see Figure 1).

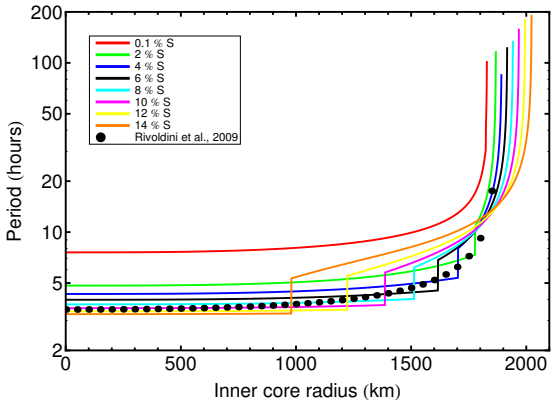

Figure 1: Slichter mode periods for the different models of Mercury. Different colors represent different initial sulfur contents of the core, from 0.1 wt% to 14 wt%. Periods obtained for full internal structure models of Mercury (models of [5]) are represented with big bullets.

3. Slichter mode detection

We then assessed whether Slichter modes of Mercury can be detected by spacecraft. As the center of mass of Mercury remains fixed during a Slichter mode oscillation, gravity anomalies due to this mode cannot be measured from orbit. However, the Slichter modes of Mercury could be detected from orbit by measuring the motion of the mantle of Mercury. For our models with the largest inner cores, the displacement of the inner core can be as small as ten meters and still allows detection of the Slichter modes by the probe BepiColombo (see Figure 2).

We studied the excitation of the Slichter mode of Mercury by an impact by a meteoroid. Assuming that the Slichter mode is the only excited mode, a meteoroid with a mass of at least 10^{10} kg (or a radius of at least 100 m) is required to be detected by BepiColombo. However, observation of the Slichter mode of Mercury by BepiColombo would require a fortunate recent impact since the estimated magnetic damping

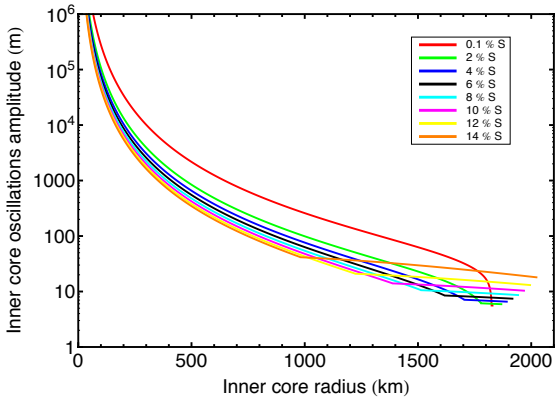

Figure 2: Amplitude of the inner core oscillations that could be detected by BepiColombo. Different colors represent different initial sulfur contents of the core, from 0.1 wt% to 14 wt%.

time of the mode is well below the average time between impacts of at least this size (about 100 My, according to [3]).

4. Summary and Conclusions

In order to study the Slichter modes of Mercury, we have developed models of the interior structure of Mercury. The Slichter mode period obtained ranges from a few hours to more than 100 hours and depends strongly on the properties of Mercury's core.

We have studied the possible observation of Slichter modes of Mercury by the probes MESSENGER and BepiColombo by measuring the motion of the mantle of Mercury using an altimeter. We have shown that the observation of the Slichter mode of Mercury is possible if the inner core is very large and is excited to an amplitude of the order or greater than ten meters. On average, such a collision occurs once every 100 My, which is much larger than the dissipation time of the Slichter mode, therefore requiring a recent impact.

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