EPSC Abstracts
Vol. 7 EPSC2012-559 2012
European Planetary Science Congress 2012

Constraints on Mercury's interior structure from recent data on its gravity field and spin state

A. Rivoldini and T. Van Hoolst
Royal Observatory of Belgium, 3 Avenue Circulaire, B-1180 Bruxelles, Belgique (Attilio.Rivoldini@oma.be)

Abstract

The recently determined global gravity field of Mercury by the MESSENGER mission [3] and the accumulated radar measurements about the spin state of Mercury [1, 3] provide important constraints on its interior structure. By combining both data sets the moment of inertia of Mercury and of its silicate shell can be determined. Both are expected to provide constraints on Mercury's core radius and on the core's light elements concentration. In this study our aim is to determine to what precision those two core parameters can be obtained by using as data Mercury's mass, its global moment of inertia, and the moment of inertia of its outer silicate shell.

1. Method

The aim of this study, is to constrain with the mass and both moments of inertia (global and of the silicate shell) the density and thickness of Mercury's crust, the density of its mantle, and the radius and sulfur concentration in its core. In agreement with the observation that the mantle of Mercury has a low iron content and with the low pressure range inside its shallow mantle we assume a mantle density that is within the $[3100, 3500]\mathrm{kg/m^3}$ range. The temperature inside the core is assumed adiabatic and is calculated from the temperature at the core-mantle boundary which is a parameter of our model. The range for the core-mantle boundary temperature is chosen such that it is below the mantle solidus and above the eutectic temperature of the iron-light element core constituents (Fig. [1]). As possible light elements for the core we assume sulfur and silicon and calculate the core's pressure- and temperature-dependent thermoelastic properties following [2]. To model the size of the inner core we use recent data on the melting temperature of iron-sulfur/silicon.

In order to infer knowledge about the model parameters from the data we use a Bayesian inversion method [4]. The result of this method is a probability density functions on the parameters of the model. From the probability density function we calculate marginal densities and estimate parameter values and regions of occurrence.

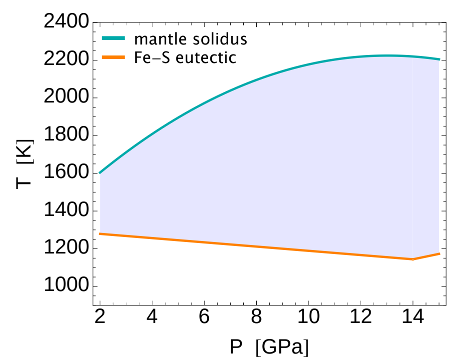

Figure 1: Peridotite mantle solidus and $\mathrm{Fe-S}$ eutectic temperature as a function of pressure.

2. Results

Fig. [2] represents the relation between the core sulfur concentration and the core radius. At 0.68 confidence the models have a core radius that is in a range of $1969 \pm 64\mathrm{km}$ and have an associated sulfur concentration that is in the range $[1, 6]\mathrm{wt\%}$ if sulfur is the only light element inside the core. However, models with larger cores that have more sulfur are also possible. The other parameters of the models are only weakly constrained by the data. In order to fit the data the models do not require an extra dense layer at the bottom of the mantle [3].

Acknowledgements

This work was financially supported by the European Space Agency in collaboration with the Belgian Federal Science Policy Office.

References

[1] J. L. Margot, S. J. Peale, R. F. Jurgens, M. A. Slade, and I. V. Holin. Large Longitude Libration of Mercury Reveals a Molten Core. *Science*, 316(5825):710–714, 2007.

[2] A. Rivoldini, T. Van Hoolst, O. Verhoeven, A. Mocquet, and V. Dehant. Geodesy constraints on the interior structure and composition of Mars. *Icarus*, 213(2):451 – 472, 2011.

[3] David E. Smith, Maria T. Zuber, Roger J. Phillips, Sean C. Solomon, Steven A. Hauck, Frank G. Lemoine, Erwan Mazarico, Gregory A. Neumann, Stanton J. Peale, Jean-Luc Margot, Catherine L. Johnson, Mark H. Torrence, Mark E. Perry, David D. Rowlands, Sander Goossens, James W. Head, and Anthony H. Taylor. Gravity Field and Internal Structure of Mercury from MESSENGER. *Science*, 336(6078):214–217, 2012.

[4] Albert Tarantola. *Inverse Problem Theory and Methods for Model Parameter Estimation*. Society for Industrial Mathematics, Philadelphia, January 2005.

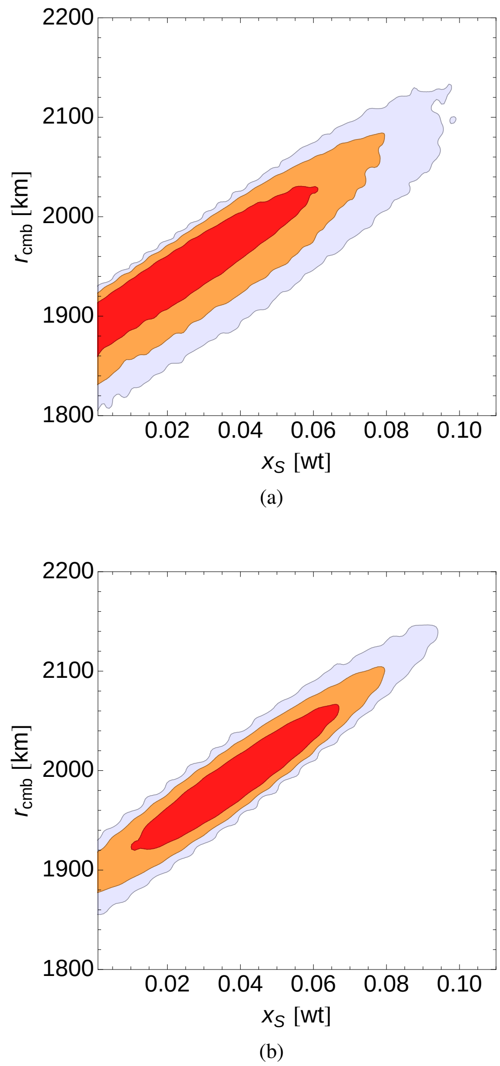

Figure 2: Core radius r_{cmb} as a function of core sulfur concentration x_{S} for interior models that have an inner core (a) and for models that have fully liquid cores (b). The color shaded domains represent 0.68, 0.95, and 0.997 Bayesian confidence regions.