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Mercury's inner core size and core-crystallization régime

M. Dumberry(1) and **A. Rivoldini**(2)
(1) Department of Physics, University of Alberta, Edmonton, T6G 2E1, Canada, (2) Royal Observatory of Belgium, Bruxelles, Belgium, (dumberry@ualberta.ca)

Abstract

Geodetic observations provide insights about the interior structure of Mercury. In particular, they constrain the radius of the core-mantle boundary and on the bulk densities of the core and mantle [5, 3]. Here, we show that they also yield information about the radius of the inner core and on the crystallization regime in the liquid core.

Recently, the MESSENGER spacecraft has measured Mercury's internally generated magnetic field and shown that the magnetic field is about two orders of magnitude smaller than Earth's [4]. Dynamo models that agree with those observations require a magnetic field that is driven by chemical convection and generated in a thin spherical shell located deep inside the fluid core that is overlain by a stable thermally-stratified layer [1].

We have build models of Mercury that include a sub-adiabatic temperature profile in the upper part of the liquid core. In those models, the dominant light element inside the core is sulfur. Unlike the Earth, upon cooling the core adiabat may first cross the liquidus near the core-mantle boundary resulting in the precipitation of solid iron snow from the liquid $Fe - FeS$ liquid alloy. Cooling extends the precipitation zone to greater depth and produces a stable compositional gradient [2]. Depending on the thermal state of the core the snow zone could extent to the inner core boundary. In that case the inner core would grow through the sedimentation of solid iron snow. If, somewhere below the snow layer, the temperature crosses the liquidus, then inner core growth will proceed in an Earth-like manner.

Our study shows that models that best agree with recently measured geodesy observations ($88 - \mathrm{day}$ libration and polar moment of inertia) require an inner core that is not larger than $1325 \pm 250\mathrm{km}$. If the inner core radius is smaller than about $650\mathrm{km}$ they have an iron snow layer in the upper part of the fluid core, consistent with a deep seated dynamo. However, if the inner core radius is larger than about $650\mathrm{km}$ the snow layer extends to the inner core boundary and dynamo action is likely prevented.

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References

[1] U. R. Christensen. A deep dynamo generating Mercury's magnetic field. *Nature*, doi: 10.1038/nature05342, December 2006.

[2] S. A. Hauck, J. M. Aurnou, and A. J. Dombard. Sulfur's impact on core evolution and magnetic field generation on Ganymede. *J. Geophys. Res. (Planets)*, doi: 10.1029/2005JE002557, 2006.

[3] Steven A. Hauck, Jean-Luc Margot, Sean C. Solomon, Roger J. Phillips, Catherine L. Johnson, Frank G. Lemoine, Erwan Mazarico, Timothy J. McCoy, Sebastiano Padovan, Stanton J. Peale, Mark E. Perry, David E. Smith, and Maria T. Zuber. The curious case of Mercury's internal structure. *Journal of Geophysical Research: Planets*, doi: 10.1002/jgre.20091, 2013.

[4] Catherine L. Johnson, Michael E. Purucker, Haje Korth, Brian J. Anderson, Reka M. Winslow, Manar M. H. Al Asad, James A. Slavin, Igor. I. Alexeev, Roger J. Phillips, Maria T. Zuber, and Sean C. Solomon. MESSENGER observations of Mercury's magnetic field structure. *Journal of Geophysical Research: Planets*, doi: 10.1029/2012JE004217, 2012.

[5] A. Rivoldini and T. Van Hoolst. The interior structure of Mercury constrained by the low-degree gravity field and the rotation of Mercury. *Earth and Planetary Science Letters*, doi: 10.1016/j.epsl.2013.07.02, 2013.