EPSC Abstracts
Vol. 13, EPSC-DPS2019-1646-2, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Stratification in the core of Mercury

Marie-Hélène Deproost (1,2), Attilio Rivoldini (1) and Tim Van Hoolst (1,2)
(1) Royal Observatory of Belgium, Brussels, Belgium, (2) KU Leuven, Belgium (marie-helene.deproost@oma.be)

Abstract

Thermal evolution studies of Mercury indicate that the present-day heat flow at the core-mantle boundary is subadiabatic. This suggests the presence of a thermally stratified layer in the upper part of the core.

We use a coupled thermal evolution model of the core and the mantle to study the formation of a thermally stratified layer in the core of Mercury. We assess the conditions of occurrence of this thermally stratified layer and whether the stratified core allows for the formation of a solid inner core and for a dynamo.

1. Introduction

Mercury is the only terrestrial planet of our Solar System, apart from the Earth, to possess a present-day global magnetic field. This field is generated by convection motions inside the liquid core of the planet. The magnetic field's strength at the surface of Mercury is about 1% that of the Earth's. This low intensity could be explained by the "deep core dynamo" scenario: the presence of a liquid conductive layer at the top of the core attenuates the rapidly varying field components by skin effect [1] [2]. This scenario is in agreement with thermal evolution studies of Mercury [3] [4], indicating a sub-adiabatic core-mantle boundary heat flow, and therefore suggesting the presence of a thermally stratified layer at the top of the core.

In this work we study the thermal evolution of Mercury with a coupled core-mantle model including the formation of a thermally stable layer in the core. Heat being transported by conduction in this stable layer, a thinner part of the core is available to generate the dynamo by convection motion when the stratified layer thickens. Furthermore, conduction being less effective than convection to transport heat, the presence of a conductive layer in the core affects its thermal evolution with consequences on the growth of a solid inner core. In our work we focus especially on the formation of the solid inner core and on the dynamo generation in a partly stratified core.

2. Method

The coupled thermal evolution model is based on energy and entropy budgets in the core [5]-[7] and in the mantle [8]. When the core begins to stratify the evolution of the stable conductive layer is dictated by the time-varying heat equation. The model for the stratified layer is based on the work of Greenwood et al. [9]. On the other hand the convective part is evolved by energy budget considerations. The temperature and heat flux continuity conditions define the position of the interface between the conductive and the convective layers. The core cooling is controlled by the mantle through the core-mantle boundary heat flux. We study the magnetic field generation by determining the entropy available for the dynamo in the entropy budget of the convective layer.

References

[1] U. R. Christensen: A deep dynamo generating Mercury's magnetic field, Nature, Vol. 444, 2006.

[2] U. R. Christensen and J. Wicht: Models of magnetic field generation in partly stable planetary cores: Applications to Mercury and Saturn, Icarus, Vol. 196, pp. 16–34, 2008.

[3] M. Grott, D. Breuer, and M. Laneuville: Thermo-chemical evolution and global contraction of Mercury, Earth Planet. Sci. Lett., Vol. 307, pp. 135–146, 2011.

[4] N. Tosi, M. Grott, A.-C. Plesa, and D. Breuer: Thermo-chemical evolution of Mercury's interior, J. of Geophys. Res.: Planets, Vol. 118, pp. 2474–2487, 2013.

[5] D. Gubbins, D. Alfè, G. Masters, D. Price, and M. Gillan: Can the Earth's dynamo run on heat alone? Geophys. J., Vol. 155, pp. 609–622, 2003.

[6] D. Gubbins, D. Alfè, G. Masters, D. Price, and M. Gillan: Gross thermodynamics of two-component core convection, Geophys. J., Vol. 157, pp. 1407–1414, 2004.

[7] C. Davies: Cooling history of Earth's core with high thermal conductivity, Phys. Earth Planet. Inter., Vol. 247, pp. 65–79, 2015.

[8] A. Morschhauser, M. Grott, and D. Breuer: Crustal recycling, mantle dehydration, and the thermal evolution of Mars, Icarus, Vol. 212, pp. 541–558, 2011.

[9] S. Greenwood, C. Davies and J. Mound: Thermal and Chemical History Modelling of a Stably Stratified Outer Core, AGU, 10–14 December 2018, Washington, USA, 2018.