The effect of a strongly stratified layer in the upper part of Mercury's core on its magnetic field

Patrick Kolhey\textsuperscript{1}, Daniel Heyner\textsuperscript{1}, Johannes Wicht\textsuperscript{2}, and Karl-Heinz Glassmeier\textsuperscript{1}

\textsuperscript{1}Technische Universität Braunschweig, Institut für Geophysik und extraterrestrische Physik, Braunschweig, Germany
\textsuperscript{2}Max Planck Institute for Solar System Research, Göttingen, Germany

In the 1970's the flybys of NASA's Mariner 10 spacecraft confirmed the existence of an internally generated magnetic field at Mercury. The measurements taken during its flybys already revealed, that Mercury's magnetic field is unique along other planetary magnetic fields, since the magnetic dipole moment of \( \sim 190 \, \text{nT} \cdot \text{R}_\text{M}^3 \) is very weak, e.g. compared to Earth's magnetic dipole moment. The following MESSENGER mission from NASA investigated Mercury and its magnetic field more precisely and exposed additional interesting properties about the planet's magnetic field. The tilt of its dipole component is less than 1°, which indicates a strong alignment of the field along the planet's rotation axis. Additionally the measurement showed that the magnetic field equator is shifted roughly 0.2 \( \cdot \text{R}_\text{M} \) towards north compared to Mercury's actual geographic equator.

Since its discovery Mercury's magnetic field has puzzled the community and modelling the dynamo process inside the planet's interior is still a challenging task. Adapting the typical control parameters and the geometry in the models of the geodynamo for Mercury does not lead to the observed field morphology and strength. Therefore new non-Earth-like models were developed over the past decades trying to match Mercury's peculiar magnetic field. One promising model suggests a stably stratified layer on the upper part of Mercury's core. Such a layer divides the fluid core in a convecting part and a non-convecting part, where the magnetic field generation is mainly inhibited. As a consequence the magnetic field inside the outer core is damped very efficiently passing through the stably stratified layer by a so-called skin effect. Additionally, the non-axisymmetric parts of the magnetic field are vanishing, too, such that a dipole dominated magnetic is left at the planet's surface.

In this study we present new direct numerical simulations of the magnetohydrodynamical dynamo problem which include a stably stratified layer on top of the outer core. We explore a wide parameter range, varying mainly the Rayleigh and Ekman number in the model under the aspect of a strong stratification of the stable layer. We show which conditions are necessary to produce a Mercury-like magnetic field and give a inside about the planets interior structure.
