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Time-varying magnetic fields of Mercury

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Abstract

In this study we derive spherical harmonic models of Mercury's magnetic field from measurements of the MESSENGER mission. The models describe large scale external and internal magnetic fields. The Gauss coefficients of the magnetic fields mainly show periodic temporal variations that are related to Mercury's orbital period around the sun. These periods are found for external and internal field variations, where internal field variations appear as internal variation, but may also originate in regions below MESSENGER and above Mercury's surface. It is known that magnetospheric fields are due to interactions of the planet's internal magnetic field and the interplanetary (solar) magnetic field. Previous research suggested internal field variations to be generated by an induction effect in Mercury's core. Such process may show a time lag between the causing external field variation and the core response. However, we do not find such time lag, which may be due to the limited temporal resolution of our analyzes. Furthermore, our new results suggest that magnetic fields may also be generated in Mercurys exosphere. Most likely by transient current systems. Possible mechanisms that generate these transient exospheric magnetic fields include wind-driven electrical current systems, and the diamagnetic effect. These results may hold implications for the production of electrically charged particles in Mercury's exosphere at altitudes upward 400 km above the Planet's surface, but also for the electrical conductivity of Mercury's mantle and crust.

1. Introduction

The planet Mercury is characterized by a peculiar internal magnetic field. Although it has a deep origin as for the Earth, it is much weaker, strongly axisymmetric, and has a much larger quadrupole-to-dipole ratio at its surface than on the Earth [1, 2, 3]. The current data coverage (by MESSENGER, between March 2011 and April 2015) is too limited to derive a global model with a high spatial resolution. However, the duration of the mission, in excess of 16 Hermean years, makes it possible to study if there are any temporal changes on the global scale. We investigate these variations of internal and external origin, as modeled from the measurements once a mean magnetic field model has been subtracted. In this study we analyze these variations and correlate them with the orbital parameters.

2. MESSENGER data and mean model

MESSENGER orbited around Mercury During this interval it flew at low altitude (below 1000 km) mainly over the northern hemisphere. This led to an uneven distribution for topics related to the description and understanding of the Hermean magnetic field. Due to this data distribution it is only possible to compute low degree and order spherical harmonic global models (e.g., [1-2]), or local models (over the northern hemisphere) with a better resolution (e.g., [3]). All these models are temporally averaged, and describe the mean magnetic field of Mercury. For self-consistency we start with the raw magnetic field measurements and compute a mean magnetic field model up to degree and order 3. We consider only night-side measurements below 1000-km altitude. The derived model is very similar to that of [3]. We then subtract the measurements from this model in order to focus on the time-varying residuals. Time-varying model Measurements are sorted into temporal bins so that each contains 8 consecutive orbits (provided that there are no significant gaps between orbits). For each subset, a SH degree and order 1 internal and external magnetic field model is computed. The misfit of each subset significantly improves, going from about 50 nT (after removal of a mean global magnetic field) to about 20 nT (after modeling of the considered subset).

3. Results

The results consist in a time series of 6 times 450 coefficients, for the internal (g10, g11, and h11) and external (q10, q11, and s11) parts. We show on Figure. 1 time series of the external and internal axial dipole terms.

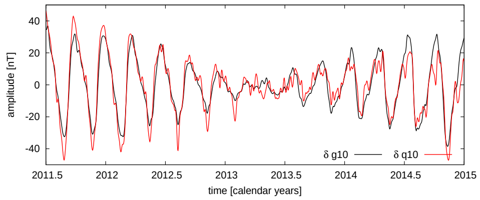

Figure 1: Time series of Gauss coefficients g10 (black) and q10 (red) over the duration of the MESSENGER mission.

4. Summary and Conclusions

External and internal magnetic field variations are highly correlated and present a periodic temporal variability. Their main period is 88 days; i.e., the duration of one Hermean revolution around the Sun. This periodic variation seems to be modulated by an additional term, which cancels out in the beginning during the first half of 2013. This corresponds to the time when MESSENGER's periapsis was the closest to the pole. Similar observations are made for the equatorial dipole terms, although the main periods are different, with two overlapping ones at 58 and 176 days (i.e., one day and two years or one solar day). In this paper we will show several statistical analyzes, which all confirm these figures. These correlated time variations of internal and external origin are very intriguing and their exact origin is under investigation. The fact that most periods are associated with the orbital parameters of Mercury make an external origin more likely, with possibly different source regions.

Acknowledgements

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References

[1] Anderson, B. J., Johnson, C. L., Korth, H., Winslow, R. M., Borovsky, J. E., Purucker, M. E., Slavin, J. A., Solomon, S. C., Zuber, M. T., & McNutt, Jr., R. L., 2012. Low-degree structure in Mercury's planetary magnetic field, *Journal of Geophysical Research (Planets)*, **117**, E00L12.

[2] Johnson, C. L., Purucker, M. E., Korth, H., Anderson, B. J., Winslow, R. M., Al Asad, M. M. H., Slavin, J. A., Alexeev, I. I., Phillips, R. J., Zuber, M. T., & Solomon, S. C., 2012. MESSENGER observations of Mercury's magnetic field structure, *Journal of Geophysical Research (Planets)*, **117**, E00L14.

[3] Thebault, E., Langlais, B., Oliveira, J., & Amit, H., 2016. A time-averaged model of the Hermean's magnetic field, 15. Symposium on Study of the Earth's Deep Interior.