Magnetic Field Structure of Mercury

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Recently planet Mercury-an unexplored territory in our solar system-has been of much interest to the scientific community due to recent flyby of the spacecraft MESSENGER that discovered its intrinsic stationary dipole like magnetic field structure with an intensity of ~ 300 nanotesla confirming Mariner 10 observations. As the planet rotates very slowly (~ 59 days), it is very unlikely that such a stationary large-scale magnetic field structure is generated and maintained by the geodynamo like processes. Alternatively, internal magnetic field structure of Mercury is modeled as a solution of magnetic diffusion equation in an incompressible medium of constant diffusivity.

In the present study, Mercury's internal structure mainly consists of the core and the mantle. For simplicity, magnetic diffusivity in both parts of the structure is considered to be uniform and constant with a value represented by suitable averages. It is further assumed that vigorous convection in the mantle disposes of the electric currents leading to very high diffusivity in the mantle. Chandrasekhar's [1, 2] MHD equations are used for modeling the internal magnetic field structure. Strength of magnetic diffusivity from the previous studies that are estimated by the constraints of thermal and dynamical history of the planet's core is used. Appropriate boundary conditions at the core-mantle boundary are applied and analytical solution of magnetic field structure for both core and mantle is obtained. In order to satisfy atmospheric latitudinal variation of magnetic field profile as obtained by MESSENGER, magnetic field structure consists of two diffusion terms in the core with a combination of uniform, dipole and quadrupole field like structures in the mantle that emanate from the lithosphere to the atmosphere. Present study puts the constraint on Mercury's core radius to be ~ 2000 km. From the estimated magnetic diffusivity and the core radius, it is also possible to estimate two diffusion eigen modes with their diffusion time scales of the ~ 8.6 and 3.7 billion yrs respectively suggesting that the planet is inherited its present day magnetic field structure from the solar nebula.

References

[1] Chandrasekhar, S., *Astrophysical Journal.* **124**, 232 (1956).
[2] Chandrasekhar, S., *Astrophysical Journal.* **124**, 244 (1956).