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A deep dynamo explaining Mercury's weak magnetic field

U.R. Christensen

Max-Planck Institute for Solar System Research (christensen@mps.mpg.de)

Mercury has a global magnetic field of internal origin. However, its amplitude at the planet's surface is only 1/100 of the geomagnetic field strength. Based on the assumption that Lorentz force and Coriolis force balance inside planetary dynamos, a thirty times stronger field would be expected. Thermal evolution models predict that the heat flux in Mercury's core is less than the heat flow that can be conducted along an adiabatic temperature gradient. They also predict the existence of a solid inner core, whose size may fall into a wide range. Convection in the fluid part of the core could be driven by the flux of sulphur that is rejected from the growing inner core. As a result, the deep parts of Mercury's outer core may be convectively unstable, whereas the upper part is stable because of the dominant influence of a subadiatic temperature gradient. Numerical models of convection-driven dynamos in such a system show that in the deep layer a strong magnetic field dominated by higher harmonics is generated. The dipole and quadrupole components are comparatively weak in the dynamo region, but vary less rapidly in time compared to small-scale components. The dynamo field diffuses through the stagnant out part of the fluid core, where its rapidly varying parts are strongly damped by the skin effect. The slowly varying axisymmetric dipole and quadrupole components pass with some attenuation and dominate the field structure at the surface. In various models the surface field strength is in the range of 20-200% of the observed strength. Model predictions, such as the strong dominance of axisymmetric low-order field components and the lack of a detectable field change on the decadal time scale, can be tested by future observations of Mercury's field by the Messenger and Bepi Colombo missions.