EFFECTS OF THERMAL BOUNDARY CONDITION AND INNER CORE SIZE ON DYNAMOS DRIVEN BY SECULAR COOLING

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Thermal evolution simulations suggest that at least the early Mars and probably also the early Earth had no solid inner cores. This leaves secular cooling as the only possible driving source for dynamos that were already operating at these times. We examine this scenario with numerical MHD simulations.

Previous dynamo models driven by purely secular cooling show two types of magnetic field morphology: Either multipolar fields, where the dipole has no special significance, or dipole dominated fields. These two types where identified in models that differ in inner core sizes as well at outer thermal boundary conditions. Multipolar fields were reported for dynamos with Earth-like inner core sizes and fixed temperature boundary conditions. Dipole dominated fields were found independently on inner core size when imposing a fixed heat flux at the outer boundary. Since it is not clear whether the inner core size or the boundary conditions where responsible for the differences it is difficult to discuss which model is more valid for early Mars and Earth.

We have investigated the effects of the thermal boundary condition and the inner core size on the morphologies of the magnetic field for dynamos driven by purely secular cooling. We find that dipole dominated fields are generated when using fixed heat-flux conditions, whereas non-dipolar fields are generated for fixed temperature conditions. The inner core size is less influential; we find rather similar results for inner cores with radii of 10% or 35% of the total core radius, respectively. The solid mantle of terrestrial planets imposes a heat flux rather than a temperature on the core. Our result therefore suggested that the early Earth and Mars already had dipole dominate magnetic fields typically found when using this more appropriate boundary condition.

Martian magnetic field, Magnetohydrodynamic dynamo, Secular cooling

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