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Force balances and magnetic field morphologies in thin shell dynamos with possible applications to Mercury and Mars

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Numerical simulations of the geodynamo have been successful at reproducing many of the salient properties of the Earth's magnetic field, including axial-dipole dominance, secular variation and reversals. These models appropriately use the known geometry of the Earth's core, namely a thick fluid electrically conducting outer core surrounding a small electrically conducting inner core.

We know very little about the core geometry of other terrestrial planets. We do know that Mars most likely possessed a dynamo in its early history that generated a strong remanent crustal field and that Mercury has an intrinsic magnetic field either due to an active dynamo or a remanent field from a past dynamo. With little knowledge of the core geometry in these planets, it is possible that either presently (for Mercury) or in the past (for both Mars and Mercury), these planets' dynamos operated in a thin shell core geometry which could produce different magnetic field morphologies than the Earth-like case.

Here we use numerical dynamo modelling to study the effects of a thin shell geometry on the resultant magnetic fields and dynamics in the core. We analyze the balance of forces, velocity field structure, magnetic field spectra and partitioning of energy in the simulations. We find that thin shell dynamos can produce a variety of behaviours not seen in our thick shell dynamo models.