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Some Recent Developments in Planetary Dynamo Simulations

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The terrestrial planets have been extensively modelled by numerical simulations of convection in rapidly rotating spherical shells using the Boussinesq approximation. While the very low geophysical values of the Ekman number, E, and magnetic Prandtl number, Pm, are not attainable, the asymptotic behaviour in these limits is becoming clearer. The question of whether low E and low Pm geodynamo models can have Earth-like behaviour is being addressed.

An emerging issue is the role of the magnetic field on the pattern of convection. In models driven by compositional convection at the inner core boundary, with little heating in the interior, the main effect is on individual rolls, where magnetic field can substantially enhance helicity. This can lead to subcritical behaviour, allowing a sudden collapse the dynamo. It also leads to a preference for dipolar dynamos over quadrupolar dynamos. In models driven by internal heating and with fixed flux boundary conditions, the magnetic field, in combination with a thermal wind, can change the whole pattern of convection. Such models might be relevant if there is significant radioactivity in the core. The mechanism by which this large scale convection occurs is discussed.

Boussinesq dynamo models are well established, but compressible models based on the anelastic approximation, are now coming onstream. An international benchmarking exercise has been conducted to verify these new codes, with very encouraging results. The compressible models are already showing some differences from the Boussinesq case: transverse dipoles and other more complex magnetic field patterns appear to be generated more readily. These codes are also beginning to be used to study giant planet dynamos.