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Planetary dynamos

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Planetary magnetic fields cover a broad range in field strength and field geometry. Jupiter's field is ten times stronger than the geomagnetic field and Mercury's field is hundred times weaker. Saturn's field is extremely axisymmetric, whereas that of Uranus and Neptune is dominated by non axial dipole components. A general theory of planetary dynamos that explains these differences is not available, but progress has been made based on numerical dynamo simulations. They suggest that the magnetic field strength is controlled by the power available for driving convection in the dynamo region. This explains the relative strength of the Jovian and the geomagnetic field, where power estimates are fairly reliable. The ratio of inertial forces to rotational forces controls whether the field is dominated by the axial dipole or by higher multipoles. Conditions in the Earth's core are estimated to lie close to the transitional point, which may explain the stochastic dipole reversals. In several planets parts of the electrically conducting core could be stably stratified with important consequences for the magnetic field. In Mercury, the skin effect of a thick stable layer in the upper part of the core could attenuate the time-dependent magnetic field generated in a deep dynamo layer. This explains both the low strength of the surface field and the dominance of the dipole and/or quadrupole component, even though the latter are weak inside the dynamo because of the planet's slow rotation. Dynamo models also support the hypothesis that in the case of Saturn differential rotation in such a stable layer, driven by a thermal wind effect, eliminates non-axisymmetric field components in the outside field.