Strong field dynamos

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Numerical models of the geodynamo are usually classified into two categories: dipolar modes, observed when the inertial term is small enough; and multipolar fluctuating dynamos, for stronger forcing. We show that a third dynamo branch corresponding to a dominant force balance between the Coriolis force and the Lorentz force can be produced numerically. This force balance is usually referred to as the strong-field limit. This solution coexists with the often described viscous branch. Direct numerical simulations exhibit a transition from a weak-field dynamo branch, in which viscous effects set the dominant length scale, and the strong-field branch, in which viscous and inertial effects are largely negligible. These results indicate that a distinguished limit needs to be sought to produce numerical models relevant to the geodynamo and that the usual approach of minimising the magnetic Prandtl number (ratio of the fluid kinematic viscosity to its magnetic diffusivity) at a given Ekman number is misleading.