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Towards realistic planetary dynamo simulations

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The last years have witnessed an impressive growth in the number and quality of numerical dynamo simulations. These models successfully describe many aspects of the geomagnetic field and also set out to explain the distinctly different fields of other planets. The success is somewhat surprising since numerical limitation force dynamo modelers to run their computations at unrealistic parameters. In particular the Ekman number, a measure for the relative importance of viscous diffusion to the Coriolis force, is many orders of magnitude too large. After giving a brief introduction into the basics of modern dynamo simulations we discuss the fundamental dynamo regimes and address the question how well the modern models reproduce the geomagnetic field. First-level properties like the dipole dominance, realistic magnetic field strength, convective flow vigor, and an Earth-like reversal behavior are already captured by larger Ekman number simulations. However, low Ekman numbers are required for modeling torsional oscillations which are thought to be an important part of the decadal geomagnetic field variations. Moreover, only low Ekman number models seem to retain the huge dipole dominance of the geomagnetic field once the Rayleigh number has been increased to values where field reversals happen. These cases also seem to resemble the low-latitude field found at Earth's core-mantle boundary more closely than larger Ekman numbers cases.