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The influence of the Ekman number on Geodynamo Simulations

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The generation of the Earth's magnetic field by dynamo processes within the molten outer core is characterized be extremely low Ekman E and Roberts Rb numbers. Although numerical simulations in a realistic parameter regime will be unattainable in the forseeable future, we are able to present simulations of non-magnetic convection and of the full dynamo problem in the range of $E = 10^{-3}$ to 10^{-5}. At the lowest Ekman number we find dynamo solutions with $Rb < 1$ which allows Joule dissipation to dominate viscous dissipation. All simulations are obtained for the full sphere without the use of hyperviscosities. This progress has been made possible by the development of a finite volume method well adapted to parallel computation. A special feature of the method is the implicit calculation of the Coriolis term which dominates the force balance at low Ekman number. Thin Ekman boundary layers and an extremely small scaled flow field in the interior of the core require the use of roughly 10^7 volume cells in order to achieve an adequate resolution. At the equator this resolution is equivalent to an expansion in spherical harmonics up to degree and order $\ell = m = 232$. We expect further progress by the use of massively parallel computation, whereas at the moment we are limited to 12 to 96 processors by the available computational resources.