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Nonlinear solutions of inviscid magnetostrophic dynamo

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The Earth's core convection is believed to be in a dynamical state where (1) viscosity has almost nothing to do with the flow and (2) the magnetic energy density is much greater than the kinetic energy density. In previous numerical simulations of the core convection, viscosity is set as small as possible to increase the effect of rotation and realize a strong-field solution. In this approach, the Navier-Stokes equation is solved numerically, and there occurs no technical problem in time integration. The problem is that the required grid and timestep sizes become small as the fluid viscosity is reduced and therefore the computation time becomes longer. This would be a straightforward approach to the geodynamo problem, by which we could understand the MHD turbulence in the core and the origins of the short-period geomagnetic field variations.

Another approach is the magnetostrophic approximation in the limit of zero viscosity and infinite magnetic energy density. As the viscous and inertial (advection) terms are neglected in the momentum equation, thin viscous boundary layers and short-period MHD waves do not appear. Therefore, this method would be important in considering how the large-scale flow and magnetic field are organized and how they change in relatively long timescales.

Two years ago, I gave a presentation about this magnetostrophic dynamo at the same session, but did not succeed in obtaining nonlinear solutions. Here, I summarize characteristics and numerical difficulties of the magnetostrophic dynamo and report on some progress made in the last two years.

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