Scale similarity of MHD turbulence in the Earth's core

Masaki Matsushima[1]

[1] Dept. Earth Planet. Sci., Tokyo Tech

http://www.geo.titech.ac.jp/~mmatsush/

The geodynamo, which is a generation mechanism of the Earth's magnetic field, has been understood through three-dimensional self-consistent magnetohydrodynamic (MHD) dynamo simulations in rapidly rotating spherical shells. Non-dimensional parameters used in numerical simulations, however, have been very far from those of the real Earth. It is impossible to carry out global geodynamo simulations taking into account molecular diffusivities because of limited spatial resolution and computational power, although anticipated turbulent motions due to very small viscosity can never be ignored. Instead, the expedient of using eddy diffusivities has usually been adopted, being one of methods to parameterize physical processes which involve the subgrid scales (SGS) unresolved.

In numerical calculations of magneto-convection in a rapidly rotating system, Buffett (2003) examined four SGS models for large-eddy simulation (LES), and concluded that the similarity model was much more successful in reproducing the anisotropy in the SGS estimates. It should be noted, however, that constants to be evaluated in the scale-similarity model were determined by comparing results of direct numerical simulations (DNS) with those of LES.

We have investigated the scale similarity of MHD turbulence in the core, aiming at finding a simple method to evaluate the SGS flux. We use results of DNS of magneto-convective turbulence in a rapidly rotating system that we have carried out so far. Dependence of turbulent fluxes, which are obtained by taking an ensemble average over the whole computational box for DNS, on a grid scale and a spatial filter width has been examined. The anisotropy of turbulent flux computed after averaging over segments into which the box is divided remains unchanged even when the size of segments changes. Dependence of turbulent flux computed from fields to which a spatial filter is applied on its width indicates that SGS flux can be evaluated through extrapolation. The validity and the availability of the method of estimating the SGS flux are then demonstrated. The present method will be helpful to carry out numerical simulations incorporating SGS physical processes.