E012-003 Room: 301A Time: May 29 9:30-9:45

Modeling the Eddy Diffusivity in the Earth's Core

Masaki Matsushima[1]

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

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

The Earth's outer core is likely to be in a turbulent state because of very small molecular diffusivities, whereas predominant are large-scale magnetic fields, which are generated by fluid motions through dynamo action within the core. This implies that a range of spatial scales of fluid motions in the core is very broad; from dissipative scales to global core scales. At the present, it is impossible to resolve such small scales in global geodynamo simulations. However, these scales cannot be ignored. Large-scales are diffused much more effectively by turbulent eddies than by molecular processes. This requires that the influence of the subgrid scales must be taken into account. It is therefore of significance to model eddy diffusivities in the Earth's core for use in future global geodynamo simulations.

Turbulent motions in the core are highly anisotropic, since they are strongly influenced by the Earth's rotation and the strong magnetic field. This means that eddy diffusivities expressed in terms of isotropic scalars are unlikely to describe subgrid scale processes. Hence importance is attached to tensor eddy diffusivity models.

We have been carrying out direct numerical simulations of magneto-convective turbulence in a rapidly rotating system to understand its anisotropy and to model the eddy diffusivity of heat. It has been found that the turbulent heat transport, by which a large-scale difference in temperature diffuses, has a preferred direction, determined by the directions of the rotation axis, the imposed strong magnetic field and the gravitational force. Thus the turbulent heat transport is represented by an anisotropic eddy diffusivity tensor. Its respective elements also depend on the local values of the non-dimensional parameters.

We have derived an alternative expression for this eddy diffusivity tensor directly from the basic equations by applying a second moment closure model. Such a model can be compared with the one computed through direct numerical simulations. The two approaches give consistent results, although some modifications are necessary to improve the agreement. The expression of an eddy diffusivity tensor in terms of a second moment closure model involves the Reynolds stress, for which we have used that obtained through direct numerical simulations. We derive a model for the Reynolds stress in the same way. It turns out that realizability should be involved to represent it adequately.