Recent developments of Yin-Yang dynamo simulation

Akira Kageyama[1]

[1] JAMSTEC

http://www.es.jamstec.go.jp/esc/research/Solid/members/kage/index.ja.html

Since the Earth is composed of spherical layers, computer simulations of the Earth's interior need efficient spatial discretization methods in the spherical shell geometry. For this purpose, we proposed a new spherical grid system, the Yin-Yang grid.

Because there is no grid mesh that is orthogonal over the entirespherical surface and, at the same time, free of coordinate singularity or grid convergence, we have chosen an overset grid approach. In the Yin-Yang grid, a spherical surface is decomposed into two identical subregions. The decomposition (or dissection) enables us to cover each subregion by a grid system that is individually orthogonal and singularity-free. Each component grid in this Yin-Yang grid is a low latitude component of the usual latitude-longitude grid on the spherical polar coordinates (90 degree about the equator and 270 degree in the longitude). Therefore, the grid spacing is quasi-uniform and the metric tensors are simple and analytically known. One can directly apply mathematical and numerical resources that have been written in the spherical polar coordinates or latitude-longitude grid. Since the two component grids are identical and they are combined in a complementary way, various routines of the code can be recycled twice for each component grid at every simulation time step. We have developed finite difference codes based on the Yin-Yang grid for the geodynamo simulation and mantle convection simulations.

The Yin-Yang grid is also useful to solve Poisson equations in the spherical shell geometry. For this purpose, we introduced the multigrid method, which is practically the optimal way to solve this kind of boundary value problem. In our Yin-Yang multigrid method, we adopt the full approximation storage algorithm of the multigird method. The Jacobi method is used as the smoother. The V-cycle is repeated for a couple of times until we get the convergence. The internal boundary condition of each component grid (Yin and Yang) are set by mutual bi-cubic interpolation at every grid level.

In the talk, recent developements of the Yin-Yang grid method and its application to geodynamo simulation will be presented.

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