Dynamo Simulation by the Yin-Yang Grid

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The spherical geometry is important in geosciences. The examples include the mantle convection simulations, geodynamo simulations, and atmospheric and oceanic GCMs. One of the most popular grid system for the spherical geometry would be the latitude-longitude (lat-lon) grid. The lat-lon grid has two problems; (1) it has the coordinate singularities on the north and the south poles; and (2) the CFL condition is very severe because of the high density of the grid points near the poles. The coordinate singularity can be removed by using the l'Hospital's theorem. The severe CFL condition can be relaxed by applying a low-pass filter in the longitudinal direction.

We have been using a finite difference method on the lat-lon grid, that incorporates with the techniques of l'Hospital's theorem and the low-pass filter, for the dynamo simulation in the spherical shell geometry. It is a fruitful code that have been reproduced the spontaneous dipole field generation as well as its sporadic reversals. However, we have found that the computational efficiency can be much improved if we could remove the filtering procedure from the computation. Since the filtering is required by the extreme non-uniformity of the grid spacing in the lat-lon grid, we need to find a grid system that covers a sphere with almost uniform grid spacings.

We have devised such a new grid system that covers the spherical surface and named it Yin-Yang grid. The Yin-Yang grid is a kind of the overset or the Chimera grid. The overset grid is a composite grid system with plural component grids. The component grids partialy overlap each other on their borders. The Yin-Yang gird is a designed overset grid for high speed calculations with massively parallel vector supercomputers.

In the talk, the details of the Yin-Yang grid and its application to the spherical shell dynamo simulation will be presented.