Substantiation of the Gauss coefficients of the geomagnetic field: a case of equatorially antisymmetric magnetic fields

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We have attempted to realize the substantial images of the Gauss coefficients applying the dynamo simulation results. Although the Gauss coefficients are regarded as a good interface between the geomagnetic and paleomagnetic data and the dynamo models, there are obviously no real multipoles in the earth's center. If there is a model with clear physical meaning, it helps us understand the real geodynamo.

Recent dynamo simulations suggest that one of the fundamental processes in the dynamo action is a structure of cyclonic and anticyclonic convection cells aligned parallel to the rotational axis just outside the tangent cylinder. Since lines of magnetic force are stretched and concentrated to those cells, the magnetic field in the core may also show some cellular structure. Therefore we possibly approximate the major structure of magnetic fields in the core with several magnetic cells parallel to the rotational axis in which magnetic flux is assumed to be confined like a solenoidal coil. The physical meaning of magnetic cells is thought to be a place where the dynamo action is so intensive.

If the cell extends northward and southward with an equal length, hereafter called 'MC', it generates only the equatorially antisymmetric fields. In terms of MC, the geocentric axial dipole (g10) corresponds nearly to a sum of strength of all MCs while nondipole fields are related mainly to geometrical distribution of MCs.

From the dynamo simulation results with relatively low Rayleigh number, the magnetic fields exhibit a clear equatorial antisymmetry to result in non-zero values of the dipole family (g10, g21, h21, ...) of the Gauss coefficients and almost null values of the quadrupole family (g11, h11, g20, ...). Therefore these magnetic fields may be represented by several MCs.

The recent geomagnetic fields such as IGRF2000 give the Gauss coefficients originated from the geodynamo, say degrees (n) of not more than 8-12, the power spectrum of which shows exponential decrease with respect to the degree except for the dipole term (n = 1). It is also seen that each power spectrum of the dipole and quadrupole families has a trend of exponetial decrease for nondipole terms, suggesting the independent sources. In this case the dipole family may be represented by a certain set of MCs as suggested for the dynamo simulations while the quadrupole family may be by another source.

We have obtained appropriate solutions of MCs for the dynamo simulation results and the observed field (IGRF/DGRF) to fit the Gauss coefficients at the core-mantle boundary (CMB) as an inverse problem. The trade-off between the fitness to the data and the number of MCs is evaluated with a statistical indicator of AIC. Based on the results from the inversion, we will discuss the feasibility of MC models in comparison with the magnetic fields at CMB.