nonlocal memory effects of electromotive force by fluid motion with two-dimensional periodicity

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One of unresolved problems is how the small-scale magnetic field produces the large-scale magnetic field, regardless of recent MHD dynamo simulations. This process is important to understand the mechanism that the dipole field is generating by columnar flow in the core.Then the electromotive force term u'∗B', which represents the effect of the small-scale field and flow to the generation of the large-scale field, plays the important role. Usually assumed to (1) instantaneous in time and (2) local in space, the term can be approximated to the form u'∗B'=aB, referred to 'the alpha-effect'. The approximation is not collect when the magnetic Reynolds number Rm is large as the earth's core, while it is collect for small Rm. However, this 'alpha-effect' has been used in usual to explain the generation of the magnetic field in the case of earth's core. It is not obvious how the electromotive forces term should be described for large Rm.

We examine the behavior of the electromotive force as a function of Rm by the kinematic dynamo model. We suppose the fluid motion with two-dimensional periodicity, which has the non-zero helicity and aligned columnar cells, first given by G.O.Roberts(1972). This fluid motion is corresponded to simplified one in the core. As a result, while we confirmed the electromotive force for small Rm could be approximated by the alpha-effect, it was found that the electromotive force for large Rm has nonlocal memory effects and this affects the dynamo action strongly. This results means that for the Earth's core we must consider in terms of the electromotive force with nonlocal memory effects, not the local instantaneous alpha-effect.