Linear analysis of slow MC waves

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Many studies of magnetohydrodynamic (MHD) waves have been carried out to explain the mechanism of the geomagnetic secular variations such as the westward drift (e.g. Braginskiy, 1967). The MHD waves are of particular importance in constraining the magnetic-field and flow structures hidden inside the Earth's core. Here we report results of a linear analysis of MC waves, which arise under the balance between magnetic and Coriolis forces, including the effects of spherical geometry and magnetic diffusion. The background magnetic field is assumed to be an equatorially antisymmetric toroidal field. The background velocity field is also toroidal and chosen to satisfy the equation of motion. As the velocity field cannot be uniquely determined because of the existence of an arbitrary geostrophic flow, we examine three cases where the flow component averaged over axial cylinders is (1) entirely zero at any radii, (2) westward or (3) eastward near the core equator. The eigenvalue problem is separately solved for different azimuthal wavenumbers and different types of symmetry in eigenmodes; namely, dipole and quadrupole families.

Magnetic instability occurs when the background magnetic field intensity is large. Interestingly, the instability easily occurs when the background velocity at the equator near the core-surface is westward (Case 2), which is suggested in recent high-resolution geodynamo simulations, and hardly occurs when the velocity is eastward (Case 3). In all cases, the most unstable wave (or the wave that has the smallest decay rate) has the azimuthal wavenumber (m) of 1. In Case 2, the most unstable wave resides in a quadrupole family. The preferred wavenumber does not coincide with the most evident drifting signal of the core-surface field (m=5) estimated by Finlay and Jackson (2003), but the fact that the quadrupole family is always preferred seems to be harmonic with the observations. Phase velocity of the quadrupole-family solution is westward, and the speed is as large as the typical speed of MC waves measured at the background magnetic field intensity. Phase velocity seems to be influenced by the basic flow at the core-surface equator. Hopefully, we show some results of wave behaviors when the background magnetic field is changed.