東西磁場が印加された回転球面上の磁気流体浅水波の極トラップモード

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Shallow water MHD waves trapped in the polar regions on a rotating sphere with an imposed azimuthal magnetic field

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Magnetohydrodynamic (MHD) shallow water waves on a rotating sphere with a background toroidal magnetic field are investigated to provide the physical interpretations of the geomagnetic variations which originate from Earth's core. We focus on the MHD waves within a stratified outermost Earth's outer core (e.g. Helffrich and Kaneshima, 2010; Kaneshima, 2018) in common with some previous studies, which including Braginsky(1993) and Buffett(2014), Chulliat et al.(2015). Not only the explanation of the geomagnetic fluctuations but also constraints on the obscure properties of the stratification can be provided by comparing with wavy variations in the geomagnetic field.

An azimuthal equatorially antisymmetric field ($B_p(t)=B_0\sin(t)\cos(t)$, where t (theta) is colatitude, p (phi) is azimuth) is adopted as an imposed magnetic field in this research. Previously, an equatorially symmetric one ($B_p(t)=B_0\sin(t)$) was examined in Marquez-Artavia et al.(2017), whose results we replicated and reported in JpGU 2018. We was also found that eigenvalue problems with the background field varying in the theta direction, except for $B_p(t)=B_0\sin(t)$, possess a continuous spectrum, which is sometimes called the Alfven continuum (Goedbloed et al., 2004), in the range where an azimuthal phase velocity is coincident with a local Alfven velocity divided by sin(t) (Nakashima and Yoshida, JpGU2019). Since the Alfven continuum results from the singularity of the governing equations with ideal MHD approximation, introducing the horizontal magnetic diffusion can exclude the continuous modes by transforming them into discreate eigenvalues, whose eigenfunctions exhibit an internal resistive boundary layer around a critical latitude which a local Alfven wave resonates. By the numerical calculation with small magnetic diffusivity, the polar trapped westward modes are found for the Earth-like parameters. As a several azimuthal wavenumber, for instance m=6, these polar trapped mode propagates with a few years period. On the other hand, the eastward modes and the equatorial trapped modes are not likely to observe according to our results.

Buffett and Matsui(2019) recently obtained the equatorial trapped waves propagating to the east with a background radial magnetic field varying in the north-south direction without horizontal magnetic diffusion. Although their system also can have the Alfven continuum, since the assumed main field do not vanish in the equator, the eigenvalues of the found slow equatorial mode are outside of the continuum.