Equatorial waves modified by the presence of a toroidal magnetic field within the stably stratified layer at the top of the Earth’s outer core

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A number of researches have suggested the existence of a stably stratified layer at the top of the Earth’s outer core (e.g. Buffett, 2014), including seismological evidence (e.g. Helffrich and Kaneshima, 2010). The stable stratification can make horizontal flow dominant at the top of the core. It is therefore expected that the hydrostatic approximation used in atmospheric and oceanic dynamics can be applied to fluid motion within this stratified layer provided that we include the influences of the magnetic field.
In this study, we investigated waves trapped in the equatorial region at the top of the liquid core. Our research is motivated by prominent geomagnetic fluctuations in the equatorial region. For example, Chulliat et al.(2015) found some standing waves with periods of about 6 years in secular acceleration data in the equatorial region. In addition, Finlay and Jackson (2003) and other scientists showed that the geomagnetic westward drift is most prominent in the low latitude region.
The governing equations we adopt are linearized non-dissipative Boussinesq-MHD equations. In addition, we use hydrostatic and equatorial beta plane approximations, and assumed that the background magnetic field has only toroidal (east-west) component. With these assumptions, the governing differential equations become separable, and can be divided into horizontal and vertical structure equations. It should be noted that the horizontal structure equations have the same form as the MHD (magnetohydrodynamics) shallow water equations (e.g. Gilman, 2000; Zaqarashvili et al., 2008).
We obtained a dispersion relation and eigenfunctions with both analytical and numerical approaches, and examined the effect of toroidal magnetic fields on equatorial waves.
Firstly, we considered the situation in which a uniform toroidal field is imposed. The frequencies of waves such as inertial gravity waves and Rossby waves are higher, and these waves decay more rapidly away from the equator than the non-magnetic situation. Moreover, MC Rossby waves, which can exist in the mid latitude, cannot be trapped in the equatorial region.
Next, we let the strength of imposed background field depend linearly on latitude. The spectrums of Alfven waves become continuous, and the resonance appears at the latitude where the east-west phase speed of an eigenmode coincides with the Alfven wave velocity.

Keywords: the uppermost outer core, stable stratification, equatorial waves, MHD shallow water equations

