Study of the excitation mechanism of storm-time Pc5 ULF waves by ring current ions based on the drift-kinetic simulation

*Tomotsugu Yamakawa[1], Kanako Seki[1], Takanobu Amano[1], Naoko Takahashi[1], Yoshizumi Miyoshi[2]

1. Department of Earth and Planetary Science, School of Science, The University of Tokyo, 2. ISEE, Nagoya University

Internally driven ULF waves are electromagnetic fluctuations in the inner magnetosphere, and can be generated by ring current ions associated with ion injections from the magnetotail during substorms. The excitation mechanism and global distribution of ULF waves are keys to understand dynamic variation of the outer radiation belt electrons, since ULF waves in the Pc5 range (1.67-6.67 mHz) are considered to contribute to the radial diffusion of radiation belt electrons [e.g. Elkington et al., 2003]. Promising candidates of excitation mechanism of internally driven ULF waves is drift-bounce resonance [Southwood, 1976]. Although previous spacecraft observations have suggested the resonant excitation [e.g., Dai et al., 2013; Yeoman and Wright., 2001], there are other possibilities such as periodic pressure inhomogeneity formed by time-dependent particle injections. Recently, Yamakawa et al. [2019] confirmed for the first time the drift resonance excitation of storm-time Pc5 waves in 3D dipole structure under the initial condition of phase space density (PSD) with north-south symmetry based on the drift-kinetic simulation. However, drift-bounce resonance excitation of ULF waves was not detected in the case of the symmetric initial PSD distribution, while this type of resonance was suggested by some spacecraft observations [e.g. Oimatsu et al., 2018]. This study aims to investigate the condition for the excitation of ULF waves associated with drift-bounce resonance based on the global drift-kinetic model.

In order to simulate the excitation of internally driven ULF waves, we perform a kinetic simulation for ring current particles using GEMSIS-RC model [Amano et al., 2011], in which five-dimensional drift-kinetic equation for the phase space density (PSD) of ring current ions and Maxwell equations are solved self-consistently under assumption that the first adiabatic invariant is conserved. In order to simulate consequence of ion injection from the plasma sheet, we set a localized high-pressure region around midnight consisting of H+ ions as an initial distribution. We compare two cases of the initial velocity distribution; the Maxwellian velocity distribution with the isotropic temperature of 16 keV (Case a) and the velocity distribution with asymmetric distribution in pitch angle direction in addition to the background Maxwellian distribution (Case b). In Case a, the simulation results show the drift resonance excitation of poloidal, toroidal, and compressional mode Pc5 waves in the dayside dusk sector. These waves are fundamental mode waves with azimuthal wave number m ˜ - 20 propagating westward. Global distribution of the excited poloidal Pc5 waves indicates that they are excited where the local growth rate resultant from the positive PSD gradient in energy is positive [Yamakawa et al., 2019]. In Case b, excitation of the second harmonic poloidal Pc3 ULF waves due to the drift-bounce resonance was identified in the dayside dusk sector. Ions contributing to the growth of poloidal mode ULF waves tend to have the pitch angle of about 90 degrees for Pc5 waves and oblique pitch angle for Pc3 waves. We will also report on characteristics of excited ULF waves with a focus of the relative contribution of the drift and drift-bounce resonances.

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