3rd URSI AT-AP-RASC, Gran Canaria, 29 May – 3 June 2022

Excitation of two types of storm-time Pc5 waves based on the magnetosphere-ionosphere coupled model

Tomotsugu Yamakawa* (1), Kanako Seki (1), Takanobu Amano (1), Yoshizumi Miyoshi (2), Naoko Takahashi (3) and Aoi Nakamizo(3)
(1) The University of Tokyo, Bunkyo-ku, Tokyo-to, Japan; e-mail: yamakawa@eps.s.u-tokyo.ac.jp; k.seki@eps.s.u-tokyo.ac.jp; amano@eps.s.u-tokyo.ac.jp
(2) Nagoya University, Nagoya-shi, Aichi-ken, Japan; e-mail: miyoshi@isee.nagoya-u.ac.jp
(3) National Institute of Information and Communications Technology, Koganei-shi, Tokyo-to, Japan; email: n.takahashi@nict.go.jp; aoi.nakamizo@nict.go.jp

Storm-time Pc5 ULF waves are electromagnetic pulsations (1.67-6.67 mHz), which can be generated by ring current ions associated with the injection from the magnetotail during substorms. Since Pc5 waves can drive radial transport of radiation belt electrons, the excitation mechanism and global distribution of ULF waves are keys to understand the dynamic variation in the inner magnetosphere. Theoretically, Southwood (1976) [1] has proposed that the drift-bounce resonance is a candidate excitation mechanism. Recently, Yamakawa et al. (2020) [2] reproduced both the drift resonance and drift-bounce resonance excitation of ULF waves in the global drift-kinetic simulation of the inner magnetosphere. However, the model does not reproduce standing Alfven waves associated with the field line resonance and the amplitude of the excited ULF waves is small compared to spacecraft observations. One possible reason is the damping of field fluctuations at the ionospheric boundary in the model.

In order to improve the ionospheric boundary condition, we have implemented Magnetosphere-Ionosphere coupling between GEMSIS-RC [3] and GEMSIS-POT [4] models. GEMSIS-RC solves the 5-D drift-kinetic equation for the phase space density (PSD) of ions and Maxwell equations self-consistently in the inner magnetosphere. GEMSIS-POT is a global 2-D potential solver in the ionosphere. We use FAC (field-aligned current) from GEMSIS-RC as an input to GEMSIS-POT for the Region 2 current, while Regin 1 FAC is assumed to simulate the ion transport from the plasma sheet. The resultant electric field potential is then used as the ionospheric boundary condition of GEMSIS-RC. The coupled model enables us to simulate ion injection from the plasma sheet into the inner magnetosphere and reproduce the field line resonance excitation of Alfven waves.

Simulation results show the excitation of two types of Pc5 ULF waves. First, we find the drift resonance excitation of Pc5 waves in the dayside. They are driven by positive energy gradient in the ion PSD with the energy of 50-120 keV. Another type of Pc5 is the second harmonic Pc5 waves in the duskside and premidnight region. We find that the drift-bounce resonance of ions occurs in the energy range of 50-80 keV and the excited waves are driven by inward gradient of PSD. We will also report on shielding effects by the Region-2 FAC on the excitation of ULF waves and what determines the Pc5 properties such as wave frequency and the azimuthal wave number.

1. D. J. Southwood, "A general approach to low-frequency instability in the ring current plasma," *Journal of Geophysical Research: Space Physics*, 81, pp.3340-3348, July 1976, doi:10.1029/JA081i019p03340.

2. T. Yamakawa, K. Seki, T. Amano, N. Takahashi, and Y. Miyoshi, "Excitation of internally driven ULF waves by the drift-bounce resonance with ring current ions based on the drift-kinetic simulation", *Journal of Geophysical Research: Space Physics*, 125, e2020JA028231, November 2020, doi:10.1029/2020JA028231.

3. T. Amano, K. Seki, Y. Miyoshi, T. Umeda, Y. Matsumoto, Y. Ebihara, and S. Saito, "Self-consistent kinetic numerical simulation model for ring current particles in Earth's inner magnetosphere," *Journal of Geophysical Research: Space Physics*, 116, A02216, February 2011, doi:10.1029/2010JA015682

4. A. Nakamizo et al., "Effect of R2-FAC development on the ionospheric electric field pattern deduced by a global ionospheric potential solver," Journal of Geophysical Research: Space Physics, 117, A09231, September 2012, doi:10.1029/2012JA017669.