Relationship between ECH waves, ionospheric F-region ionization and pulsating aurora based on ground-based optical, EISCAT and Arase satellite observations

*Mizuki Fukizawa[1], Takeshi Sakanoi[1], Yasunobu Ogawa[2], Keisuke Hosokawa[3], Yoshiya Kasahara[4], Shoya Matsuda[5], Ayako Matsuoka[6]

1. Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University, 2. National Institute of Polar Research, 3. Department of Communication Engineering and Informatics, University of Electro-Communications, 4. Information Media Center, Kanazawa University, 5. Institute of Space and Astronautical Science/Japan Aerospace Exploration Agency, 6. Research Division for Space Plasma, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency

When a substorm occurs, various plasma waves are excited near the magnetic equator of the inner magnetosphere. In particular, there are chorus waves and electrostatic electron cyclotron harmonic (ECH) waves from midnight to morning. These waves can scatter a pitch angle of electrons by cyclotron resonance and the electrons scattered in a loss cone precipitate into the Earth’s atmosphere, causing diffuse auroral emission. Since the resonance energy of chorus waves is a few keV to tens of keV and that of ECH waves is a few hundred eV to a few keV, chorus waves contribute to the auroral emission in the ionospheric D–E region and ECH waves contribute to that in the ionospheric F region (Fukizawa et al., 2018, GRL). The relationship between chorus waves and pulsating aurora and ionization in the D–E region has been clarified by previous studies (e.g., Kasahara et al., 2018, Nature; Miyoshi et al., 2015, JGR: Space Phys.; Nishimura et al., 2010, Science). However, the relationship between ECH waves and pulsating aurora and ionization in the F region is not well understood. In this study, based on ground-based optical, incoherent scatter radar, and satellite-based observations, we investigated the relationship between ECH waves, pulsating aurora and ionization in the F region.

First, we analyzed the observation data of an all-sky imager and European Incoherent Scatter (EISCAT) radar from September 2016 to December 2019. The proportion of events where ionization was observed in the F region by EISCAT radar was 50 % of the events where pulsating aurora was observed at the magnetic zenith by the all-sky imager (filter transmission wavelength: 560 nm ±5 nm) installed in Tromsø (69˚35’ N, 19˚14’ E, invariant latitude: 66˚12’ N), Norway. When a pulsating aurora with a wavelength of 557.7 nm is generated, there are chorus waves as a driving source near the magnetic equator. It has been confirmed by statistical analysis of satellite observation data that the probability that ECH waves are also excited in the magnetic equator when chorus waves are excited is high (Meredith et al., 2009, JGR: Space Phys.). Therefore, ECH waves may be the driving source of the F-region ionization detected by our analysis.

Secondaly, we investigated a simultaneous EISCAT-Arase event obtained from 01:40 to 03:00 UT on September 26, 2019. Although the ionospheric footprint of the Arase satellite was located within the filed of view of the all-sky imager, the weather in Tromsø was cloudy and no pulsating aurora was detected by the all-sky imager. However, chorus and ECH waves were observed by the Arase satellite and ionization in the D–E and F regions was observed by EISCAT radar. The chorus wave and ECH wave observed by the Arase satellite are partially observed exclusively, and the D–E region ionization and the F region ionization observed by the EISCAT radar show similar characteristics. Although the footprint of the Arase satellite at an altitude of 110 km derived from the IGRF magnetic field model was located about 170 km south of the EISCAT radar observation point, these results suggest that there is a relationship between chorus wave

©2020. Japan Geoscience Union. All Right Reserved.

and ionization in the D–E region and that between ECH wave and ionization in the F region.

In the future works, we will analyze spectroscopic data with a wavelength of 427.8 nm that emits in the D–E region and those with a wavelength of 844.6 nm that mainly emits in the F region to investigate whether the time change of each emission has characteristics similar to that of chorus waves or ECH waves.

Keywords: Electrostatic wave, Pulsating aurora, EISCAT radar, ERG (Arase) satellite

©2020. Japan Geoscience Union. All Right Reserved.