Relationship between lower-band chorus, electrostatic electron cyclotron harmonic waves and pulsating aurora based on conjunction between Arase and ground-based imager

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In this study, we report the relationship between pulsating auroral emission intensity obtained from ground-based imager and electrostatic electron cyclotron harmonic (ECH) and lower-band chorus (LBC) waves detected by the Arase (ERG) satellite. Pulsating aurora typically shows two types of temporal variations. One is the temporal variation at oscillation period ranges from a few to a few tens of seconds (main pulsation), and the other is a few Hz modulation (internal modulation, or 3Hz modulation). Pulsating aurora is thought to be generated by precipitating electrons which are scattered by whistler mode waves at the magnetic equator. *Nishimura et al.* [2010, 2011] reported that temporal variations of LBC waves had one-to-one correlation with those of PsA for 15 events, and a temporal variation of ECH had correlation with that of diffuse aurora without pulsation for one event. On the other hand, Liang et al., [2010] reported that a periodicity of ECH observed by the THEMIS satellite was similar with that of PsA observed by the Fort Smith all-sky imager (FSMI ASI). However one-to-one correlation between a time variation of ECH and that of PsA has not been found. Therefore, we investigated whether not only LBC but also ECH waves have correlation with PsA.
We examined the coordinated Arase satellite and ground-based observation data on March 21, 2017. The footprint of Arase passed through the field of view of panchromatic all-sky imager at Husafell, Iceland (64.67 °geographic latitude, 338.97 °. geographic longitude, 69.13 °geomagnetic latitude, 71.67 ° geomagnetic longitude) during the period of 04:00-06:00 UT (03:40-05:40 MLT). The solar wind data indicates that the corotating interaction region (CIR) reached the Earth during this period. Assuming that 557.7 nm aurora is dominant in the observed panchromatic image, we mapped images at 110 km altitude in the geographic coordinate. Arase was located near the morning side magnetic equator (3.9-4.8 MLT, -7.2-1.7 °MLAT) with L~6 R_E. We estimated cross-correlation coefficients between the auroral luminosity at each image pixel and the plasma wave intensity at frequencies of LBC (0.1 f_{ce}-0.5 f_{ce}) and ECH (f_{ce}-2 f_{ce}) waves where fce is the local electron cyclotron frequency. The electron cyclotron frequency was calculated from the background magnetic field observed by Arase. For this event, apparent temporal variations attributed to eastward drifting patches traversing the selected pixel occasionally interblend into measurements. These contaminations disperse the high-correlation region with time (even shorter than 2 minutes), although the footprint of the ERG satellite hardly moves within such a short interval. Then we define the high-correlation region as an area where the correlation coefficient is higher than 0.50

independent on selection of the time interval from 2 to 5 minutes. As a result, we succeeded in identifying a few intervals when pulsating aurora was not only correlated with LBC but also with ECH.
In addition, we investigated another conjunction event on March 29, 2017. In this case, ECH and LBC were simultaneously observed by Arase in conjunction with the all-sky imager at Sodankylä, Finland (67.37 °geographic latitude, 26.63 °geographic longitude, 64.14 °geomagnetic latitude, 106.59 ° geomagnetic longitude). Looking at footprint locations in the all-sky images, we found that high correlation region between pulsating aurora and ECH was adjacent to that between pulsating aurora and LBC. This fact implies that the source region of pulsating aurora caused by ECH would exist in adjacent to that caused by LBC in the magnetosphere. Since the electron resonant energy with LBC is higher than that with ECH, we will estimate the time delay between the energy of precipitating electrons in the pulsating aurora correlated with ECH and that correlated with LBC.

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