$4f_{ce}$ auroral roar の初観測

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First observations of $4f_{ce}$ auroral roar

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Several types of electromagnetic emissions in the MF and HF bands up to 4.5 MHz have been detected in auroral latitudes by recent satellite and ground-based observations: terrestrial hectometric radiation (THR), auroral roar and MF burst. Auroral roar is narrowband auroral radio emissions observable at ground level in the MF/HF range. Weatherwax et al. [1993] confirmed the occurrence of auroral roar near 2.5–2.8 MHz and discovered another component at 3.7-4.3 MHz. Because these frequencies are considered to be close to the second and third harmonics of the electron cyclotron frequency (f_{ce}) in emission sources, each type of auroral roar is called $2f_{ce}$ roar and $3f_{ce}$ roar. It has been believed that the auroral roar is originated from strong excitation of upper hybrid wave in the auroral ionosphere when $f_{UH} \sim nf_{ce}$ (n = 2, 3) is satisfied and propagates to the ground after the mode conversion into the L-O mode electromagnetic wave. In this study, we present the existence of an additional frequency component of auroral roar, whose emission frequency range is 5.4-5.7 MHz, using spectrum measurement data obtained by ARS-S at Svalbard (75.2 CGM latitude). This type of auroral roar is referred to as $4f_{ce}$ roar in this study, since this frequency range is equal to $4f_{ce}$ in an altitude range of 170-310 km. Its long duration (from several minutes to several hours) and narrowband feature are similar to $2f_{ce}$ and $3f_{ce}$ roar; however, MLT dependence of $4f_{ce}$ roar is different from that of $2f_{ce}$ and $3f_{ce}$ roar. $4f_{ce}$ roar appears during 14-22 MLT (usually 17-19 MLT) and accompanies neither $2f_{ce}$ nor $3f_{ce}$ roar. Typical intensity of $4f_{ce}$ roar is very low: Even maximum peak intensity of $4f_{ce}$ roar is 1.5×10^{-19} W/m^2/Hz, which is only 10-dB higher than background noise level and a few percent of typical intensity of $2f_{ce}$ roar. Not only the geomagnetic activity but also background noise levels affect appearance of $4f_{ce}$ roar. $4f_{ce}$ roar can be recognized only when absorption of man-made radio noises from distant places in the D/E regions is severe in the daylight. There are two possible candidates for the generation mechanism of $4f_{ce}$ roar: (1) linear conversion of upper hybrid waves excited when $f_{UH} \sim 4f_{ce}$ is satisfied and (2) nonlinear wave coupling between the two upper hybrid waves excited under the matching condition of $f_{UH} \sim 2f_{ce}$. The former is a straightforward presumption based on the existing mechanism for generation of auroral roar, while the latter is originally proposed for the explanation of second harmonic THR emissions emanating from the topside ionosphere. The altitude profile of electron densities measured with Dynasonde shows that the frequency of $4f_{ce}$ roar (f_{roar}) nearly equals to the matching frequency of $f_{UH} \sim 4f_{ce}$, while matching frequency of $f_{UH} \sim 2f_{ce}$ does not correspond to $f_{roar}/2$. This Dynasonde experiment supports the former generation mechanism; however, the discussion should be substantiated by both further data and polarization measuremts in the future.

References

Weatherwax, A. T., J. LaBelle, M. L. Trimpi, and R. Brittain, Ground-based observations of radio emissions near $2f_{ce}$ and $3f_{ce}$ in the auroral zone, Geophys. Res. Lett., 20(14), 1447–1450, 1993.