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Characteristics of subpacket structures in Ground EMIC waves at Indian Antarctic station

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Electromagnetic ion cyclotron (EMIC) waves with ultra-low frequency 32 (0.1-5 Hz) range are observed by various spacecrafts in Earth's magnetosphere These waves play an important role in the dynamics of the Earth's radiation belts by contributing to loss mechanism of relativistic electrons through a process called anomalous cyclotron resonance. Recent studies using satellite observations have reported that the subpacket structures play an important role in determining the characteristics of electromagnetic ion cyclotron (EMIC) rising/falling tone emissions. The purpose of present study is to investigate the subpacket structure characteristics in the ground observations of the EMIC wave. This study will help to understand the effect of propagation of the EMIC subpacket structures to the ground. The induction coil magnetometer (ICM) observations from Maitri, Antarctica (Geog. 70.77o S, 11.75o E, Geomagnetic 63.11° S, 53.59° E, L=5) are used. Six quiet time EMIC events occurred during 2015-2016 are analyzed and their details are presented. These six events are shown in Figure 1. It should be noted that the signatures of discrete rising tone EMIC waves are clearly evident in ground observations.

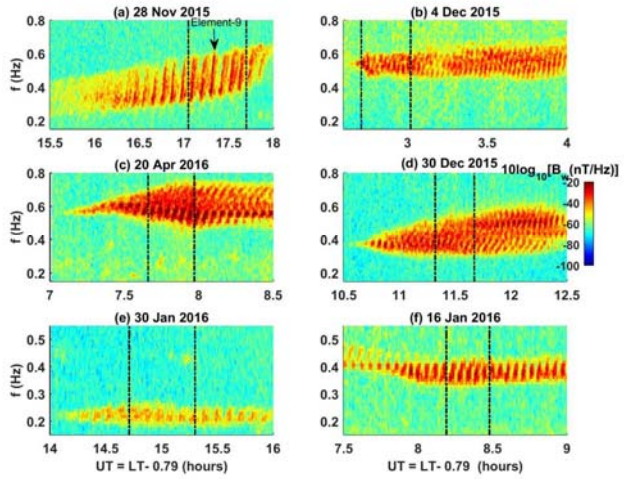

Figure 1: Six EMIC events considered for the present study are shown. The Fourier spectrogram for 28 November 2015, 4 December 2015, 20 April 2016, 30 December 2015, 30 January 2016, 16 January 2016 are plotted in the panels (a) to (f), respectively. The presence of strong and distinct EMIC rising tone emissions are clearly seen on these days. The vertical dotted lines represent the time interval taken for the analysis of instantaneous amplitude-frequency

Duration of EMIC events is around 1.4--2.5 hours. The occurrence of EMIC rising tone wave (i.e. repetitive period of EMIC) is found to be in the range of 1.9--6.7 minutes for these events, which are attributed to PC5 ULF field line oscillations. More than 70% of times the EMIC events are found to be associated with RH polarization. The eccentricity and polarization analysis suggest that the EMIC waves observed on the ground are mainly characterized by right-handed elliptical polarization. Occasionally, left-handed elliptical polarization is also found to be present. Presences of subpacket structures are clearly evident in the ground EMIC observations. In the proton band, single EMIC rising tone wave is associated with nearly 6-12 subpacket structures, whereas in helium band there are nearly 4-5 subpacket structures. The instantaneous amplitude-frequency analysis shows that the wave frequency increases during the period of increase in the amplitude of EMIC rising tone wave. The duration of the subpackets is in the range of 2--60 seconds and it is found to be dependent on the maximum amplitude of the subpacket structure. This tendency is consistent and found to be followed by all events studied here with the correlation coefficients of 0.53--0.87. Such tendency is followed by subpacket structures because the nonlinear growth rate is inversely proportional to the wave amplitude. So smaller amplitude subpacket has higher nonlinear growth rate, and hence its duration is smaller. The instantaneous amplitude-frequency information of subpacket structures retrieved from ground observations are compared with the theoretical estimates of the optimum and threshold amplitudes [Omura et al., 2010; Shoji and Omura 2013]. The amplitude-frequency relation of the ground EMIC subpacket structures are found to be in good agreement with the theory. On the ground, the amplitude of the EMIC waves is found to be lower than the expected theoretical estimates of wave amplitude in the source region. This exercise reveals that the amplitude-frequency dependence of EMIC wave subpacket structures is not much affected during the propagation of EMIC. In the frequency domain the EMIC wave information is not altered, however, the amplitude is reduced by 16--80 times.

Reference:

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Shoji, M., and Y. Omura (2013), Triggering process of electromagnetic ion cyclotron rising tone emissions in the inner magnetosphere, Journal of Geophysical Research:Space Physics, 118 (9), 5553–5561