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Statistical properties of the distribution of EMIC waves in the magnetosphere observed by the Cluster satellite in 2011-2022

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Electromagnetic ion cyclotron (EMIC) waves are important for the loss of radiation belt electrons and ring current ions. After being excited by an instability driven by the temperature anisotropy followed by nonlinear wave-particle interactions occurring near the magnetic equator of the inner magnetosphere, EMIC waves propagate parallel along the magnetic field lines with left-handed polarization. As the waves propagate to higher latitudes, their wave normal angles with respect to the magnetic field increase. At latitudes where the wave frequency is the same as the crossover frequency, the polarization changes from left-handed to right-handed, called polarization reversal. After the polarization change to right-handed , EMIC wave cannot interact with radiation belt electrons. By utilizing this characteristic and investigating the location where polarization reversal occurred, it is possible to estimate the range in which EMIC waves can interact with radiation belt electrons.

Previous statistical studies of EMIC waves using Cluster data have been performed in the period from 2001 to 2010(Allen+ 2015,2016). We extend the analysis to the period from 2011 to 2022 to investigate the statistical properties especially polarization characteristics of EMIC waves in different solar cycles. The period from 2011 onwards corresponds to solar cycle 24, whose solar activities were weaker than those in solar cycle 23. Furthermore, since the Cluster's orbital coverage has changed since the earlier studies, extending the statistical analysis to the period of 2011-2022 is expected to yield new insights into EMIC wave characteristics under different solar activity levels and spatial coverage. The Cluster's polar orbit provides a unique advantage, enabling us to investigate EMIC wave properties at higher latitudes and throughout a wider range of L-shell.

In the present study, we show statistical distribution on the occurrence probability, spatial distribution, and polarization characteristics of EMIC waves in the magnetosphere observed by Cluster which cover the range of magnetic latitude up to 60 degrees and L-values up to 15. In particular, in order to investigate the relationship between magnetic latitude and polarization characteristics, the most frequent values and standard deviation of wave polarization derived by the SVD method were calculated. In this result, As latitude increases, a tendency toward right-handed polarization was observed, while no correlation was found in the standard deviation values. Furthermore, when the distribution was examined using L-values and MLT, left-handed polarization was observed even in high-latitude regions, with L-values exceeding 10. The data suggests that the plasma environment of the outer magnetosphere is reflected. This region has a lower concentration of heavy ions than the inner magnetosphere, but estimating the extent of left-handed polarization in the radiation belts still necessitates an analysis of its dependence on geomagnetic activity. This presentation will also address these points and report comprehensive analysis results of EMIC waves in the entire magnetosphere and radiation belt region.