

Natural Cyclotron Harmonic Radiation from the Ionosphere

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Earth's auroral ionosphere emits several types of spontaneous emissions, including auroral hiss, medium frequency burst, and roar. Auroral roar occurs at harmonics of the electron cyclotron frequency. The most commonly observed harmonic is $2f_{ce}$, first reported in the 1970's. Since the 1990's, the $3f_{ce}$ harmonic has also been regularly observed from ground level. These emissions both favor pre-midnight magnetic local times and require darkness for observation at ground-level. Significant evidence has accumulated that they result from mode conversion of upper hybrid waves excited where the upper hybrid frequency matches the cyclotron harmonic. Satellite and rocket observations of the $2f_{ce}$ emission support that mechanism. Recently, two papers report observations of $4f_{ce}$ and $5f_{ce}$ emissions in Svalbard and in Antarctica. These higher harmonic emissions also favor pre-midnight magnetic local times but require sunlit ionosphere for observation. For all harmonics observed so far, the frequency scales linearly with the strength of the geomagnetic field at the observing station. Combining data from multiple stations allows estimation of source altitudes. Observations of the harmonics at a given station also provides a method for remotely sensing the ionospheric density.