

X-mode HF pump-induced phenomena for a frequency stepping through the fifth electron gyro-harmonic

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We report the first experimental evidence of the sensitivity of phenomena induced by extraordinary (X-mode) polarized HF high power radio waves to pump frequency stepping across the fifth electron gyro-harmonic ($5f_{ce}$) from below to above. The results were obtained at the EISCAT (European Incoherent Scatter Scientific Association) HF heater facility near Tromsø under effective radiated powers of 456 – 715 MW, when the HF pump wave was transmitted into the magnetic zenith. We have analyzed the behavior and intensities of various spectral lines in the narrowband stimulated electromagnetic emission (SEE) spectra observed far from the heater, HF-enhanced plasma and ion lines (HFPL and HFIL) from EISCAT UHF incoherent scatter radar spectra, and artificial field-aligned irregularities from CUTLASS (Co-operative UK Twin Located Auroral Sounding System) observations, depending on the frequency offset of the pump field relative to the $5f_{ce}$. At pump frequencies below $5f_{ce}$ the narrowband SEE spectra exhibited very intense so-called stimulated ion Bernstein scatter (SIBS), accompanied by other spectral components, associated with stimulated Brillouin scatter (SBS), which are greatly suppressed and disappeared in the vicinity of $5f_{ce}$ and did not reappear at $f_H > 5f_{ce}$. As the pump frequency reached $5f_{ce}$, the abrupt enhancements of the HFPL and HFIL power, the appearance of cascade lines in the plasma line spectra, and the onset of increasing CUTLASS backscatter power occurred. That is opposite to the ordinary mode (O-mode) effects in the vicinity of $5f_{ce}$. The X-mode pumping at frequencies below and in the vicinity of the fifth electron gyro-harmonic clearly demonstrated an ascending altitude of generation of induced plasma and ion lines from the initial interaction height, whereas for O-mode heating the region of interaction descended. The observations are consistent with the coexistence of the electron acceleration along and across the geomagnetic field at $f_H < 5f_{ce}$, while only very strong electron acceleration along the magnetic field was observed at $f_H \geq 5f_{ce}$.