A New Incoherent Scatter Radar Technique to Measure the Ionospheric Electron Temperature Inside the HF Modified Region

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HF plasma line enhancements (HFPL) occur where the high-power HF waves interact with the ionospheric plasma, modifying the electron density \(N_e\) and electron temperature \(T_e\). The electron density can be estimated with high accuracy using the Incoherent Scatter Radar (ISR) plasma line measurements at the Arecibo Observatory. However, the ISR electron temperature inside the interaction region has been impossible to assess with the traditional ISR techniques. For natural conditions, the temperatures are estimated by 1) fitting the ISR ion line using a theory based on Maxwellian approximations, or 2) using the behavior of the free Langmuir waves that create an asymmetry between the upshifted and downshifted ISR plasma line (PL) spectrum. Since the plasma–wave interaction forces Langmuir waves and generates Non-Maxwellian instabilities, the traditional techniques can’t be used to estimate \(T_e\) inside the HF interaction region \((HFT_e)\).

An analysis of the physics that produced the HFPL is presented to obtain the electron temperature inside the enhanced region. The Parametric Decay Instability (PDI) is responsible for the HFPL. The frequency spacing of the decaying lines inside the HFPL was predicted by Perkins et al., 1974 as a function of the ion-acoustic frequency \(f_{ia}\). Technological advances at Arecibo make it possible to detect a high-resolution PL spectrum at the interaction region. The \(f_{ia}\) is measured using the Arecibo PL. Also, the background ion mass is obtained from the corresponding ion line just below the interaction region. The first estimations of \(HFT_e\) are achieved by using the \(f_{ia}\), and the ion mass.

The \(HFT_e\) for a quiet experiment is obtained during no exceptional enhanced ion and plasma lines during the Probing Regions via Ionospheric Modification (PRIM) campaign in June 2019. A high-resolution altitude vs. time \(HFT_e\) distribution is developed. The results agree with theoretical expectations, where \(HFT_e\) increased during the HF experiments.

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