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Electron Acceleration by High Power Radio Waves in the Ionosphere[1]

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At the highest ERP of the High Altitude Auroral Research Program (HAARP) facility in Alaska, high frequency (HF) electromagnetic (EM) waves in the ionosphere produce artificial aurora and electron-ion plasma layers. Using HAARP, electrons are accelerated by high power electrostatic (ES) waves to energies >100 times the thermal temperature of the ambient plasma. These ES waves are driven by decay of the pump EM wave tuned to plasma resonances. The most efficient acceleration process occurs near the harmonics of the electron cyclotron frequency in earth's magnetic field. Mode conversion plays a role in transforming the ES waves into EM signals that are recorded with ground receivers. These diagnostic waves, called stimulated EM emissions (SEE), show unique resonant signatures of the strongest electron acceleration. This SEE also provides clues about the ES waves responsible for electron acceleration. The electron gas is accelerated by high frequency modes including Langmuir (electron plasma), upper hybrid, and electron Bernstein waves. All of these waves have been identified in the scattered EM spectra as downshifted sidebands of the EM pump frequency. Parametric decay is responsible low frequency companion modes such as ion acoustic, lower hybrid, and ion Bernstein waves. The temporal evolution of the scattered EM spectrum indicates development of field aligned irregularities that aid the mode conversion process. The onset of certain spectral features is strongly correlated with glow plasma discharge structures that are both visible with the unaided eye and detectable using radio backscatter techniques at HF and UHF frequencies. The primary goals are to understand natural plasma layers, to study basic plasma physics in a unique "laboratory with walls," and to create artificial plasma structures that can aid radio communications.

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