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Stimulated Second Harmonic Emissions During Ionospheric Heating Experiments

W. Scales*[1,2], A. Yellu [1,2], A. Mahmoudian[3], P. Bernhardt[4], C. Siefring[4], E. Nossa[4], S. Briczinski[4], and M. Mccarrick[5]

(1) Bradley Department of Electrical and Computer Engineering, Virginia Tech, Blacksburg, VA, USA
(2) Center for Space Science and Engineering Research, Virginia Tech, Blacksburg, VA, USA
(3) Space Physics Department, Institute of Geophysics, University of Tehran, Iran
(4) Plasma Physics Division, Naval Research Laboratory, Washington DC, USA
(5) Information Technology Division, Naval Research Laboratory, Washington DC, USA

Extended Abstract

Stimulated Electromagnetic Emission (SEE) is secondary radiation produced during experiments involving the interaction of high power high frequency (HF) radio waves with the ionosphere. SEE has been a vibrant area of investigation for the past four decades and SEE has been developed into an important remote sensing tool for the ionosphere with substantial potential for aeronomy studies. The earliest experiments primarily considered emissions within a bandwidth of 100 kHz or so of the pump (transmit) frequency ω_0, so-called wideband SEE (WSEE), but work over the past decade has concentrated on SEE within 1 kHz of the pump frequency, so-called narrowband SEE (NSEE). The most recent investigations over the past few years carried out at the High Frequency Active Auroral Research facility (HAARP) in Alaska, have considered Second Harmonic Generation (SHG) in the narrowband SEE spectrum around twice the pump frequency $2\omega_0$. To this end, a review of the recent experimental observations of SHG at HAARP is presented as well as some basic concepts of the nonlinear wave-wave processes that have been proposed to produce SHG. A highlighted focus on SHG in the SEE spectrum will be placed on the potential for diagnostic information during ionospheric heating experiments. In the past, it has been shown in the Laser Plasma Interaction (LPI) community, that SHG is a highly useful diagnostic tool and this has attracted a large interest in experiments, theory, and modeling. This sizeable knowledge base may be applied to ionospheric heating, however, for ionospheric interactions with high power radio waves, the earth's magnetic field is found to play a major role in the spectral characteristics of the SHG spectrum. Therefore, the impact of the geomagnetic field will be discussed in some detail. Initial attempts at developing plasma simulation models to study the more strongly nonlinear evolution associated with SHG will also be presented. It will be shown that the SHG spectrum is easily as richly structured as the spectrum near the pump frequency which underscores the importance of SHG as potentially a critical diagnostic tool during ionospheric heating experiments.