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Improving the Performance of High-Power Radio Facilities for Plasma Wave Generation in Space

PAUL BERNHARDT, United States Naval Research Laboratory

High power radio are used for ionospheric modification experiments from ground VLF and HF facilities with large antenna arrays and transmitters. VLF signals are generated by both Navy systems to communicate with submarines and by HF signal modulation of the currents in the E-region electrojet. The HF facilities at HAARP in Alaska and EISCAT Heating in Norway can produce electromagnetic wave beams with effective radiated powers in excess of one Gigawatt. New techniques are being developed to increase the effectiveness of these facilities for generation of field-aligned irregularities, artificial plasma clouds, and intense whistler modes waves that interact with the earth's radiation belt electrons. Techniques to increase the intensity of waves in space plasma from these facilities include EM wave beam focusing with artificial lenses and parametric amplification of whistler modes by extracting energy from an external lower-hybrid pump. For focusing, a large lens is formed in the lower ionosphere using the thermal pressure inside the heated plasma or a chemical release that rapidly attaches electrons, yielding a plasma hole in the bottom side of the ionosphere. Since the refractive index is larger inside the neutralized region of the electron hole, HF wave become focused by 20 dB. For amplification, a rocket burning in the ionosphere above a ground transmitter drives a ring beam distribution in the pickup ions yielding lower-hybrid waves that pumps a parametric amplification process. The parametric waves may also be produced by decay of an upper hybrid wave sustained by the HF EM wave into daughter UH and LW waves. When wave and wave-number matching conditions are met, the whistler traveling wave parametric amplifier (WTWPA) process yields 30 to 50 dB amplification of whistler waves generated by modulation of the earth's electrojet with fluctuating HF signals in the VLF frequency range. Amplifying whistlers is a new concept for influencing the energetic electron population in the radiation belts. Any existing whistler wave generator produces, at most, signals of 10 pT strength. The WTWPA can boost the artificial whistler amplitudes to greater than 300 pT. Several configurations for active amplification of VLF signals in space will be discussed.