Mode conversion of downward-propagating Langmuir waves in the topside ionosphere

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The Stanford full-wave method (StanfordFWM) was developed in order to calculate generation and propagation of electromagnetic waves in cold magnetized stratified plasmas. We generalize it by including the effects of electron temperature, by following a procedure analogous to that of *Budden and Jones* [1987, doi:10.1098/rspa.1987.0077]. The new method is used to calculate mode conversion between electron acoustic (Langmuir) and electromagnetic modes for propagation in a warm ionospheric plasma with a gradient of electron density and an arbitrary direction of the background geomagnetic field, in the vicinity of density corresponding to the plasma resonance. We demonstrate good agreement with previous calculations obtained using a numerically-unstable full-wave method scheme [*Budden and Jones*, 1987]; by the method of contour integration in the complex n_z-plane [*Mjolhus*, 1990, doi:10.1029/RS025i006p01321] and by electron fluid simulation [*Kim et al*, 2008, doi:10.1063/1.2994719].

We applied the new method to propagation of MF and HF waves at the topside ionosphere across irregularities perpendicular to background magnetic field in the vicinity of the plasma resonance. We found a very efficient conversion of electrostatic waves incident onto the irregularity from the lower density region into both left-handed extraordinary electromagnetic wave in the higher density region and Z-mode in the lower density region. We found that the first process proceeds in two stages: (1) conversion of electrostatic wave into a backward Z-mode wave on the resonance cone; (2) conversion of the backward Z-mode wave on the resonance cone into the forward Z-mode wave off the resonance cone, which, being an extraordinary wave, does not interact with the plasma resonance and may propagate undisturbed into the higher density region, where it becomes the left-handed mode. The second process (scattering of Z-mode back into the lower density region) consists only of the first stage.

This mechanism may contribute to the explanation of the ground observations of Langmuir waves generated at the topside ionosphere, because it enables the wave energy initially generated as Langmuir waves at the topside ionosphere to propagate downward through the F-region.