ELECTRON ACCELERATION BY WAVE PROCESSES IN THE EARTH'S IONOSPHERE

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"ELECTRON ACCELERATION BY WAVE PROCESSES IN THE EARTH'S IONOSPHERE"

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The support provided by ONR contract N00014-85-K-0538 over the period August 15, 1985 through December 31, 1986 has yielded several important results pertaining to the acceleration of electrons in the earth's ionosphere. Two complementary problems have been investigated: 1) acceleration of electrons by whistler waves excited in the topside ionosphere, and 2) modification of the ambient ionosphere electron distribution function by ground based high-power HF transmitters. In addition to having arrived at a detailed description of the underlying physical processes in these two acceleration scenarios, several theoretical results having broad applicability have been generated. Outstanding among these are: solution of a general 4th order differential equation describing mode conversion, and description of resonant field excitation in a density gradient including the self-consistent of Landau damping caused by fast electrons. It is expected that the techniques developed in this project can facility the description of more involved processes encountered in applications in which particle acceleration in a density gradient plays an important role.

Technical results obtained with partial support from this contract have been reported in 5 conference presentations and 3 long papers are expected to appear in refereed journals. As of this writing one paper has already been published in The Journal of Geophysical Research, another is being refereed by The Physics of Fluids, and the third is in the final stages of preparation.

The content of the paper published in The Journal of Geophysical Research is summarized as follows:
The nonlinear modification of the electron distribution function caused by the interaction with a resonant electrostatic field is studied analytically using a perturbation analysis. This interaction produces tail heating and for a limited range of parameter values can form a bump in the distribution, which may lead to emission of secondary waves. These results are applied to the ionosphere's F and upper E regions in the context of ionospheric modification experiments using ground-based powerful HF transmitters.

The results of the paper being refereed by The Physics of Fluids is described in following abstract:

An analytic study is made of the second order modifications produced on the fast tail electron distribution function of a nonuniform plasma subjected to resonant excitation by wave sources. The source models considered can represent excitation by external electromagnetic waves propagating obliquely to the plasma density gradient, mode-conversion of electrostatic whistlers, beat of two transparent electromagnetic waves, and direct conversion from ripples in the density profile. The calculation treats the Landau damping provided by fast tail electrons self-consistently and is applicable to plasmas having a long density scale length L, i.e., 

\((k_D L)^{1/3} \gg 1\),

where \(k_D\) is the Debye wave number of the warm background electrons. A threshold condition is found for the
formation of a positive slope in the tail distribution by the various excitation mechanisms.

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Technical Manuscripts


Conference Presentations


