A Preliminary Investigation of the Pseudospectral Numerical Solution of the Perkins Instability Equations

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A pseudospectral method code has been developed to simulate the electrodynamic turbulence (spread-F) behavior of the mid-latitude ionosphere by numerically solving two of Perkins' equations (Journal of Geophysical Research, 78, 218-226, 1973). This work follows that of Miller (Ph.D. thesis, Cornell university, 1996) and provides significant extensions in both the solution method and the solution results. For example, in the instability linear-growth stage, the simulation result is very consistent with Perkins' prediction yielding relative differences of less than 0.5%. A random initial condition case like that of Miller (1996) is then carried out and the results agree with Miller's approach. In addition, the effect of non-linearity of the system is observed—the damping region of the linear stage in wave vector space now exhibits growth regions. Results also indicates that over a large wavelength range, self-similar ionospheric structures (Mathews et al., Geophysical Research Letter, 28, 4167-4170, 2001) can be generated in potential and conductivity (the field-line integrated electron concentration is constant). By using two-mode excitation with suitable parameters, saturation of the instability process is observed—an example is presented. We additionally show that some two-mode excitation processes are much different from that of the single mode excitation in many aspects—especially in wavelength dependence. It is found that the saturation state is related to the fundamental mode wave vector, the perturbation amplitudes of the fundamental mode and the secondary mode, electric field, etc. On the other hand, some two-mode excitation processes do not display a saturation state. In this case, the process follows the path of the corresponding single mode excitation. Reasons are discussed.