2D Particle-in-cell Simulations for ESW Research in Space Plasma

Section IV Discussion

Two-dimensional (2D) electrostatic particle-in-cell simulations were performed to investigate the nonlinear evolution of electron bi-stream instability in weakly ($\Omega_e = 0.5\omega_{pe}$, where Ω_e and ω_{pe} were the electron frequency and electron plasma frequency, respectively) and strongly ($\Omega_e = 2.0\omega_{pe}$) magnetized plasma.

4.1 Brief review and discussion of the results

The phenomena of the two circumstances were similar to the linear evolvement phase of electron bi-stream instability. Nearly monochromatic electrostatic waves were firstly excited. In the nonlinear evolvement phase, the nearly monochromatic ESWs in the strongly magnetized plasma were coalescing with adjacent waves till at last only one quasi-one-dimensional structure was formed (that is to say, they were limited in the direction parallel with background magnetic field, while in the perpendicular direction they were unlimited). The parallel cut of the parallel electric field exhibited bipolar structures while the perpendicular electric field was unipolar, and these structures would be destroyed by the electrostatic whistler waves in the future.

However, the phenomena of the evolvement of electron bi-stream instability were different in the weak magnetized plasma. While the ESWs were coalescing, these solitary structures were evolving to be 2D structures which were limited in scale in the *x* and *y* direction. These structures were observed by many satellites [Ergun, et al., 1998; Franz, et al., 1998 and 2000]. The results of this paper explained these

phenomena well. Furthermore, it was found that these structures corresponded to electron phase-space holes.

4.2 Weak points and further work doable

Though the results of this paper are well coincident with the current observations, the limits of dimension and the simple hypothesis should not be ignored. However, 3D electrostatic particle-in-cell simulations and 2D electromagnetic particle-in-cell simulations will be performed in our further study.