Particle simulations of solitary waves in the auroral region

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We perform two-dimensional electrostatic particle simulations of electron beam instabilities using parameters characteristic of the auroral region. Counter-streaming electron beams interact strongly to form large electrostatic potentials trapping the beam electrons The potentials coalesce with each other to form electrostatic solitary waves (ESW) which have been observed by recent spacecraft in various regions of the magnetosphere.The nonlinear trapping of the electron beams leads to the formation of electron holes in the velocity phase space.

In this study, we study the nonlinear evolutions of warm electron beam instabilities including ion dynamics. In this simulation, two-dimensional potentials are excited by initial electron beam instability. These two-dimensional potentials coalesce with each other in the parallel direction and are aligned in the perpendicular direction, then come to form one-dimensional potentials due to electron dynamics. However, they are separated in the perpendicular direction by ion Benstein waves and become isolated two-dimensional potentials. In this phase, parallel potential energy decay to perpendicular waves through coupling between parallel drifting electron holes and quasi-perpendicular ion Bernstein waves. We can find excited ion Bernstein waves coupling with electron holes. In addition, these isolated two-dimensional potentials are very similar to the potential of solitary waves observed in the auroral region. In the long time evolution, these isolated two-dimensional potentials are aligned in the perpendicular direction and finally form one-dimensional potential. This is due to electron striation process.