Collaborative research: Dynamcis of electrostatic solitary waves and their effects on current layers

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Final Project Report

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The project has accomplished the following achievements including the goals outlined in the original proposal.
Generation and measurements of Debye-scale electron holes in laboratory: We have generated by beam injections electron solitary waves in the LAPD experiments. The measurements were made possible by the fabrication of the state-of-the-art microprobes at UCLA to measure Debye-scale electric fields [*Chiang et al.*, 2011]. We obtained a result that challenged the state of knowledge about electron hole generation. We found that the electron holes were not due to two-stream instability, but generated by a current-driven instability that also generated whistler-mode waves [*Lefebvre et al.*, 2011, 2010b]. Most of the grant supported a young research scientist Bertrand Lefebvre who led the dissemination of the laboratory experimental results. In addition to two publications, our work relevant to the laboratory experiments on electron holes has resulted in 7 invited talks [*Chen*, 2007, 2009; *Pickett et al.*, 2009a; *Lefebvre et al.*, 2010a; *Pickett et al.*, 2010; *Chen et al.*, 2011c, b] (including those given by the co-I Jolene Pickett) and 2 contributed talks [*Lefebvre et al.*, 2009b, a].
Discovery of elecctron phase-space-hole structure in the reconnection electron layer: Our theoretical analyses and simulations under this project led to the discovery of an inversion electric field layer whose phase-space signature is an electron hole within the electron diffusion layer in 2D anti-parallel reconnection [*Chen et al.*, 2011a]. We carried out particle tracing studies to understand the electron orbits that result in the phase-space hole structure. Most importantly, we showed that the current density in the electron layer is limited in collisionless reconnection with negligible guide field by the cyclotron turning of meandering electrons.
Comparison of electrostatic solitary waves in current layers observed by Cluster and in LAPD: We compared the ESWs observed in a supersubstorm by the Cluster spacecraft and those measured in LAPD. One of the similarities in the characteristics of ESWs observed in space and in LAPD is that the time duration tends to be approximately the inverse of the electron plasma frequency [*Pickett et al.*, 2009b].
Discovery of suprathermal electron bursts inside a series of magnetic islands: Our effort in examining the roles of ESWs in reconnection current layers resulted in the serendipitous discovery that was published in Nature Physics. In earth's magnetosphere, we observed through the measurements from the four Cluster spacecraft, a series of magnetic islands and suprathermal electron bursts within the islands. The islands were identified to be effectively acceleration sites for electrons [*Chen et al.*, 2008, 2009].

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