## Broadband Electrostatic Waves in the Magnetotail

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Spiky pulses in broadband electrostatic "noise" (BEN) in the plasma sheet boundary layer (PSBL) observed by Geotail led to a model for BEN as Bernstein-Greene-Kruskal (BGK) modes, which has been explored by a number of simulations. A recent modified model proposed by *Grabbe* [1980a,b] for BEN well into the magnetotail, in which these trapped-particle modes only occur in the top of the spectrum, whereas the bulk of the spectrum below that which propagates obliquely to the magnetic field consists of modes driven by unstable electron/ion beams, predicts that such solitary waves are only present in the source region, whereas they are not in BEN that has propagated well outside the source region.

Motivated by that prediction and features of the model, observations were examined from POLAR of BEN data poleward of and within the near-Earth part of the PSBL in *Grabbe and Menietti* [2002]. Wave data examined poleward of the near-Earth PSBL (in the plasma mantle) exhibit a constant level of turbulent waveforms over extensive regions, but little evidence of solitary waves. However, the wave data confined narrowly to near the PSBL source region shows a persistent level of turbulence propagating at large oblique angles with respect to the magnetic field, within which solitary-like waves are embedded, several of which saturate the receiver. The non-solitary portion of the observed wave data, which appears over much broader regions, fits well the theory of electron/ion beam instabilities developed from a computer code for a magnetized kinetic plasma with generalized kappa distributions, which are fairly robust over a broad frequency band and up to $90°$ with respect to the magnetic field. However, the higher-frequency portion above the plasma frequency, which is confined to the PSBL vicinity, appears nonlinear in character, with a stronger magnetic field playing a vital role in that nonlinearity. These waves are seen have different structure parallel and perpendicular to the magnetic field, with the structure differing from the observations further out in the magnetotail. While these tests agree with earlier predictions, important questions remain.

A theoretical analysis of nonlinear plasma waves using coupled equations for a magnetized plasma yield a generalized BGK-like equation for trapped-particle distributions in the guiding-center approximation. A conditional requirement was found for electron trapping, and the amount of trapping decreases as the angle of the electric field relative to the magnetic field increases, ceasing at a critical finite angle. The results were applied to BEN in the magnetail, including cases for $\omega_{ce} >> \omega_{pe}$ for near-Earth observation of BEN in the plasma mantle [*Grabbe and Menietti*, 2000], and $\omega_{ce} << \omega_{pe}$ for more distant magnetotail observations [*Grabbe* [1989]. It was found that trapping can occur over larger angles in the near-Earth case because of the large magnetic field, whereas trapping is confined to virtual alignment with the magnetic field at distances out 10-15 Earth radii and above. An obvious conclusion is that in cases further out into the magnetotail the solitary waves are highly field-aligned.

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