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Nonlinear Waves at the Bow Shock: Theory and Observations by Cluster

K. STASIEWICZ

Swedish Institute of Space Physics, Uppsala, Sweden
e-mail: k.stasiewicz@irfu.se, www: http://cluster.irfu.se/ks/

A fluid model of nonlinear electron and ion inertial waves in anisotropic plasmas is presented. It is shown that warm plasmas support four types of nonlinear waves, which correspond to four linear modes: Alfvénic, magnetosonic, sound, and electron inertial waves. Each of these nonlinear modes has slow and fast versions. It is shown by direct integration that the exponential growth rate of nonlinear modes is balanced by the ion and electron dispersion leading to solutions in the form of trains of solitons or cnoidal waves. By using a novel technique of phase portraits it is shown how the dispersive properties of electron and ion inertial waves change at the transition between warm and hot plasmas, and how trains of solitons ("mirror modes") are produced in a hot, anisotropic plasma. The applicability of the model is illustrated with data from Cluster spacecraft.

References

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