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Theoretical Modeling of Large Amplitude Boundary Layer Waves in the Magnetosphere

S. S. GHOSH and GURBAX S. LAKHINA
Indian Institute of Geomagnetism, Kalamboli, New Panvel(W), Navi Mumbai, 410 218, India

Solitary waves are found to be ubiquitous throughout the magnetosphere including the plasma sheet boundary, the bow shock, within the solar wind and at high altitude cusp regions. They are also observed in strong currents, such as those associated with auroral acceleration region. The interpretation and modeling of the observed solitary structures poses a serious challenge for theoretical space plasma physics. They are essentially one dimensional and are broadly categorized into ion and electron modes respectively. They drew considerable attention because of their significant roles in accelerating particles in the auroral region and in ionosphere--magnetosphere interactions. Ion mode solitary waves are associated with density depletion (negative potential) and are interpreted as rarefactive ion acoustic solitary waves. The electron mode solitary waves, on the other hand, move with much faster velocities compared to ion modes, being of the order of the electron drift velocity and were found to be associated with electron beams. The observed positive amplitude potential structures are often interpreted as BGK electron phase space holes [1]. However, Berthomier et al. [2] have shown that it may well exist for an electron acoustic mode. Interestingly, it is observed that the width of such ion/electron mode solitary waves increases with their amplitude which contradicts the existing weakly nonlinear theory. This has motivated us to study the width--amplitude variation profiles of ion (electron) acoustic solitary waves in detail. A fully nonlinear solution of the ion (electron) acoustic solitary wave has been obtained by adopting the Sagdeev pseudopotetial technique. The plasma is assumed to be magnetized and traversed by the ion (electron) beam. Based on our theoretical analysis, it is proposed that the observed increase in the width with increasing amplitude is essentially an intrinsic characteristics of large amplitude rarefactive solitary waves which differs qualitatively from its small amplitude limits [3]. The theoretical results of rarefactive ion acoustic waves are compared with the recent POLAR spacecraft observations which shows a good qualitative agreement [3]. A similar analysis has been extended to electron modes which also show a similar trend.

References

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