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ORIGINAL ARTICLE

Study of gradient effects on inertial Alfvén waves in plasma sheet boundary layer region—kinetic approach

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Abstract Inertial Alfvén waves are investigated using Maxwell-Boltzmann-Vlasov equation to evaluate the dispersion relation and growth/damping rate in inhomogeneous plasma. Expressions for the dispersion relation and growth/damping rate are evaluated in inhomogeneous plasma. The effects of density, temperature and velocity gradient are included in the analysis. The results are interpreted for the space plasma parameters appropriate to the plasma sheet boundary layer. It is found that the inhomogeneities of plasma contribute significantly to enhance the growth rate of inertial Alfvén wave. The applicability of this model is assumed for auroral acceleration region and plasma sheet boundary layer.

Keywords Inertial Alfvén wave · Kinetic approach · Plasma sheet boundary layer · Inhomogeneous plasma

1 Introduction

The most energetic Alfvén waves have been recently found in the Plasma-sheet-boundary-layer (PSBL). It was shown that these waves are magnetically conjugate to auroras (Wygant et al. 2000; Keiling et al. 2002) and occur during times of substorm expansion phase (Keiling et al. 2000, 2005). Since shear Alfvén waves propagate along magnetic field lines, the observations showed that one important role of these waves is to carry significant electromagnetic energy from remote regions, possibly the reconnection region, to the auroral regions. Once they reach the auroral region, the Alfvén waves are one of the candidates for the acceleration of electrons that cause the aurora (Goertz 1984; Lysak and Lotko 1996; Chaston et al. 2000). It is suggested that large-scale shear Alfvén waves (presumably those reported in the PSBL) become kinetic Alfvén waves in the small-scale limit, which can provide the parallel electric field necessary for auroral electron acceleration. Some evidences exist and predict that Alfvén waves accelerate electrons above the auroral acceleration region along magnetic field lines (Wygant et al. 2002; Morooka et al. 2004). Additional support for their role in auroral phenomena comes from global distribution maps at both low (FAST satellite) and high (Polar satellite) altitude that show that Alfvén waves occur on auroral field lines along the entire auroral oval (Chaston et al. 2003; Keiling et al. 2003).

Lysak (2008) treated strong perpendicular gradients due to cavity, and thus perpendicular wave number $k_\perp \rho_i$ cannot be fixed. In the presence of such gradients, localized modes are reported inside and outside the cavity. The dispersive Alfvén waves inside the cavity and outside the cavity have different phase velocities and therefore, should be treated separately. In the present investigation we have assumed the weak gradients not affecting the wave fields and thus $k_\perp \rho_i$ can be fixed. However, more rigorous kinetic treatment is needed for the full description of inertial Alfvén wave due to steep perpendicular gradients. In the recent past Kumar (2012) has thoroughly investigated the non-linear evolution of inertial Alfvén wave turbulence including electrons collision for low $\beta(\beta < \frac{m_e}{m_i})$ plasma and found that electron col-

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