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ORIGINAL ARTICLE

Study of gradient effects on kinetic Alfven wave with inhomogeneous plasma

P. Agarwal · P. Varma · M.S. Tiwari

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Abstract The kinetic Alfven waves are investigated using Maxwell-Boltzmann-Vlasov equation to evaluate the kinetic dispersion relation and growth/damping rate with magnetic field gradient, density gradient, temperature gradient and velocity gradient with inhomogeneous plasma. The effect of gradient terms is included in the analysis for both the regions $k_\perp \rho_i < 1$ and $k_\perp \rho_i > 1$, where $k_\perp$ is the perpendicular wave number and ρ_i is the ion gyroradius. This study elucidates a possible scenario to account for the particle acceleration and the wave dissipation in inhomogeneous plasmas. This model is able to explain many features observed in plasma sheet boundary layer as well as to evaluate the dispersion relation, growth rate, growth length and damping rate of kinetic Alfven wave. The applicability of this model is assumed for auroral acceleration region, plasma sheet boundary layer and cusp region.

Keywords Kinetic Alfven wave · Kinetic approach · Plasma sheet boundary layer · Magnetosphere-ionosphere coupling

1 Introduction

Onishchenko et al. (2009) have stated that, the spacecraft observations (e.g. Chmyrev et al. 1988; Chaston et al. 2005; Sundkvist et al. 2005a, 2005b) provide the evidence that large-and small-amplitude perturbations of the drift-and kinetic Alfven waves are permanently present in the near Earth's plasma environment. The Cluster observations on 18 March 2002 in the vicinity of a reconnection X-line of the Earth's magnetopause (Chaston et al. 2005) reveal small amplitude electromagnetic wave perturbations that have been identified as kinetic Alfven and drift-Alfven waves with perpendicular wavelengths of the order of the ion Larmor radius. Chen and Wu (2012) stated that the KAWs are able to play an important role in solar physics, especially in the non uniform heating of coronal magneto-plasma structures. Thus, the excitation and generation mechanism of KAWs in the solar atmosphere is becoming an increasingly interesting subject. The solar corona has a highly dynamic and complex structure, which consists of a large number of constantly evolving loops or filaments constructed by the solar magnetic fields. Complex dynamics of the coronal magneto-plasma loops indicate that the majority of them are current-carrying structures (Khodachenko et al. 2009).

Takada et al. (2006), using Cluster spacecraft data, have studied the electromagnetic low -frequency waves in the magnetotail lobe closed to the plasma sheet boundary layer (PSBL). The lobe waves show Alfvenic properties and transport their wave energy (Poynting flux) on average toward the earth along the magnetic field lines. Keiling et al. (2005) recently reported Polar observations of substorm associated lobe Alfven waves at geocentric distances of 5–6 R_E. Some theories about Alfven resonance coupling in the PSBL assume waves propagating through the lobe, supposedly generated by an outer source (Smith et al. 1986; Harrold et al. 1990; De Keyser 2000) or an inner source (Liu et al. 1995; Allan and Wright 1998, 2000). More abundant and enhanced waves are observed in the PSBL (e.g., Tsurutani et al. 1985; Akimoto et al. 1987; Angelopoulos et al. 1989). Takada et al.

P. Agarwal · P. Varma (✉) · M.S. Tiwari
Department of Physics, Dr. H.S.Gour Central University, Sagar, M.P., 470003, India
e-mail: poornimavarma@yahoo.com

P. Agarwal
e-mail: priyanka.phd@gmail.com

M.S. Tiwari
e-mail: tiwarims@yahoo.co.in