Astrophys Space Sci
DOI 10.1007/s10509-013-1743-4

ORIGINAL ARTICLE

Nonlinear interaction of inertial Alfvén wave with magnetosonic wave and cavitation phenomena

K.V. Modi · R.P. Sharma

Received: 12 October 2013 / Accepted: 7 December 2013

Abstract In the present paper, authors have investigated nonlinear interaction of inertial Alfvén wave with magnetosonic wave for low β-plasma ($\beta \ll m_e/m_i$). Authors have developed the set of dimensionless equations in presence of ponderomotive force due to inertial Alfvén wave in the dynamics of magnetosonic wave. Stability analysis and numerical simulation have been carried out to study the effect of nonlinear coupling between waves which result in the formation of localized structures and density cavity, applicable to auroral region and solar corona. The result reveals that localized structure and density cavity becomes more complex and intense in nature in quasi steady state. From the obtained result, we found the density fluctuations $\sim 0.1n_0$, consistent with the FAST spacecraft observation.

Keywords Auroral region · Coronal heating · Cavitation · Inertial Alfvén wave · Magnetosonic wave

1 Introduction

Alfvén wave (AW) was discovered by Hannes Alfvén in 1942. AWs are low frequency electromagnetic waves propagating along background magnetic field in conducting fluid. The restoring force and inertia for AWs is provided by pressure of the magnetic field and ion mass respectively. The dispersion relation for the low-frequency AW is obtained from the magnetohydrodynamic (MHD) equations, which do not have dispersion (Alfvén 1942; Cramer 2001). AW becomes dispersive (Damiano et al. 2009; Dastgeer and Shukla 2009; Brodin and Stenflo 1990; Shukla et al. 1999; Stefant 1970) due to the finite frequency ($\frac{\omega_0}{\omega_{ci}}$) and electron inertial force along magnetic field in cold magnetoplasmas. In a warm magnetoplasma, dispersion comes due to finite ion gyro radius effect and the gradient of the electron pressure. When AWs generate a large perpendicular wave number, which is transverse to the background magnetic field (Hollweg 1999; Lysak and Lotko 1990), in low-β plasmas (i.e. $\beta \ll m_e/m_i$, where β is thermal to magnetic pressure ratio) is known as inertial Alfvén wave (IAW), which plays an important role in the auroral region. This was observed by S3-3, Freja, Viking, FAST (Wahlund et al. 1994; Chaston et al. 1999, 2005, 2008).

The dispersion in AW may result ultimately in heating and acceleration of the plasma particles (Shukla et al. 1998; Seyler and Liu 2007), wave-particle and wave-wave interactions (Hasegawa and Chen 1976; Shukla et al. 2007) and the formation of localized structure (Sundkvist et al. 2005; Stasiewicz et al. 2003; Shukla et al. 2012). Specifically, it is a presumption that the dispersion in AW provides a power to auroral activities (Chaston et al. 2008) and causes the solar coronal heating (Tomczyk et al. 2007; Jess et al. 2009; McIntosh et al. 2011), which is an important mode of energy transfer from one region to another in solar plasmas.

Non-linear interaction of dispersive Alfvén wave field line resonance (FLRs) and ion acoustic waves has been studied by Frycz et al. (1998), under an envelope (WKB) approximation, for low frequency plasma in earth's magnetosphere. For low-β plasma (dispersion is dominated by electron iner-

K.V. Modi (✉) · R.P. Sharma
Centre for Energy Studies, Indian Institute of Technology Delhi, Delhi 110016, India
e-mail: kvmodi.iitd@gmail.com

R.P. Sharma
e-mail: rpsharma@ces.iitd.ac.in

K.V. Modi
Mechanical Engineering Department, Government Engineering College, Valsad, Gujarat 396001, India

Published online: 18 December 2013