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ORIGINAL ARTICLE

Propagation of magnetoacoustic shock waves in cylindrical geometry

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Abstract Cylindrical Korteweg-de Vries-Burgers (cKdVB) equation for magnetoacoustic wave is derived for dissipative magneto plasmas. Two fluid collisionless electromagnetic model is considered and reductive perturbation method is employed to study the propagation of magnetoacoustic shock waves in cylindrical geometry. Two level finite difference method is employed by using Runge-Kutta method to solve cKdVB equation numerically. The effects of nonplanar geometry, plasma density, magnetic field strength, temperature dependence and kinematic viscosity on magnetoacoustic shocks are investigated. The numerical results are also presented for illustration.

Keywords Magnetoacoustic waves · Shocks · KdvB · Nonplanar · Runge-Kutta

1 Introduction

The nonlinear magnetoacoustic waves have been studied by many researchers due to their importance in space and laboratory plasmas. The Alfvén and magnetoacoustic waves are the basic low-frequency modes in electron-ion (e-i) magnetized plasma and have been the subject of intense study in the succeeding decades. Magnetoacoustic wave propagates perpendicular to ambient magnetic field and known as fast hydromagnetic wave which has phase speed always greater than the Alfvén wave. Magnetoacoustic wave propagates in the direction along $E \times B$ drift owing the fact that both magnetic field and density compressions are responsible for the formation of this mode. Oblique propagation of wave to the ambient magnetic field results in both fast and slow magnetoacoustic waves. Fast mode arises when magnetic field and plasmas density oscillations are in phase, while slow mode exists when these two oscillations are out of phase. These modes have both transverse and longitudinal components and also form nonlinear wave structures such as solitons, shocks and double layers etc. The magnetosonic waves are believed to be responsible for particle acceleration in the Earth's magnetosphere and plasma heating in the solar atmosphere. They are also used in the fusion devices for plasma heating (Adlam and Allen 1958; Davis et al. 1958; Gardner and Morikawa 1965; Berezin and Karpman 1964; Kakutani and Ono 1969).

Mushtaq and Shah (2005) investigated the obliquely propagating magnetoacoustic wave in electron-positron-ion (e-p-i) plasma. They studied the effects of positron concentration, ion temperature and plasma β (ratio of kinetic pressure to magnetic pressure) value on linear and nonlinear two-dimensional magnetosonic waves in e-p-i plasmas. Janaki et al. (1991) studied the decay of magnetosonic wave in a warm collisional plasma. They found that decay rate of fast and slow modes are equal in case of low beta plasmas. Chakraborty and Das (2000 studied the magnetoacoustic waves propagating obliquely to an external uniform magnetic field in a warm homogeneous plasma. They derived the Kadomtsev-Petviashvili (KP) equation and studied the propagation of nonlinear structures in plasmas.

It is well known fact that the some phenomenons like Landau damping, kinematic viscosity, collisions between the plasma constituents may lead to the dissipation in the system which cause formation of shock waves in the plasma

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