Astrophys Space Sci (2012) 338:49–55
DOI 10.1007/s10509-011-0904-6

ORIGINAL ARTICLE

Beam propagation and Langmuir wave generation in a plasma with κ distribution function

H. Khalilpour · G. Foroutan

Received: 24 August 2011 / Accepted: 22 October 2011 / Published online: 9 November 2011

Abstract Using a kappa velocity distribution function for the electrons of the background plasma, the dynamics of a beam of hot electrons streaming through the plasma and the generation of Langmuir waves are investigated in the frame work of quasilinear theory. It is shown that the Langmuir waves are strongly damped by high energy tail of the Kappa distribution function. The spatial expansion of the beam is reduced and the spectral density of Langmuir waves becomes narrower. The height of the plateau in the beam distribution function increases at small velocities and the average velocity of beam is larger than that of a Maxwellian distribution. The influence of Kappa velocity distribution function on the gasdynamical parameters is investigated. It is found that, the height of plateau in the beam distribution function, and its lower velocity boundary are enhanced while, the local beam width in velocity space decreases.

Keywords Quasilinear theory · Kappa distribution function · Gasdynamic description

1 Introduction

Electromagnetic wave emission near the plasma frequency and its harmonic is a fundamental process in solar radio physics. It has been fairly accepted that the energetic electron beams accelerated during solar flares and guided along open magnetic fields lines are the source of the observed electromagnetic radio emissions (Goldman 1983; Dulk and Suzuki 1980). As move from the corona into the interplanetary medium, these electrons excite the electrostatic Langmuir waves via beam instability, and then the Langmuir waves are converted into electromagnetic radiation (type III bursts) at the fundamental frequency and/or its second harmonic via various linear or nonlinear plasma processes such as nonlinear wave-wave interactions (Gurnett and Frank 1975; Grognard 1982; Robinson 1992; Robinson et al. 1993a, 1993b; Robinson and Cairns 1998a, 1998b).

For investigation of beam plasma system various alternative theories have been suggested. When the level of Langmuir waves generated is quite low, and also beam-to-background density ratio is small, the evolution of the electron beam and generation of Langmuir waves, are often described using quasilinear theory (Vedenov et al. 1962; Drummond and Pines 1962). The quasilinear theory describes the dynamics of interactions between the electrons and Langmuir waves which are in resonant with the beam. The influence of Langmuir waves on propagation of the electron beam results in diffusion of the beam distribution function in velocity space. As a result, the beam distribution function relaxes in velocity space toward a plateau characterized by its height and upper boundary (Takakura 1977, 1979; Grognard 1982).

The rate of beam-plasma interaction is determined by the quasilinear relaxation time $\tau \simeq n/n_b\omega_p$ where n_b and n are the beam and background number densities, respectively and ω_p is the plasma frequency. For a small beam-to-background number density ratio the quasilinear time is much smaller than the beam propagation time, and therefore the quasilinear relaxation is normally considered to be the fastest process governing the beam dynamics. If this condition is satisfied, we proceed from a quasilinear kinetic de-

H. Khalilpour (✉)
Physics Department, Payame Noor University, 19395-4697, Tehran, Iran
e-mail: H_khalilpour@pnu.ac.ir

G. Foroutan
Physics Department, Faculty of Science, Sahand University of Technology, 51335-1996, Tabriz, Iran