On the modelling principles of electrostatic solitary waves and shocks in non-Maxwellian plasmas: A survey of recent results

I. Kourakis
Centre for Plasma Physics, Queen’s University Belfast, Northern Ireland, UK

Space plasmas are often characterized by the presence of energetic particles, due to various electron acceleration mechanisms [1], leading to a power-law dependence at high (superthermal) velocity values. Various theories have been proposed to model this phenomenon; the most promising scenario seems to be the kappa-type (family of) distribution function(s), which reproduces observed data more efficiently that the standard Maxwell-Boltzmann approach [2].

Electrostatic Solitary Waves (ESWs) [3] and shock structures [4] are ubiquitous in Space observations, and also in the laboratory experiments on beam-plasma interactions [5]. It has been shown from first principles that excess electron superthermality may alter the dynamical properties of electrostatic nonlinear modes, and does in particular modify the propagation characteristics of solitary waves [6]. Recent studies have also indicated that the dynamical characteristics of expanding plasma fronts are affected by excess electron superthermality [7].

In this presentation I will review, from first principles, the effects of a non-Maxwellian electron distribution on the characteristics of electrostatic plasma modes. A kappa distribution function [1] is employed to model the deviation of a plasma component (e.g. electrons) from Maxwellian equilibrium. It will be shown that the excess in superthermal propagation modifies the charge screening mechanism, affecting the dispersion laws of both low-frequency (ion-acoustic) and high frequency (Langmuir) modes. Various experimental observations may thus be interpreted as manifestations of excess superthermality [2, 5]. Focusing on the features of nonlinear excitations (shocks, solitons), we investigate the role of superthermality in their propagation dynamics (existence laws, stability profile) and dynamical profile [6].

The relation to other nonthermal plasma theories [8] may also be briefly discussed.