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

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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 equlibrium. It will be shown that the excess in superthermal propulation 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.

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