URSI AP-RASC 2019, New Delhi, India, 09 - 15 March 2019

Nonlinear waves and shock structures in beam interactions with high-density plasmas: selected topics and overview of recent results

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Nonlinear excitations in the form of potential pulses associated with localized ambipolar *E*-field forms (often referred to as collisionless shocks) are ubiquitous in interactions of a laser beam with material or plasma targets, and also in Space plasma environments. The parametric conditions for the formation of localized structures and their propagation characteristics have been the focus of a plethora of works in modern date plasma research.

In this paper, the criteria for occurrence and the dynamical features of electrostatic solitary waves propagating in a homogeneous ultradense plasma penetrated by an ion beam are investigated [1, 2]. Magnetic field generation is considered to be negligible, as a simplifying hypothesis, by assuming an ultra-tenuous beam. Adopting an existing quantum hydrodynamic (Q-HD) model as starting point [1], the (two) ionic components are modeled as "cold" inertial fluids (a quiescent positive ion fluid and a streaming ion fluid), while the relativistic electrons obey Fermi-Dirac statistics [2-5]. Linear analysis shows the existence of two acoustic type modes in addition to a Langmuir (electron plasma) like high frequency mode. A beam-driven instability is predicted. In the nonlinear regime, a new set of exact analytical conditions for the occurrence of solitary waves (pulses) are obtained in terms of relevant configurational parameters. A parametric analysis reveals that these depend sensitively on the negative ion beam characteristics (beam velocity and density) in addition to the (high) plasma density. In the case of a negatively charged ion beam [4], simultaneous occurrence of positive and negative potential pulses is predicted, identified by their respective bipolar electric field structure(s), a feature absent in positive beams [3].

Acknowledgments: This research was carried out while I.K., currently with Sorbonne University Abu Dhabi[1], was at Queen's University Belfast[2]. The authors acknowledge support from the European Union under EU-FP7 IRSES Programme (Grant No. 612506 QUANTUM PLASMAS FP7-PEOPLE-2013-IRSES) and from the Brazilian research fund CNPq (*Conselho Nacional de Desenvolvimento Científico e Tecnológico-Brasil*).

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