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Biswajit Sahu, Debasish Roy

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Nonlinear quantum ion acoustic shock wave dynamics with exchange-correlation effects

Biswajit Sahu[1,*] and Debasish Roy[2]
1. Department of Mathematics, West Bengal State University, Barasat, Kolkata-700126, India
2. Mitrapur Anchal High School, Mitrapur, Birbhum-731221, West Bengal, India

ABSTRACT

The dynamics of linear and nonlinear electrostatic shock excitations is studied in homogeneous, unmagnetized, unbounded and dissipative quantum plasma consisting of electrons and ions. The dissipation in the system is taken into account by incorporating the ion kinematic viscosity. The system is modelled using the quantum hydrodynamic equations in which the electrons are significantly affected by the quantum forces, viz., the quantum statistical pressure, the quantum Bohm potential and electron exchange-correlations due to electron spin. In the weakly nonlinear limit, using reductive perturbation method deformed Korteweg-de Vries Burgers's (KdVB) equation, which elegantly combines the effects of nonlinearity, dispersion and dissipation is derived. It is found that the present model predicts the existence of both nonlinear oscillatory and monotonic shock structures. The temporal evolution, stability and phase-space dynamics of nonlinear ion acoustic shocks are investigated numerically to elucidate the effects of quantum diffraction, electron exchange correlation and ion kinematic viscosity.

Keywords: Ion acoustic waves; Quantum hydrodynamics; Shock structures

$^*E - mail : biswajit\_sahu@yahoo.co.in$