On the interaction of a negative-ion beam with ultradense plasma:
linear beam-plasma instability and electrostatic soliton characteristics

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Ion beam-plasma interaction is an area of fundamental importance in the physics of charged matter [1]. In the limit of ultra-high density and ultra-low temperature, quantum effects (manifested via electron degeneracy) become significant and the classical treatment is invalidated. Electrostatic excitations in ultradense (quantum) plasmas are effectively studied via quantum-hydrodynamic models [2], which incorporate an electron momentum equation consistently taking into account the equation of state of the Fermi (degenerate) electron gas [3].

In this contribution, we present a multifluid model for a plasma consisting of a negative ion beam, positive ions and degenerate electrons. A linear dispersion relation is derived as a basis for stability analysis, revealing the existence of two unstable modes. Based on the relativistic version of the Sagdeev pseudopotential method [3], we have investigated the existence of nonlinear localized solitary excitations in the presence of a negative ion beam. The existence diagram for quantum electrostatic solitary waves is depicted, and the structural characteristics (e.g. polarity, amplitude) of electrostatic pulses are discussed. Bipolar structures for the electric field are thus obtained, qualitatively reminiscent of earlier results obtained via proton imaging techniques [4, 5]. Our results extend and corroborate earlier findings on quantum plasmas [3, 6].

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References