Electron waves coupling and spiky solitons in piezoelectric semiconductor quantum plasma

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Due to drastic miniaturization of semiconductors in electronic devices, the length of doping profile is now of the order of thermal de Broglie wavelength, where the typical quantum effects such as the exchange correlation, degenerate pressure and quantum potential play a significant role in the electronic components to be constructed in future. Study of piezoelectric effects, nonlinearities and the plasma effects in such semiconductors play a significant role in countless technological and industrial applications [1,2]. Quantum Hydrodynamic Model (QHD) for each of the electron - hole species may give complete understanding of many semiconductor lasers and nano-sized semiconductor devices [3,4], electron beam pumped semiconductor lasers [5-7], nanophotonics and nanowires [8-10], resonant tunneling diodes [11,12], high-gain photoconductive semiconductor switches [13], current filament semiconductor lasers and picosecond superluminescence [14].

In the present paper, we have studied the coupling between the lattice ion vibrations and electron waves using QHD model for piezoelectric semiconductor quantum plasma incorporating the various quantum effects. The study has been performed in linear as well as in nonlinear regime. A set of coupled nonlinear equations have been developed and analyzed numerically using the physical parameters for n-type piezoelectric semiconductor quantum plasma. Further, soliton solutions have been obtained using the modified quantum Zakharov equations and the nonlinear Schrodinger equation (NSE) for the electron waves coupled to the lattice ion vibrations due to piezoelectric effects.

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