Abstract

The primary purpose of this dissertation is to study the nonlinear screening effect of electrostatic field and the nonlinear structure of ion-acoustic solitary waves in relativistic degenerate electron-positron-ion plasmas.

Nonlinear screening process in ultrarelativistic degenerate electron-positron gas is investigated by deriving a generalized nonlinear Poisson equation for the electrostatic potential. In the simple one-dimensional case, the nonlinear Poisson equation leads to Debye-like (Coulomb-like) solutions at distances larger (less) than the characteristic length. When the electrostatic energy is larger than thermal energy this nonlinear Poisson equation converts into the relativistic Thomas-Fermi equation whose asymptotic solution in 3D shows that the potential field goes to zero at infinity much more slowly than the Debye potential. The possibility of the formation of a bound state in electron-positron plasma is also indicated. Further, it is investigated that the strong spatial fluctuations of the potential field may reduce the screening length and that the root mean square of this spatial fluctuating potential goes to zero for large distance rather slowly as compared with the case of the Debye potential.

The arbitrary and small amplitude ion acoustic solitary waves are studied separately in all three regimes (relativistic, non-relativistic and ultra-relativistic). The former is studied by using Sagdeev type-pseudo potential approach in plasmas consisting of collisionless, unmagnetized and degenerate dense electron-positron, and the non-relativistic cold classical ions. The electrons and positrons are assumed to follow the corresponding Fermi Dirac distribution function while the ions are described by the hydrodynamic equations. It is significant to note that the ion-acoustic speed in the degenerate pair-ion plasma does not only depend upon the electron Fermi temperature and ion mass, it also depends upon the concentration of the positrons and the ions in the plasma. Along with approximate solution, the exact amplitude solitary structure is also investigated numerically. It is seen that only compressive and supersonic solitary waves can propagate through such plasmas. The presence of the positions in the plasma drastically reduces the amplitude of the ion-acoustic solitary waves while the plasma thermal temperature increases it slightly.