Abstract

The ground state energy of plasma particles in case of Maxwell-Boltzman distribution function is zero, which in case of Fermi-Dirac distribution function is non-zero due to Pauli-Exclusion principle. At ground state, the energy of highly occupied system is known to be Fermi-Energy. When its corresponding Fermi-temperature becomes equivalent to thermal temperature ($\frac{T_F}{T} \approx 1$), this scenario becomes important to model the borderline intermixed dilute-dense plasmas. These intermediate quantum-classical borderline systems have many important applications both in non-relativistic ($E = \frac{p^2}{2m}$) and ultra-relativistic ($E = cp$) plasmas. Inertial Confinement Fusion (ICF) Plasmas and laser produced plasmas from solid targets are striking examples in non-relativistic case. On the other side, white dwarfs and supernova regimes are the striking examples of ultrarelativistic borderline plasmas. The choice of the parameter μ/k_BT plays a significant role to model the borderline systems, its value is -1.75 for ultrarelativistic plasmas whereas its value is zero in case of nonrelativistic plasmas. Firstly, we have studied the dispersion properties of high frequency parallel propagating Langmuir waves and R-&-L waves with arbitrary degeneracy in isotropic ultrarelativistic electron plasmas. Equilibrium number density associated with the Fermi-Dirac distribution function is calculated in terms of Polylog functions of order 3 and argument ($-e^{\mu/k_BT}$). The polylog functions are expanded in non-degenerate and completely degenerate limits by using power series expansion and asymptotic expansion respectively. The graphical trend of the real parts of longitudinal and transverse waves shows that cutoff frequencies shift upward and wave propagation become weaker for large values of μ/k_BT. Debye screening length of Langmuir wave is calculated, its magnitude decreases for large values of μ/k_BT. Anomalous spatial damping of R-&-L waves is found larger in non-degenerate regions having less values of μ/k_BT, the same result is obtained in low frequency ($c^2k^2 >> \omega^2$) limit. The dispersion properties of R-&-L waves in weakly magnetized limit are graphically investigated. It is found that the difference of left and right cutoff points is larger in case of non-degenerate environments as compared to other (partially and completely) degenerate ones. This indicates that the strength of the ambient magnetic field becomes weaker as we move from weakly to strongly degenerate ultrarelativistic electron plasma regions. Finally, we introduce the concept of momentum space anisotropy and derive the linear dispersion relation of transverse waves in un-magnetized ultrarelativistic electron plasma. The maxwell-Vlasov model is used to derive the polarization tensor component Π_{xx} containing the momentum space anisotropy. The linear dispersion relation of electromagnetic waves under geometrical conditions $\mathbf{E}_1 = (E_{1x}, 0, 0)$, $\mathbf{B}_1 = (0, B_{1y}, 0)$, $\mathbf{k} = (0, 0, k_z)$ is obtained in the arbitrary degenerate limit ($\frac{T_F}{T} \approx 1$). The magnitude and direction of momentum space anisotropy are $\xi \approx \left(\frac{T_\perp^2}{T_\parallel^2} - 1\right)$ and $\hat{n}_j = (0, 0, 1)$ respectively, where $T_\perp$ and $T_\parallel$ are the perpendicular and parallel thermal energies. It can further be observed that ξ is positive large for $T_\perp >> T_\parallel$ and *zero* for $T_\perp = T_\parallel$. Equilibrium number density associated with the Fermi-Dirac distribution function is calculated in terms of momentum space anisotropy, polylog functions of order 3 and argument ($-e^{\mu/k_B T}$). The graphical trend of modified dispersion relation of electromagnetic waves dictates that the frequency cutoff points shift downward as we increase the strength of momentum space anisotropy for ultrarelativistic limit $\mu/k_B T = -1.75$. This suggest that thermal momentum space anisotropy becomes more effective in under dense plasma systems as compared to highly dense ones. Previously reported result can be obtained by putting $\xi = 0$.