Abstract

Relativistic plasmas can be found in nature e.g., in supernovae explosions, in pulsar and black hole magnetospheres, in the bipolar outflows (jets), in the active galactic nuclei, in the primordial Universe, in cosmic rays and so on. Artificially, in laboratories, the development of laser intensity up to 10^{21} W/cm^2 confirms the possibility to create relativistic electron-positron plasma, now a days. Previously, several wave dynamics have been discussed in non-relativistic regimes.

In present study, by using linear kinetic model, the propagation characteristics of waves are discussed (analytically, numerically and graphically) in various relativistic regimes. Relativistic plasmas are further divided in to two main categories: (1) degenerate (2) non-degenerate plasmas. Firstly, we have studied the spectra of the perpendicular propagating Bernstein wave and Extra-ordinary wave in ultra- relativistic fully degenerate electron plasma. On considering the contribution of electrons only, the equilibrium particle distribution function is assumed to be isotropic. The analysis of high frequency spectra of the waves is carried out in the weak propagation $\Omega \gg \mathbf{k.v}$ and in the weak magnetic field $|\omega - \mathbf{k.v}| \gg \Omega$ limits. Secondly, the dispersion relation of the extraordinary mode in a relativistic degenerate electron plasma is investigated on employing Fermi-Dirac distribution at zero temperature. The propagation characteristics are examined in different relativistic density ranges. The shifting of cutoff points due to relativistic effects is observed analytically and graphically. Non-relativistic and ultra-relativistic limiting cases are also presented. Thirdly, the dispersion relation of obliquely propagating Bernstein wave in a relativistic degenerate electron plasma is derived. In particular, the results are obtained in the propagation range $k_z > k_x$ with $k_x \neq 0$. In the high frequency ($\omega \gg \mathbf{k.v}$) and weak propagation $\Omega \gg \mathbf{k.v}$ or $\mathbf{k} \rightarrow 0$) limiting cases, the generalized results reduce to the Upper hybrid wave for $\theta' = 0^\circ$ and Langmuir wave for $\theta' = 90^\circ$(where Ω is the gyro-frequency and θ' is the propagation angle of $\mathbf{k}$ with respect to x-axis). The graphical analysis is made in different relativistic density ranges with respect to a dimensionless factor $a_F = ((8\pi m_0{}^3c^3)/(3h^3n_0))^{1/3}$.

At the end, the temporal (Landau) damping effects for relativistic un-magnetized longitudinal wave is looked for non-degenerate environment under high frequency limit ($\omega \gg \mathbf{k.v}$) and its screening length results are retrieved under low frequency ($\omega \ll \mathbf{k.v}$) limit. The graphical trends are discussed in detail with respect to a dimensionless factor $a_c = m_0c^2/k_BT_0$ which provides assistance to decide the temperature ranges correspond to different relativistic regimes.