Abstract

The longitudinal and transverse dispersion relations using four-dimensional covariant Maxwell's equations and three dimensional Maxwell's field equations are derived. Their equivalence is found be in agreement in both the formulations.

Employing ambient weak magnetic fields, collective modes of electron plasma are derived. Two different approaches are used.

(i) In first case, a covariant form of Maxwell's equations is used along with Vlasov model and 4-dimentional polarization tensor is derived. Using temporal axial gauge $A_0=0$ and employing ultra-relativistic Maxwellian distribution function, dispersion relations for both parallel and perpendicular propagations are derived. Some limiting cases are also discussed.

(ii) In second case, Maxwell's field equations are used along with Vlasov model and 3-dimentional polarization tensor is derived. It is observed that the response of polarization tensor obtained by using temporal gauge $A_0=0$ in the covariant form of magnetized dielectric tensor and the polarization tensor obtained from the Maxwell's fields equations is same. The problem is extended for isotropic relativistic Maxwellian velocity distribution function and generalized relativistic dispersion relations for weakly magnetized electron plasma are obtained. The integrals (called Meijer G functions) which arise due to relativistic effects are studied in various limits and dispersion relations are derived for the non-relativistic, weakly-relativistic, strongly-relativistic and ultra-relativistic Maxwellian velocity distributions. It is generally observed that the propagation domains of the modes are enlarged as one proceeds from the non-relativistic to the highly relativistic regime. Resultantly, due to the relativistic effects, the Whistler mode is suppressed in the R-wave, the non-propagation band of X-mode is reduced and the X-mode itself approaches the O-mode. Further, the results derived in the ultra-relativistic and non-relativistic limits found to be in agreement with the earlier calculations.