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Signatures of quantum effects on the nonlinear Landau damping of transverse electromagnetic waves in degenerate plasma

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One of the important areas of plasma studies is the investigation of propagation of nonlinear waves and, more notably the study of nonlinear interaction of high frequency electromagnetic (EM) waves in an electron-ion plasma, which has been investigated for a considerable period of time. A quantum kinetic approach along with the Landau theory of quantization (LQ) is followed to study the impact of a quantum effects on the nonlinear Landau damping (NLD) of transverse electromagnetic waves in degenerate electron-ion plasma. For this purpose, a specific quantum regime is considered, for which the degenerate electron Fermi velocity is assumed to be of the order of the group velocity of EMWs. This eventually leads to the existence of a nonlinear Landau damping of EMWs in the presence of electron ponderomotive force.

The electron–ion density oscillations may have arisen from the nonlinear interaction of EMWs, leading to a new type of nonlinear Schrödinger equation in terms of a complex amplitude EM pump waves. A new type of kinetic nonlinear Schrödinger equation is derived in the presence of Landau quantization parameter η, which involves both local and nonlocal nonlinearities, where the latter accounts for the NLD of electromagnetic waves, the damping rate is calculated. The profiles of nonlinear damping rates reveal that EMWs become more damped for increasing the quantum tunneling effects. The electrostatic response of the linear electrostatic waves is also investigated and derived from a linear dispersion for the ion-acoustic damping rate.

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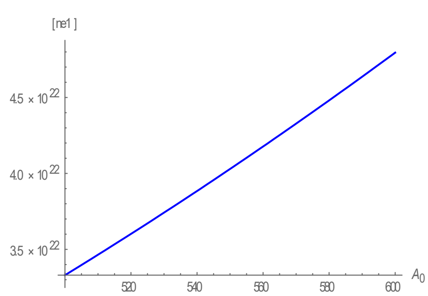

Fig.1

Group velocity of EM waves become function of EM waves shown in Fig. (1)

The obtained results are numerically analyzed for two radio waves of different harmonics in the context of nonrelativistic astrophysical dense plasma environments, e.g., white dwarfs, where the electron quantum corrections cannot be ignored.

References

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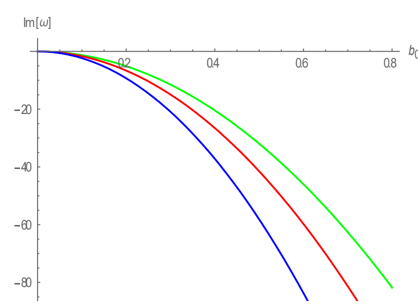

Fig.2

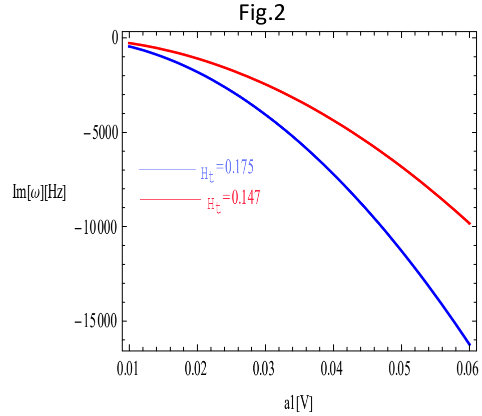

Fig.3

Nonlinear Landau damping of EM waves is shown in Figs. (2) and (3) respectively, where Ht is the varying Bohm potential term.