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Kinetic Study of twisted waves in non-Gyrotropic Plasmas

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Twisted waves are usually characterized as the waves carrying orbital angular momentum (OAM). The characteristic parameter of orbital angular momentum appears due to presence of helical electric field. The propagation of twisted waves is predominantly defined by the longitudinal and azimuthal wave numbers for the unmagnetized case. The longitudinal wave number reflects the variation in the spatial symmetry while the varying phase of non-planar helical wave fronts is shown by the azimuthal wave number.

The study of twisted waves is inspired by the recent investigations of orbital angular momentum, relevance to the Alfvenic and magnetic tornadoes, High Frequency Active Auroral Research Program (HAARP) ionospheric radar facility, twisted gravitational waves, ultra intense twisted laser beams, quantum entanglement of twisted photons, neutrino physics, and astrophysics in the radio frequency range. In the optical frequency range, it has potential application such as ultra- fast optical communication, quantum computing, microscopy and imaging. The observed morphologies of such modes are spiral, ring like or helical, which is suitable for the astrophysical and terrestrial environment like spiral galaxies, gravitational waves around rotating black holes, solar corona, Cometary tails etc.

Therefore, few years ago, the kinetic study of twisted waves is made for the Maxwellian distributed plasmas. It is evident from the literature that Maxwellian distribution is not ideal for most of the space plasmas due to presence of superthermal particle in the tails of the energy spectrum and some of laboratory plasmas as well. For this reason, the non-Maxwellian distributed kinetic modeling is developed by considering non-gyrotropic Generalized Lorentzian or Kappa distribution function. In this context, the Landau damping is studied for the twisted Langmuir and ion acoustic waves. The study of twisted waves is further extended for the dusty plasmas. As dust is ubiquitous in astrophysical environment, planetary rings and interplanetary media, Comets, interstellar medium, Eagle nebula, supernovae remnants, Jupiter's dusty rings and Earth's mesosphere. These studies lead to the prediction of instabilities for the dust ion acoustic (DIA), dust acoustic (DA) twisted waves and their threshold conditions along with the quasi-electrostatic nature of twisted waves.

The solutions of twisted modes can be well defined by the Laguerre Gaussian (LG) mode function in cylindrical coordinates, which decomposes the perturbed distribution function and helical electric field into planar and non-planar components identified by the longitudinal and azimuthal wave numbers. The Vlasov-Poisson equation is obtained and solved to obtain the dielectric function for the twisted waves in the presence of helical electric field. The analytical and exact numerical solution is also shown to check the dependence of Landau damping and growth rates on various parameters like normalized wave numbers, normalized drift velocities, temperature ratios, dust charging parameters, spectral indices etc.