

Kinetic theory of twisted waves: Application to space plasmas having superthermal population of species

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Nowadays electromagnetic (EM) fields have various applications in fundamental research, communication, and home appliances. Even though, there are still some subtle features of electromagnetic field known to us a century ago, yet to be utilized. It is because of the technical complexities to sense three dimensional electromagnetic field. An important characteristic of electromagnetic field is its orbital angular momentum (OAM).

The angular momentum consists of two distinct parts; intrinsic part associated with the wave polarization or spin, and the extrinsic part associated with the orbital angular momentum (OAM). The orbital angular momentum (OAM) is inherited by helically phased light or helical (twisted) electric field. The investigations of Allen on lasers carrying orbital angular momentum (OAM), has initiated a new scientific and technological advancement in various growing fields, such as microscopy and imaging, atomic and nano-particle manipulation, ultra-fast optical communications, quantum computing, ionospheric radar facility to observe 3D plasma dynamics in ionosphere, photonic crystal fibre, OAM entanglement of two photons, twisted gravitational waves, ultra-intense twisted laser pulses and astrophysics.

Recently, the plasma modes are also investigated with orbital angular momentum. The production of electron vortex beams and its applications are indicated by Verbeeck et al. The magnetic tornadoes (rotating magnetic field structures) exhibit three types of morphology i.e. spiral, ring and split. Leyser pumped helical radio beam carrying OAM into the Ionospheric plasma under High Frequency Active Auroral Research Program (HAARP) and characteristic ring shaped morphology is obtained by the optical emission spectrum of pumped plasma turbulence. The scattering phenomenon like (stimulated Raman and Brillouin backscattering) is observed to be responsible for the interaction between electrostatic and electromagnetic waves through orbital angular momentum.

The ring shape morphology of a beam with orbital angular momentum (OAM) is ideal for the observation of solar corona around the sun where the intensity of the beam is minimum at the center, in solar experiments, and Earth's ionosphere. The twisted plasma modes carrying OAM are mostly studied either by the fluid theory or Maxwellian distributed Kinetic Theory. But most of the space plasmas and some laboratory plasmas have non-thermal distributions due to super-thermal population of the plasma particles. Therefore the Kinetic Theory of twisted plasma modes carrying OAM are recently studied using non-thermal (κ) distribution of the super-thermal particles in the presence of the helical electric field and significant change in the damping rates are observed by tuning appropriate parameters.