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Collective excitations in a pair plasma carrying orbital angular momentum

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Orbital angular momentum (OAM) states associated with collective plasma dynamics were identified by Mendonca and co-workers [1] for the first time in the process of pumping of a plasma with a laser beam carrying OAM. In the processes of stimulated Brillouin scattering (SBS) and stimulated Raman scattering (SRS), the excited acoustic and Langmuir modes, respectively, carry finite OAM. The waves exhibit twisted profiles with helical field structures. Recently, high density electron-positron plasma is generated in the laboratory with density ~ 10^{16} cm^{-3} in a compact laser-driven setup [2], thereby providing a path to laboratory investigations of collective effects [3] and phenomena involving the collimated beams interaction with electron-positron plasma [4].

We study the properties of electrostatic excitations in a non-relativistic electron-positron pair plasma carrying finite OAM. Starting from the usual procedure to derive the wave dispersion relation, an approximate paraxial equation is derived. Solution of the paraxial equation for Laguerre-Gaussian (LG) type density and potential perturbations shows the existence of non-zero OAM for longitudinal electrostatic oscillations which give rise to twisted waves (vortex-like). The electric field energy and momentum density are evaluated and the effects of the twist due to azimuthal phase components of density and potential profiles are elaborated. Role of the parameters like radial and angular mode numbers and phase angle is discussed in the numerical analysis and relevance of the results to laser-plasma interactions specifically stimulated scattering processes is described.

References

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