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Magnetized Plasma based q-plate for generation of ultraintense optical vortices

Qing Jia[1], Kenan Qu[2], Nathaniel J. Fisch[2]

[1] Department of Engineering and Applied Physics, University of Science and Technology of China,

[2] Department of Astrophysical Science, Princeton University, USA

e-mail (speaker): qjia@ustc.edu.cn

An optical vortex is a light wave with a twisting wavefront and null intensity in the beam center. The unique field structure and intense orbital angular momentum lends the relativistic intensity vortex pulse to a broad range of applications in the research frontiers of high energy density physics, including particle acceleration, high brightness secondary radiation source, and laser fusion. However, accessible intensity of optical vortices is limited to be under the relativistic regime due to the material thermal damage threshold. This limitation might be removed by using the plasma medium. Recently, by using the anti-Helmholtz coil pairs, we propose the design of suitably anisotropically magnetized plasma which, functioning as a q-plate, leads to a direct conversion from a high-intensity Gaussian beam into a twisted beam[1, 2]. A circularly polarized laser beam in the plasma accumulates an azimuthal-angle-dependent phase shift and hence forms a twisting wavefront (see Fig.1). Our three-dimensional particle-in-cell simulations demonstrate extremely high-power conversion efficiency. The plasma q-plate can work in a large range of frequencies spanning from terahertz to the optical domain. This method relaxes the experimental complexity and owns a higher power conversion efficiency, as compared to the previous plasma-based optical vortex generation schemes. In this talk, this method will be introduced theoretically and numerically in detail, and new schemes of plasma-based q-plate with different q numbers will be explored. This technical innovation on the vortex pulse production will help to develop new scientific frontiers and gain new physical discoveries on the present 5-100PW laser facilities.

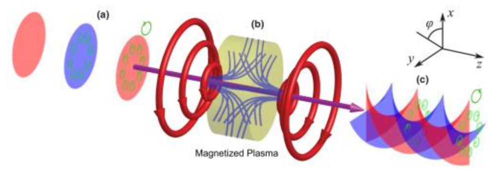

Figure 1 Converting a Gaussian laser beam into an LG beam in magnetized plasma. An input Gaussian laser beam (a) is sent through a plasma, which is mediated in an axial symmetric magnetic field generated by anti-Helmholtz coils (b). The wavefront of the output laser beam [shown in (c)] becomes twisted. In (a) and (c), the light red and blue shades show the isosurfaces of the wavefront in which the electric fields are parallel and perpendicular to the azimuthal directions, respectively. The small green circles show the polarization. The ticks show the instantaneous directions of the electric fields. In (b), the green shaded cylinder is the plasma and gray lines illustrate the magnetic field lines.

References

[1] Kenan Qu, Qing Jia and Nathaniel J. Fisch, Physics Review E, **96**, 053207 (2017)

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