8th Asia-Pacific Conference on Plasma Physics, 3-8 Nov, 2024 at Malacca

Particle acceleration driven by intense spatial vortex and spatiotemporal vortex lasers

Wenpeng Wang[1], Name[2]

[1] State Key Laboratory of High Field Laser Physics, Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences

e-mail (speaker): wangwenpeng@siom.ac.cn

With the advancement of ultra-intense and ultra-short laser technology, lasers have achieved new parameters in femtosecond and petawatt ranges. Particle acceleration driven by these lasers has become a prominent research area. However, most research still relies on traditional Gaussian lasers, posing challenges in enhancing the low divergence angle, high flux, and high collimation of ion beams. Then a novel laser mode — the Laguerre-Gaussian (LG) laser in the relativistic domain. LG lasers feature a hollow intensity distribution and angular momentum, offering centripetal force and phase modulation at the axis center, reducing particle beam divergence and enabling focused acceleration. High-quality particle beams driven by ultra-intense, ultra-short LG lasers have promising applications in various fields.

Our previous research shows that the electric fields periodically concentrate and emanate within every laser wavelength for the reflected right CP LG_p^l ($p = 0$, $l = 1$, $\sigma_z = 1$) laser, together with the longitudinal electric field on the laser axis, can generate a relativistic ultra-short collimated electron cluster with a constant period in space. A single particle model is given and verifies that the cluster formation has a close relation with the parameters of orbital angular momentum (l) and spin angular momentum (σ_z).[1] Such relativistic vortex cutter can be potentially applied for the accelerator, generating high-flux particle and coherent radiation sources, and so on.

Recently a relativistic isolated attosecond electron sheet was further modulated by another vortex laser, that is a relativistic reflected spatiotemporal optical vortex (STOV) laser.[2] Electrons can be trapped in spatiotemporal phase singularity within the STOV pulse center, modulated into a ~600-as duration sheet, and phase-locked-accelerated to the GeV order in the longitudinal direction. Such an isolated attosecond electron sheet driven by the intense STOV pulse can be used in isolated attosecond pulse generation, ultrashort x/γ-ray radiation, and attosecond electron diffraction.

In addition, a high-reflectivity phase mirror is applied in the femtosecond petawatt laser system to generate a relativistic hollow laser at the highest intensity of 10^{20} W/cm^2 for the first time.[3] With the development of the petawatt laser, this scheme opens up possibilities for the convenient production of the relativistic hollow laser at high repetition and possible collimating particle acceleration on our SULF PW laser facility.

References

[1] W. P Wang, *et al.* Phys. Rev. Lett. **122** (2), 024801 (2019).

[2] F. Y. Sun, *et al.* Physical Review Research 6 (1), 013075 (2024).

[3] W. P Wang, *et al.* Phys. Rev. Lett. **125** (3), 034801 (2020).

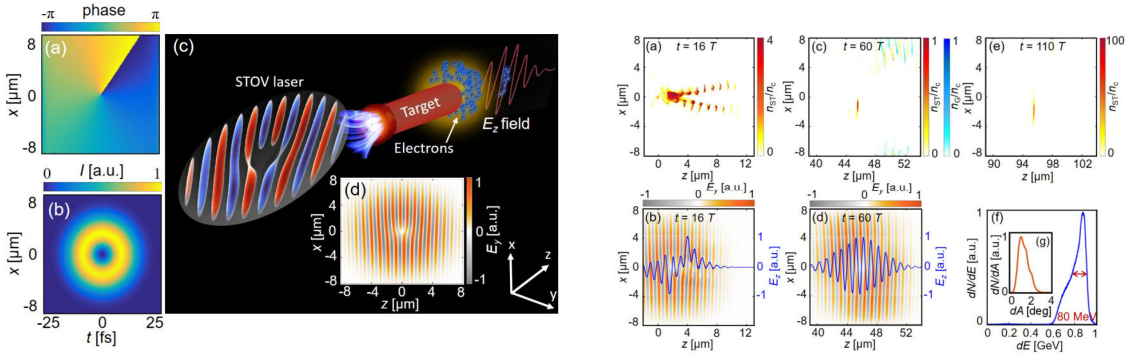

Fig.1 Attosecond Electron acceleration driven by intense STOV laser.[2]