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New Optical Manipulation of Relativistic Vortex Cutter

W. P. Wang[1], C. Jiang[1,4,5], B. F. Shen[2], Feng Yuan[3], Zhaoming Gan[3], H. Zhang[1,5], S. H. Zhai[1,5], and Z. Z. Xu[1]

[1] Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences, [2] Department of Physics, Shanghai Normal University, [3] Shanghai Astronomical Observatory, Chinese Academy of Sciences, [4] School of Physical Science and Technology, ShanghaiTech University, [5] University of Chinese Academy of Sciences

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

A. Ashikin, G. Mourou, and D. Strickland awarded the 2018 Nobel Prize in Physics for groundbreaking inventions in the field of laser physics. A. Ashikin awarded for the optical tweezers and their application to biological systems. In 1970, he firstly realized the micrometer-scale particle acceleration and trapping by the radiation pressure from the continuous laser. Since then the optical tweezers are wildly used for plucking, pushing and pulling atoms and molecules without damaging them. With the invention of the chirped pulse amplification (CPA) technology by G. Mourou and D. Strickland, the intensity of the femtosecond laser goes into the relativistic region (>10^{18}W/cm^2), by which the matter can be instantaneously ionized into plasmas (including ions and electrons). Now we subvert the classical optical tweezers into the relativistic-fs (CPA) interaction region for the first time in three-dimensional particle-in-cell simulations. A single particle model is proposed to illustrate the action of such a vortex cutter on electrons. Studies show that the electric fields periodically concentrate and emanate within every laser wavelength for the reflected CP LP $^{l}_{p}$ (p = 0, l = 1, σ_z = -1) laser, which just works like a vortex cutter, resulting in a relativistic ultra-short collimated electron cluster with a constant period in space. These clusters can be potentially used as a controllable particle injector for the laser wakefield accelerator, THz radiation source, and Betatron radiation source. In addition, it should be noted that the electron clusters are highly collimated by the LG laser, which can also provide potential high-flux sources for the ultrafast electron diffraction, fast ignition, and ultrafast electron diagnostics, and so on.

References

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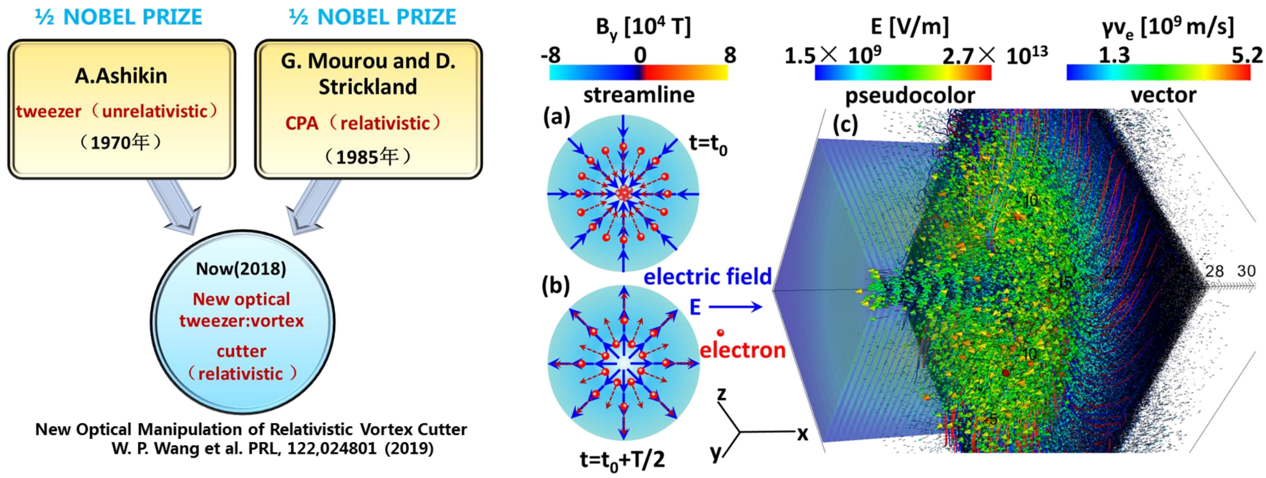

Collimated electron cluster driven by CP LG laser