Scientists develop new optical manipulation of relativistic vortex cutter

With the support by the National Natural Science Foundation of China, the Chinese Academy of Sciences, and the Ministry of Science and Technology of China, Prof. Wang WenPeng (王文鹏) and his cooperators at the State Key Laboratory of High Field Laser Physics, Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Science, reported a new relativistic vortex cutter driven by the Laguerre—Gaussian (LG) mode. This research was published in *Physical Review Letters* (2019, 122: 024801).

A. Ashikin, G. Mourou, and D. Strickland were awarded the 2018 Nobel Prize in Physics for their groundbreaking inventions in the field of laser physics. A. Ashikin was 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 have been widely 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). Prof. Wang subverts 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$_p^l$ ($p=0$, $l=1$, $\sigma_z=-1$) 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, ultrafast electron diagnostics, and so on.

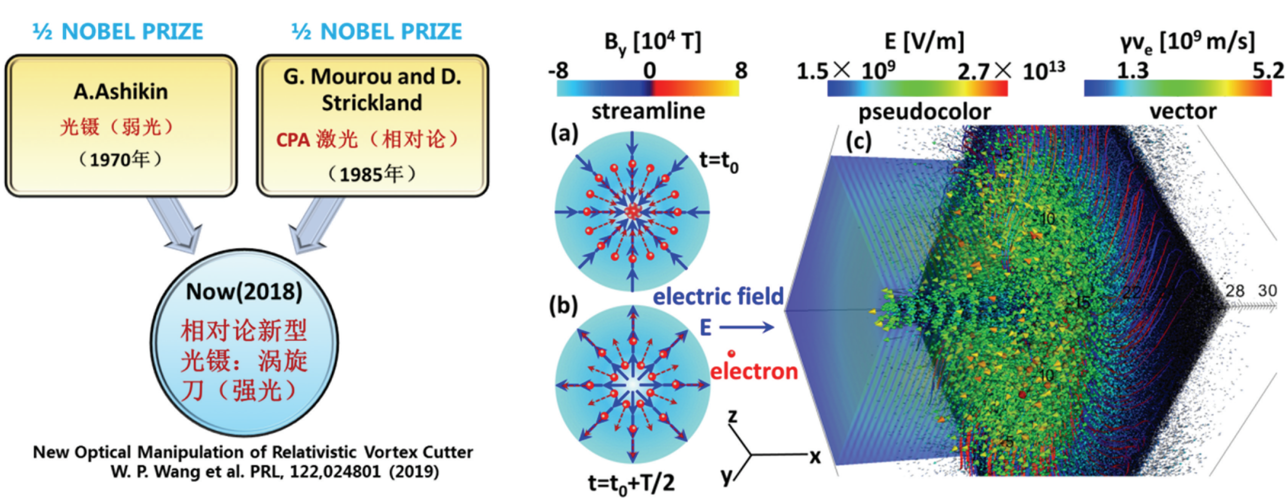

Figure The collimated electron cluster driven by CP LG laser.