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Ultra-brilliant quasi-monoenergetic positron bunches generation driven by twisted laser pulses

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Bright X/γ-ray sources are broadly useful tools for scientific researches and practical applications. So far they are normally produced based upon conventional accelerators, such as synchrotron radiation, which is subjected to limited tunabilities in spectrum, polarization, and pulse duration. X/γ-ray sources from laser-plasma interactions may provide such tunabilities with compact sizes, which will open up opportunities, for the first time, to be capable of realizing pico-meter spatial and sub-femtosecond temporal resolutions.

On the other hand, the generation of attosecond bunches of energetic electrons and positrons offers significant potential from ultrafast physics, particle physics to novel radiation sources. However, it is currently still a great challenge to stably produce such beams with lasers. Here we propose novel schemes for generating dense attosecond Breite-Wheeler positron bunches via the interaction of a circularly polarized LG (01)-mode laser pulse with near-critical-density (NCD) plasmas.

At the first stage, attosecond GeV gamma-ray bunch train can be generated via the nonlinear Compton scattering of energetic electrons driven by the LG laser pulse with zero angular momentum. Figure 1 shows the energy density distribution of electrons at t=45 T_0, which show an obvious attosecond structure in the space. At the second stage, the nonlinear Breit-Wheeler process is triggered by counter-propagating a second normal Gaussian laser pulse and copious positrons are produced. At the third stage, these positrons can be well trapped by the potential well of the LG laser and are accelerated in a phase-stable manner. Figure 2 below present the final distribution of positrons in the phase-space.

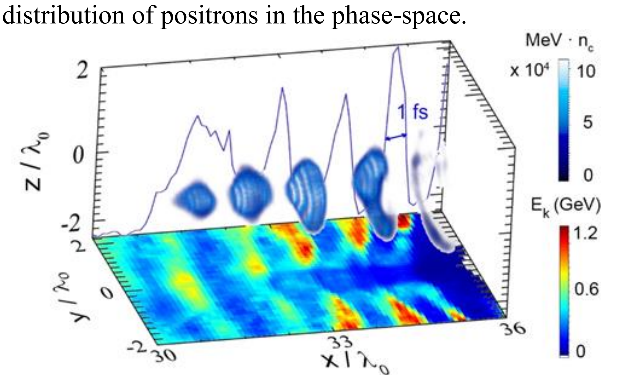

Fig.1. Energy density distribution of electrons at t=45T_0. Here the electron energy distribution is shown in the x-y plane and the on-axis electron density distribution is illuminated in the x-z plane.

Full three-dimensional particle-in-cell simulations show that the brightness of the positron bunches generated is seven orders of magnitude higher than the conventional positron source, e.g., NEPOMUC. This paves the way for wide applications in various fields in the near future.

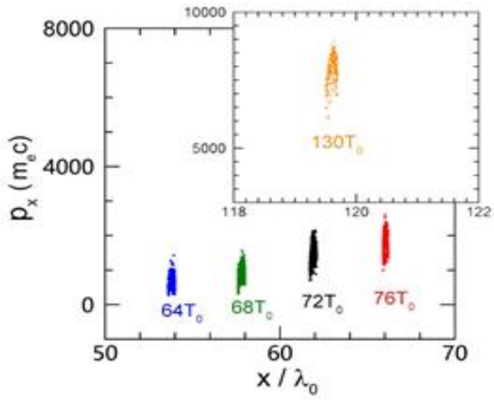

Fig.2. Evolution of the first positron bunch in $x - p_x$ phase space.

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