Vacuum Laser Acceleration of Electrons from Nanotips

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Vacuum laser acceleration (VLA) of electrons has been an intense field of research for a long time due to the extremely high accelerating fields (>1 TV/m). However, it is very challenging to realize and only a few promising experiments have been performed which have demonstrated the principle. Here, we report on the interaction of relativistic intensity (10^{20} Wcm^{-2}) sub-two optical cycle (< 5 fs) laser pulses with nanotips to realize and optimize VLA. Various properties of accelerated electrons (angular distribution, charge, and electron spectrum) are measured with different intensities and carrier envelope phase values of the laser pulse. Among others, waveform dependence of the electron propagation direction is observed. Furthermore, comparable or even higher electron energies, beyond 10 MeV, are detected with lower laser intensity, *i.e.*, longer focusing, than with high intensity. These surprising results are reproduced using Particle-In-Cell simulations, which indicate a nanophotonics electron emission from the nanotip followed by VLA. In fact, the unexpected observations are a direct proof of the VLA process and provide a way to optimize it towards higher energy, isolated, attosecond electron bunch generation.