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Generation of Sub-femtosecond Electron Pulses Based on Photocathode RF Gun

Ultra-short pulsed electron beam has a wide range of applications in accelerator-based X-ray sources, wake-field acceleration, ultrafast electron microscopy, etc. Using pump-probe technology, MeV ultrafast electron diffraction (MeV-UED) can reveal the ultrafast dynamic processes of matter changes at the atomic scale. Further improving its temporal resolution to few-fs or even sub-fs will open up new opportunities for frontier scientific research. We proposed two schemes for generating sub-fs electron beams based on photocathode RF gun. The first scheme involves modulating the electron beam close to the cathode surface using a radially polarized laser pulse. When the driving laser pulse is about 50 fs, an isolated attosecond electron pulse can be obtained. Furthermore, to improve the charge and reduce the time jitter of the pulsed electron beam, we proposed a scheme to modulate the electron beam using two radially polarized laser pulses of varying frequencies. Due to the diffraction effect of the laser pulse, several asymmetric acceleration and deceleration cycles are experienced by the electron beam near the focused laser focus, resulting in energy modulation. By using the current gigawatt-power-level laser systems, an electron beam with a pulse width of 3.3 fs (rms) and a time jitter of 1.35 fs (rms) can be obtained.

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