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Sub-picosecond ultracold electron bunches

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The Ultra Cold Electron Source (UCES) being developed at Eindhoven University of Technology is based on near-threshold, femtosecond photoionization of a laser-cooled rubidium gas in a magneto-optical trap. The UCES accelerates bunches containing ˜1000 electrons in a DC field up to energies of ˜10 keV with a normalized emittance of ˜1 nm·rad.
Recently, bunch lengths as short as 735±7 fs (rms) have been measured in the self-compression point of the DC source by means of ponderomotive scattering of the electrons by a 25 fs, 800 nm laser pulse. This is an improvement by more than an order of magnitude compared to the previous bunch length record. The observed temporal structure of the electron bunch depends on the central wavelength of the ionization laser pulse, in agreement with detailed simulations of the atomic photoionization process. This shows that the bunch length limit imposed by the atomic photoionization process has been reached.
To increase the range of applications of the UCES, the ultracold bunches have recently been accelerated in a standing wave RF cavity up to energies of 35 keV. During acceleration the transverse bunch quality was preserved as measured by diffraction on a single crystal gold foil. Transverse coherence lengths as high as 20 nm were obtained in a spot a few tens of microns across, paving the way towards applications such as ultrafast protein crystallography.

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