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# Coherent 3D Microstructure of Laser-Wakefield-Accelerated Electron Bunches

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Recent breakthroughs in laser wakefield accelerator (LWFA) technology have allowed them to drive free-electron lasers [1]. This is a significant accomplishment as LWFA electron beams are not as well controlled as beams from conventional accelerators. However, longitudinal structure in LWFA beams could be harnessed to accelerate the self-amplified spontaneous emission (SASE) process. Pre-bunched beams have been shown to achieve gain with shorter saturation length than conventional beams [2]. Because of the nature of the LWFA process, electron beams from LWFAs emerge from the plasma with preformed microstructures. The parameters of the accelerator dictate the shape, size and coherence of these features. Coherent optical transition radiation (COTR) can diagnose features in microbunched portions of the electron beam. We present experimental results across three different LWFA regimes demonstrating extreme visible microbunching (up to 10%), as well as sub mm-mrad emittance substructures in LWFA electron beams. In each regime we examined the near field COTR at eight different wavelengths from a foil directly after the end of the accelerator. Depending on the LWFA operating regime, we observe different levels of bunch substructure. How this structure evolves across optical wavelengths is also LWFA-regime dependent. The COTR point spread function model enables the annular shapes observed in the near field to be remapped as the actual 2D beam distributions [3]. We have also used COTR interferometry to measure sub mm-mrad divergence of the microbunched portion of the beam. In addition, we employed a multi-octave spectrometer to measure the spatially averaged TR spectrum from IR to near-UV wavelengths to characterize longitudinal beam shape. Wavelength-dependent variations in the size and radial distribution of the TR images can be correlated with features in the reconstructed longitudinal profile. Combining the longitudinal information acquired by the multi-octave spectrometer with multi-wavelength images of the foil, we observe features in the 3D beam that are unresolvable using other techniques. Moreover, with the aid of physically reasonable assumptions about the bunch profile, reconstructions of the 3D electron bunch distribution will be presented.

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Yes

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