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Single-Shot Reconstruction of Electron Beam Phase-Space in a Laser Wakefield Accelerator

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We report on a single-shot longitudinal phase-space reconstruction diagnostic for an electron beam in a laser wakefield accelerator via the experimental observation of distinct periodic modulations in the angularly resolved spectrum. Such modulated angular spectra arise as a result of the direct interaction between the ultra-relativistic electron beam and the laser driver in the presence of the plasma wakefield. A constrained theoretical model for the coupled oscillator, assisted by a machine learning algorithm, can recreate the experimental electron spectra, and thus fully reconstructs the phase-space distribution of the electron beam. In particular, it reveals the slice energy-spread of the electron beam, which is important to measure for applications such as XFELs. In our experiment, the root-mean-square *slice* energy spread retrieved is bounded at 17 MeV, corresponding to 1.7-4.2% relative spread, despite the overall GeV energy beam having ~100% relative energy spread.

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