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Lighting Up the Inner Workings of LWFA –How Radiative Particle-in-Cell Simulations can Shed New Light into the Dynamics of Laser-Accelerated Electrons

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We present simulations of angularly resolved radiation spectra from laser-wakefield accelerated electrons (LWFA) based on classical Liénard-Wiechert potentials ranging from infrared to the X-ray wavelengths.
These radiation spectra give insight into the momentum distribution with a spatial resolution small enough to study in detail the electron dynamics during the formation of the wakefield, the injection of electrons into the wakefield and in the coherent motion of electrons during acceleration. As spectral information is accessible in experiments, our results can serve as a valuable input to new diagnostics. A quantitative comparison of measured and simulated spectra poses a unique method to determine the phase space distribution of electrons in the LWFA process. Our code is capable of computing the spectra of all particles in the simulation and fully accounts for coherent effects. We thus can quantitatively predict the spectral intensities observed in experiment and are able to link them to specific phase space regions much smaller than the plasma wavelength.
We show that radiation diagnostics can serve as a powerful tool to understand a large variety of plasma phenomena and how large-scale simulations of Petaflop performance can in the future help to optimize LWFA.

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