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Optical control of electron beams in a lossless monochromator

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An important metric for electron microscopes is the electron beam energy spread, which determines the energy resolution in electron spectroscopy. Monochromation of electron beams traditionally requires rejecting the vast majority of the beam, leading to a tradeoff between energy resolution and electron flux. In ultrafast experiments where flux is already limited by the need for pulsed electron beams, the necessary integration times for high resolution electron spectroscopy are prohibitively long. We propose a design for an entirely optical, lossless electron monochromator, which uses a few cycles of terahertz radiation to manipulate the longitudinal momentum of a pulsed electron beam, removing energy correlations in both the radial and time domains. We find from numerical calculations that the monochromator can achieve an energy spread reduction of almost an order of magnitude, with laser timing stability of ten femtoseconds. Our design will demonstrate the ability of optical radiation to control the entire phase space of electron beams, and pave the way for new possibilities in ultrafast research.

Footnotes

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