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Laser control of the electron wave function in transmission electron microscopy O. SCHWARTZ, J. J. AXELROD, S. L. CAMPBELL, C. TURNBAUGH, R. M. GLAESER, H. MÜLLER, University of California, Berkeley —
Laser-based manipulation of atoms and molecules is key to modern metrology and enables quantum simulation, sensing, and information processing. The emergent field of laser control of free electrons has applications ranging from compact accelerators to new electron-based imaging methods. So far, research in this field has focused on temporal modulation of the electron wave functions, which enabled ultrafast transmission electron microscopy (TEM) and diffraction. However, coherent spatial shaping of the electron wave function is needed to efficiently probe radiation-sensitive systems, such as biological macromolecules. I will present recent results on spatial manipulation of the electron wave front in a TEM via electron retardation in a high-intensity continuous-wave laser beam. We have realized an electron interferometer using a standing light wave as a beam-splitter and phase retarder, and captured TEM images of the light wave. We then used laser-induced electron retardation to demonstrate Zernike phase contrast in TEM, and achieved a substantial increase of image contrast. Laser-based Zernike phase contrast will advance TEM studies of protein structure, cell organization, and complex materials.

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