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Generation and Characterization of Free Electron Vortices BENJAMIN MCMORRAN, AMIT AGRAWAL, Center for Nanoscale Science and Technology, National Institute of Standards and Technology, IAN ANDERSON, Surface and Microanalysis Science Division, National Institute of Standards and Technology, GREGG GALLATIN, HENRI LEZEC, JABEZ MCCLELLAND, JOHN UNGURIS, Center for Nanoscale Science and Technology, National Institute of Standards and Technology — Free electron vortex beams – composed of electron wavefunctions imprinted with a helical phase – are remarkable for their unique topology, quantized orbital angular momentum, and magnetic moment. We recently produced free electron vortex beams in a transmission electron microscope (TEM) using nanofabricated diffraction holograms. We used this technique to generate well-defined free electron vortices in various orbital states, demonstrating beams with up to 100 $\hbar$ of orbital angular momentum per electron.The helical phase of the electrons was measured directly using interferometric techniques. The orbital magnetic moment of the electron vortex scales with the topological charge of the vortex, and leads to interesting behavior in magnetic fields. As one example of several immediate applications for the electron vortex beam, we discuss how these beams can provide elementally sensitive magnetic imaging capabilities in a TEM by using the transfer of quantized orbital angular momentum to induce preferred atomic excitations in a sample.

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