Progress in probing magnetic information at the atomic scale using dynamic electron vortices in a TEM

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In a transmission electron microscope (TEM), materials are probed by electron plane waves, but alternative beams are possible. Here, plane waves are replaced by vortex waves with a typical azimuthal phase factor exp(i m ϕ), ϕ being the angle in the plane perpendicular to the optical axis and m the topological charge. Such waves carry an orbital angular momentum (OAM) $m\hbar$ and a quantized magnetic moment μ_B due to the electron charge.
We use the magnetic field created at the tip of a long ferromagnetic rod, approximating a magnetic monopole field, to create high purity and high intensity electron vortex beams with sub-Ångström resolution. OAM value very close to one can be obtained and is revealed by the measurement of the phase shift caused by the magnetic field close to the tip of the rod using holography in field-free conditions. The presence of an electron vortex was verified through a focal series experiment and by cutting the defocused probe with a sharp edge. Changing the vortex handedness in-situ was made possible by inserting a small solenoid in the same plane as the magnetic rod aperture.
The interaction of such an electron beam with magnetic samples will be discussed in detail. Special attention is paid to the atomic resolution magnetic dependence of the EELS, linked to electron magnetic chiral dichroism (EMCD).