Electron Bessel beam interferometry

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Unlike most waves that spread upon propagation, a wave function whose transverse intensity distribution takes the form of a Bessel function of zeroth order is immune to the effects of diffraction [1]. Bessel beams can also recover their intensity profiles after being partially obstructed by obstacles, demonstrating their robustness against perturbations. These properties have resulted in the application of Bessel beams in photonics and in their proposed application in electron microscopy [2].

Different from well-established holographic elements made by focused ion beam, here we report an electron-beam-lithographic generation of off-axis holograms that are able to sculpt electron waves into Bessel-form wave functions. By optimizing the fabrication process, the half pitch widths of the holograms could be decreased below 30 nm, highlighting the strength of the approach for beam-shaping applications.

The holograms were inserted into the conventional selected area aperture position of a FEI Titan 60-300 transmission electron microscope. The generation of electron Bessel beams was confirmed by the observation of multiple concentric rings in the first diffraction order in the Fresnel regime, arising from the interference of different plane wave components in the conical wavefront. The hologram used here is equivalent to an optical element termed an axicon, which bears interesting similarities to a biprism but has rotational symmetry. As for an electron biprism, delocalized electron Bessel beams with many rings can be generated and used in electron interferometry. The experimental demonstration of such applications, which involve the interaction of electron Bessel beams with objects or other shaped electron wave functions, will be presented.

References

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