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IT-1-P-2604 Holographic generation of Electron quasi-Bessel beams

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Recently the attention of electron microscopy community has been attracted by the generation of electron beams by means of holographic element that allows to shape the electron wavefront through a modulation of the phase or amplitude transmittance. This new degree of freedom has already demonstrated huge potentialities in application with electron vortex beams [1]. In this contribution we discuss the case of the quasi-Bessel beams obtained as a coherent superposition of conical plane waves along a closed ring of finite angular aperture [2].
Fig 1a shows the simulated transverse distribution of the electron Bessel beam at the first order of diffraction propagating, in the Fresnel region, from the hologram shown in b). In Fig 1c is reported the scanning electron microscope image of the nanofabricated phase hologram with a zoom-in image of the central region shown in the upper inset. The hologram is obtained from of a FIB-milled silicon nitride membrane, which is almost transparent to the 200keV electron beam [3]. Different depths modify the local projected potential; thus, electrons see different effective paths at grooves. In Fig 1d the distribution of the diffracted electrons in the Fraunhofer region of propagation, is reported. In the first order of diffraction, the Bessel beam forms a ring in the far-field. Due to the limited number of grooves of the hologram, the ring, typical of the Bessel beam, is convoluted with the Airy function of the hologram aperture, thus forming a quasi-Bessel beam. In Fig 1e is shown the measured transverse intensity distribution of the quasi-Bessel beam of the zeroth order generated by the hologram shown in Fig 1c, in Fresnel regime. In Fig 1f the experimental radial intensity distribution of the Bessel beam, blue solid curve, is compared with simulations by varying the convergence of the beam incident on the hologram plane, thus showing the effect of the partial coherence on the Fresnel ring contrast.
Bessel beams have many interesting properties, namely resistance to diffraction and the smallest spot diameter compared to other ordinary type of beams that could be exploited in STEM tomography. In Fig 2 is reported the diffraction free range of the quasi Bessel beam shown in Fig 1c.

[1] J. Verbeeck, H. Tian, and P. Schattschneider, Nature 467, 301 (2010).
[2] V. Grillo, E. Karimi et al. Phys. Rev. X 4, 011013 (2014)
[3]V. Grillo, G.C. Gazzadi, E. Karimi et al. Appl.Phys. Lett. 104, 043109 (2014)

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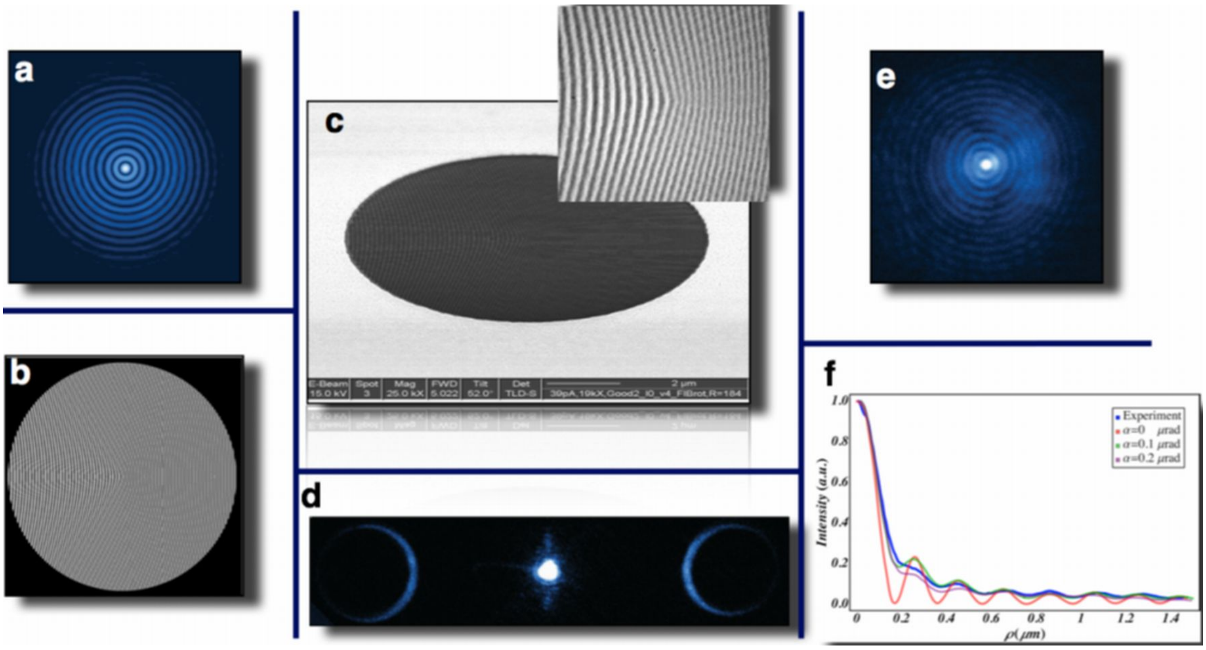

Fig. 1: Computer generated hologram and electron Bessel beams of the zeroth order.

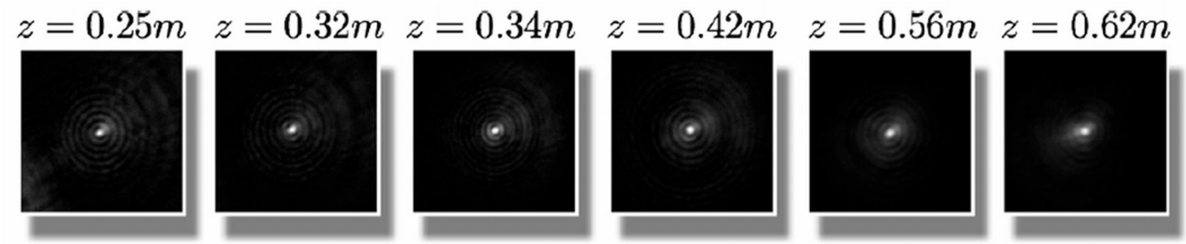

Fig. 2: Propagation of Bessel beams of the zeroth order in the Fresnel regime.