New perspectives and results for giant vortex beams: fabrication and future experiments

Venturi, F.[1], Rosi, P.[1], Lu, P.[2], Tavabi, A.H.[2], Medici, G.[1], Zanfrognini, M.[1], Gazzadi, G.C.[3], Frabboni, S.[1], Dunin-Borkowski, R.E.[2], Karimi, E.[4] and Grillo, V.[3]

[1] Università di Modena e Reggio Emilia, Italy, [2] Forschungszentrum Jülich, Germany, [3] CNR, Italy, [4] University of Ottawa, Canada

The scientific field of electron beam shaping has expanded in recent years, starting from the initial idea of vortex beams [1, 2]. Many steps have been made in the direction of fabricating electron holograms with increasing complexity. A benchmark of progress is the realization of electron vortex beam holograms with increasing quanta of orbital angular momentum (OAM) [3,4]. We will describe our progress in this direction (L >2000 h) and in the direction of optimized holograms (e.g., high efficiency hologram reaching about 70% on a single diffraction). As an example some of the recent patterns produced by FIB patterning are described in figure 1 but we also devoted time to improve EBL for hologram fabrication. We will discuss new ideas for nanofabrication, for engineering the radial shape of the electron beam and for the carrier frequency, which currently limit vortex generation to a few 10000 h.

A relevant property of large OAM vortexes is that they have a non-negligible in-plane component of momentum even in focus (see figure 2). Using this property, we have realized the first measurement of the out-of-plane component of a magnetic field by making large use of a large vortex [5]. Moreover a recent paper [6] has proposed the use of large OAM to test spin-dependent effects. We will discuss the feasibility of this idea, in the general context of spin-dependent effects in electron microscopy. Further ideas include the use of large vortices as rotation detectors and vortex-beam-related optical phenomena such as cathodoluminescence and transition radiation.

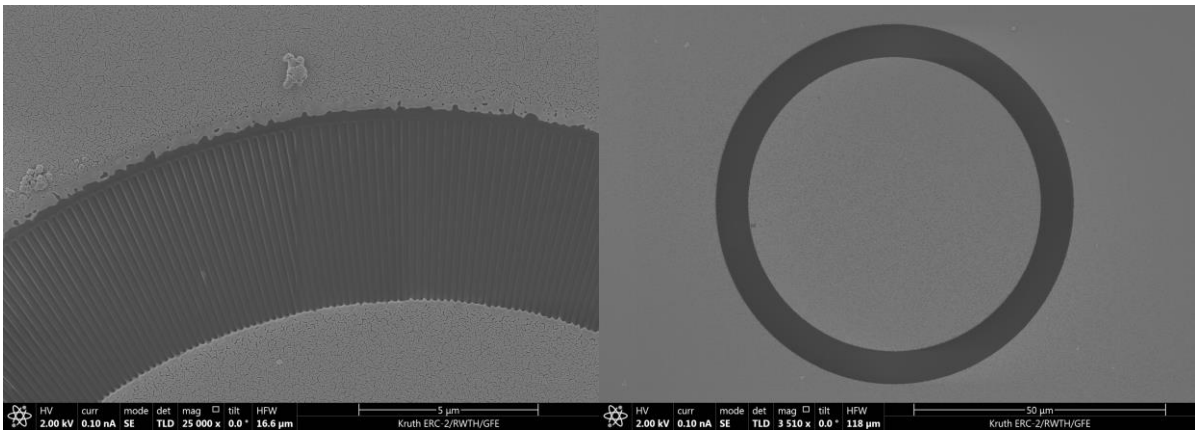

Figure. 1 Detail and overview of patterns obtained by FIB nanofabrication that "easily" provide large L= 1000h OAM beams.

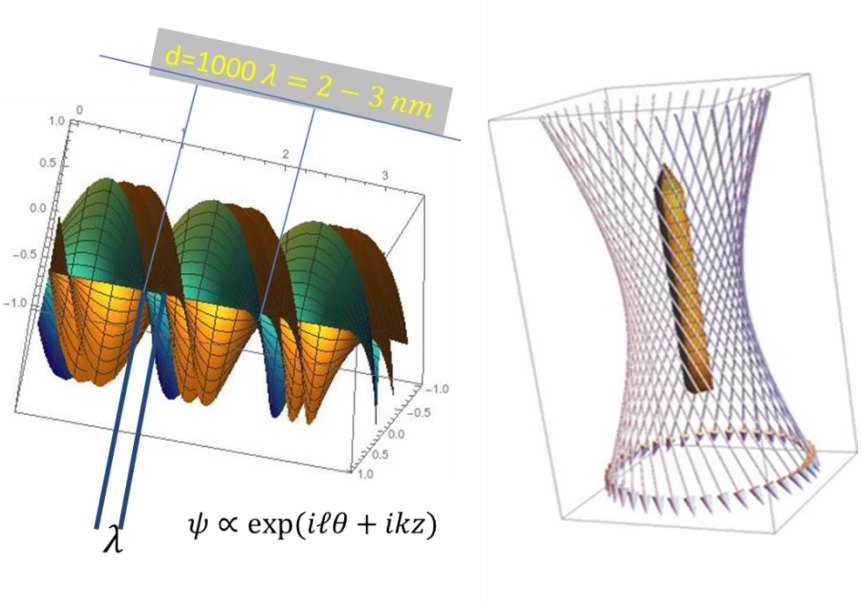

Figure. 2 Large vortex beams have a large step distance and a large in-plane component of momentum.

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