Light-Matter Interaction of Optical Vortices

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Abstract. In scientific research with X-rays at synchrotrons and free electron lasers, there is a strong interest in utilizing highly coherent X-ray beams with a specifically tailored wavefront [1, 2]. An intriguing example for this is the creation of X-ray beams that carry an orbital angular momentum (OAM). The OAM corresponds to the spatial phase distribution of the wave front. One method to create X-ray beams that carry OAM is the use of spiral zone plates (Figure 1).
In contrast to circular dichroism that is caused by the circular polarization of the electromagnetic field, transferring an OAM to an electron is generally considered extremely challenging and hardly detectable. Such an OAM transfer to matter was demonstrated recently in a row of experiments from the infrared to the hard X-ray regime. For instance, the orbital momentum has been transferred to photoelectrons that were emitted from Rydberg state helium atoms [3]. Dichroic effects from an OAM beam have been observed on magnetic vortices at a free electron laser [4]. As a final example, an experiment will be reported on that was carried out at the *cSAXS* beamline at the Swiss Light Source. By investigating an enantiopure chiral iron complex, helical dichroism at the iron K-edge was demonstrated [5].

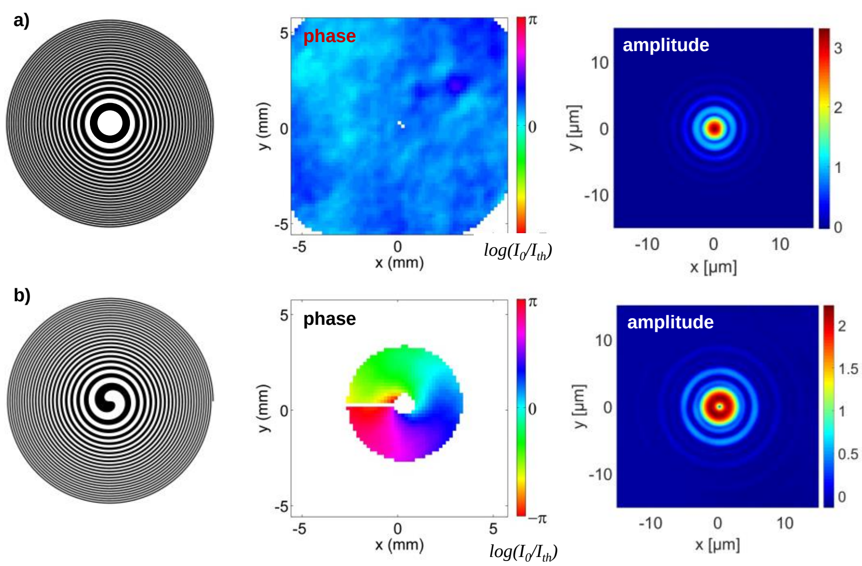

Figure 1: The use of tailored optics to create beams with special properties: a) A normal Fresnel zone plate yields a focused spot with a flat phase profile. b) A spiral zone plate produces an X-ray beam with a phase vortex and a torus-shaped focus.

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[2] Rösner B, F Döring, P R Ribič *et al*, Opt Express **25** (2017), p. 30686. https://doi.org/10.1364/OE.25.030686
[3] De Ninno G, J Wätzel, P R Ribič *et al*, Nat Photon (2020), https://doi.org/10.1038/s41566-020-0669-y
[4] Fanciulli M, M Pancaldi, E Pedersoli *et al*, Phys Rev Lett **under review** (2021)
[5] Rouxel J, M Chergui and B Rösner, in preparation (2021)