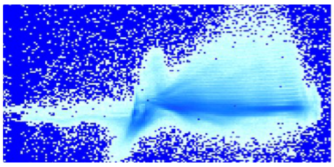

COHERENCE 2024
11th International Conference
on Phase Retrieval
and Coherent Scattering

MAX IV

Contribution ID: **100**

Type: **Invited speaker**

Magnetic spectroscopy and imaging with x-rays carrying orbital angular momentum

Monday 17 June 2024 14:05 (30 minutes)

M. Pancaldi, M. Fanciulli, A.-E. Stanciu, M. Guer, P. Carrara, C. Spezzani, E. Pedersoli, M. Luttmann, M. Vimal, D. Bresteau, D. De Angelis, P. R. Ribic, B. Rösner, C. David, M. Manfredda, F. Guzzi, C. B. Bevis, J. Barolak, S. Bonetti, I. Bykova, L. Novinec, A. Ravindran, A. Simoncig, D. E. Adams, G. Kourousias, G. Mancini, P. Vavassori, R. Sousa, I.-L. Prejbeanu, L. Vila, L. Buda-Prejbeanu, B. Dieny, G. De Ninno, F. Capotondi, T. Ruchon, M. Sacchi

The interaction of light beams with magnetic materials defines the rich set of analytical tools in magneto-optics, covering photon energies from infra-red to hard x-rays. In addition to the spin angular momentum (SAM) associated to the light polarization, Laguerre-Gaussian (LG) beams carry also an orbital angular momentum (OAM) of $\ell\hbar$/photon [1] associated to an azimuthal dependence $\exp(i\ell\phi)$ of the electric field phase. Over the last thirty years, OAM beams at vis-IR wavelengths found applications in biology, telecommunication, imaging and quantum technologies [2]. Their capability to exert a mechanical torque was exploited to create optical spanners for manipulating small particles. The azimuthal phase dependence introduces a singularity on the propagation axis and a radial modulation of the intensity (ring-shaped), properties that have been used to modify magnetic ordering, to improve the spatial resolution in microscopy, and to enhance the edge sharpness in phase-contrast imaging.
Over the last decade, the generation of OAM beams at shorter wavelengths, from XUV to hard x-rays, is also finding an increasing number of applications, often based on extrapolations of previous work carried out in the visible range. For instance, as it happened for the SAM, the handedness imposed by the OAM has been exploited to perform x-ray spectroscopic studies of magnetic materials [3] and of chiral molecules [4], and a recent ptychography study [5] showed that the attainable spatial resolution in the reconstructed XUV images increases with ℓ.
We will review recent extensions in the use of OAM beams from visible to short wavelengths, with focus on applications of 10-100 fs XUV-OAM pulses for element-selective spectroscopy and imaging of magnetic structures. We will show how time-resolved resonant scattering experiments offer new perspectives for tracking the dynamics of complex magnetic topologies.

1. L. Allen at al., ***Orbital angular momentum of light and the transformation of Laguerre-Gaussian laser modes***, Phys. Rev. **A 45**, 8185 (1992).
2. Y. Shen et al., ***Optical vortices 30 years on: OAM manipulation from topological charge to multiple singularities***, Light: Science & Applications **8**, 90 (2019).
3. M. Fanciulli et al., ***Electromagnetic theory of Helicoidal Dichroism in reflection from magnetic structures***, Phys. Rev. **A 103**, 013501 (2021); T. Ruchon, M. Fanciulli, M. Sacchi, ***Magneto-Optics with light beams carrying orbital angular momentum***, in The 2022 magneto-optics roadmap (A. Berger, P. Vavassori Eds.), J. Phys. D: Appl. Phys. **55**, 463003 (2022); M. Fanciulli et al., ***Observation of magnetic helicoidal dichroism with extreme ultraviolet light vortices***, Phys. Rev. Lett. **128**, 077401 (2022).
4. J. R. Rouxel et al., ***Hard X-ray helical dichroism of disordered molecular media***, Nature Photonics **16**, 570 (2022).
5. M. Pancaldi et al., ***High-resolution ptychographic imaging at a seeded free-electron laser source using OAM beams***, Optica (2024), in press (https://doi.org/10.1364/OPTICA.509745)

Primary author: SACCHI, Maurizio (CNRS - INSP and Synchrotron SOLEIL)

Presenter: SACCHI, Maurizio (CNRS - INSP and Synchrotron SOLEIL)

Session Classification: XPCS, polarised and chiral beams