XAS at Extremes:
Magnetic Materials under Pressure and Pulsed Magnetic Fields

O. Mathon, R. Torchio, C. Strohm[1], F. Duc[2] and S. Pascarelli[3]

ESRF, 71 Av. des Martyrs, 38640 Grenoble, France
[1]DESY, Notekestrasse 85, 22607 Hamburg, Germany
[2]LNCMI, CNRS-UPR3228, 143 Av. de Rangueil, 31400 Toulouse, France
[3]European XFEL GmbH, Holzkoppel 4, 22869 Schenefeld, Germany
mathon@esrf.fr

BM23 and ID24 are two ESRF beamlines dedicated to X-ray Absorption Spectroscopy. BM23 is a bending magnet energy-scanning beamline dedicated to high quality EXAFS and XANES. Magnetic materials are being routinely investigated, with focus on superconductivity, nanomaterials or magnetoelectricity for example. XAS sheds light on the evolution of the electronic state and local structure with parameters like doping, temperature, pressure or magnetic field. ID24 is an energy-dispersive XAS beamline installed on a high β straight section equipped with four undulators. Using Quarter Wave Plates, polarization dependent studies such as X-ray Magnetic Circular Dichroism (XMCD) can be performed. A large part of ID24's scientific activity is dedicated to study materials under extreme conditions.

Pressure directly acts on interatomic distances, allowing to tune both bandwidths and bandgaps, thus possibly inducing correlated magnetic and structural instabilities. In Fe, Co and Ni magnetism arises from the partially filled spin-polarized 3d band, whose properties are strongly determined by the crystal structure and by external factors such as temperature, magnetic field, and pressure. Therefore, exploring the stability limits of ferromagnetism as a function of these thermodynamical variables is an essential issue to get a deeper insight on its appearance [1].

As applying pressure, coupling XAS to a high magnetic field is a powerful tool to investigate the correlation between structural, electronic and magnetic degrees of freedom. On ID24, since 2005, we are developing a setup to measure XAS and XMCD under high pulsed magnetic fields. Recently, we investigated sublattice magnetization processes in ferrimagnetic $Er_3Fe_5O_{12}$ garnet [2] and in the rare earth transition metal intermetallics $HoFe_5Al_7$ [3] at the Fe K-edge and at the rare earth L-edges in pulsed fields up to 30 T.

For ID beamlines, the EBS will provide a factor 30 reduction in emittance. The EBS project offers opportunities (brilliance increase) that are difficult to exploit with the ED-XAS spectrometer. We thus propose an evolution of ID24 with the following aims: I) Convert one ED-XAS branch into a branch equipped with a scanning spectrometer dedicated to high brilliance XAS. II) Optimize EDXAS-L for dedicated applications where the ED spectrometer demonstrates a clear advantage, like pulsed magnetic field, applications.

References

[1] - R. Torchio et al., Coordination Chem. Rev. **227-228**, 80 (2014).
[2] - C. Strohm et al., Phys. Rev. Lett. **122**, 127204 (2019).
[3] - D. Gorbunov et al., Phys. Rev. Lett. **122**, 127205 (2019).