Magnetochiral dichroism in $GaFeO_3$

C. Piamonteze[1], Y. Bodenthin[1], M. Garcia-Fernandez[1], S. W. Lovesey[2,3], U. Staub[1]

[1]*Swiss Light Source, Paul Scherrer Institut, CH-5232 Villigen PSI, Switzerland*
[2]*ISIS Facility, Harwell Science and Innovation Campus, Oxfordshire OX11 0QX, United Kingdom*
[3]*Diamond Light Source Ltd., Oxfordshire OX11 0DE, United Kingdom*

Current interest in multiferroic materials has reinvigorated studies of magnetoelectrics. Together with chromium sesquioxide, gallium ferrate ($GaFeO_3$) is a classic magnetoelectric [1] that is ferroelectric above room temperature and ferrimagnetic below T_c = 200K [2]. The magnetic moment is along the c-axis, perpendicular to the electric polarization along b. Essential to understanding the coupling between magnetic and electric polarization in multiferroics is the magnetoelectric order parameter, a toroidal or anapole atomic multipole. By way of orientation, an anapole may be viewed as the vector product of the magnetic moment and electric polarization. It therefore reflects the symmetry properties of magnetoelectric systems, a violation of both time and spatial inversion symmetry. Several experimental and theoretical works have been published in the interpretation and measurement of the anapole moment, several of those in $GaFeO_3$. Absorption spectroscopies in the optical range [3] as well as at the Fe K-edge [4] have been measured showing interesting dichroic signals as non-reciprocal linear dichroism and magnetochiral dichroism. Resonant x-ray scattering experiments at the Fe K-edge also showed the presence of a magnetic difference signal exhibiting non-reciprocity under the inversion of the incoming light propagation direction [5]. All these experiments were designed to measure parity odd events, as E1-E2 or E1-M1, necessary to observe magnetoelectric and polar multipoles. Later theoretical description of these experiments showed that the measured signals turn out to be due to several magnetoelectric multipoles, [6] being not a straightforward task to disentangle the different contributions. A first step in this direction was done by soft x-ray Bragg diffraction experiment at the Fe $L_{3,2}$ edges, where the azimuthal dependence of a charge forbidden reflection was measured. This experiment provided tantalizing information on the magnetoelectric monopole, a magnetic charge, and solid evidence for the magnetoelectric quadrupole in multiferroic $GaFeO_3$ [7].

Magnetochiral dichroism in the Fe $L_{3,2}$ edges is a direct measurement of the anapole moment. In order to measure the magnetochiral dichroism, the signal difference in a magnetic field is taken. Since the magnetochiral dichroism is polarization independent, right and left circular polarized light contribute equally. In this work, we will show dichroic signals at the Fe $L_{3,2}$ edges of $GaFeO_3$ which are proportional to the magnetic, polar and magnetoelectric moments.

References

[1] G. T. Rado, Phys. Rev. Lett. **13**, 335 (1964)
[2] T. Arima *et al.*, Phys. Rev. B **70**, 064426 (2004)
[3] J. Jung *et al.*, Phys. Rev. Lett. **93**, 037403 (2004)
[4] M. Kubota *et al.*, Phys. Rev. Lett. **92,** 137401 (2004)
[5] T. Arima *et al.*, J. Phys. Soc. Japan **74**, 1419 (2005)
[6] S. W. Lovesey *et al.*, J. Phys.: Condens. Matter **19**, 376205 (2007)
[7] U. Staub *et al.*, Phys. Rev. B **80**, 140410 (R) (2009)

Email corresponding author: Cinthia.Piamonteze@psi.ch Preference: Poster