

# Soft x-ray resonant scattering of magneto-electric materials

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This presentation will give an introduction to resonant x-ray scattering and concentrate on magnetic materials, for which the magnetic ions occupy atomic sites without inversion symmetry. In the resonant process, this will open up the possibility to have more exotic channels such as electric dipole –electric quadrupole or even electric dipole – magnetic dipole processes. Though these processes are generally believed to produce only very small effects compared to conventional magnetic scattering based on the electric dipole –electric dipole transitions, our results show that these effects can lead to significant observable intensity when interfering with other channels of scattering. The first example concerns magneto-electric GaFeO<sub>3</sub>, for which resonant x-ray diffraction at the Fe L<sub>2,3</sub> edges probes magneto-electric multipoles, such as the magnetic-electric quadrupole. These results are consistent with resonant diffraction data taken at the K-edge, which probes the same multipoles when applying a magnetization difference method. The second example is concerned with multiferroic CuO, for which the magnetic (1/2 0 -1/2) reflection has a strong and strange dependence on the circular light polarization in the simple collinear antiferromagnetic ground state of CuO. This can be related to a significant contribution of the toroidal (anapole) moment to the scattering. The observation of an antiferro type order of the toroidal moment, would produce a ferroelectric moment already in the ground state, which may explain our difficulties to influence the magnetic domain population in the multiferroic high-temperature phase probed by neutrons.

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