Strong hard X-ray magneto-chiral dichroism in molecular helices

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Chiral magnetic structures have been recently the focus of intense research because they offer the possibility to store information in topological protected structures like skyrmions. Chirality and magnetism are also directly connected in the interaction between matter and electromagnetic radiation through the magneto-chiral dichroism and birefringence. Magneto-chiral dischroism (MχD), a non-reciprocal effect with different absorption of unpolarized light by systems with opposite chirality in the presence of a magnetic field, is a fascinating phenomenon that has been suggested to be at the origin of homochirality of life on the earth and observed only recently. It is in general very weak, being assumed in first approximation to be related to the product of natural (NCD) and magnetic circular (MCD) dichroism, and only few examples are available in literature with limited information on the factors that originate the phenomenon. We report here a detailed synchrotron investigation of the magneto-chiral effect detected at the 3d-metal K edge in two isostructural molecular helices comprising either isotropic Manganese(II) or anisotropic Cobalt(II) bridged by stable organic radicals. The experiments have revealed a strong magneto-chiral dichroism associated with the non-collinear spin structure of the Co^{II} derivative, which is also the archetype of Single-Chain Magnets, i.e. one-dimensional structures showing magnetic bistability due to short-range magnetic correlation.

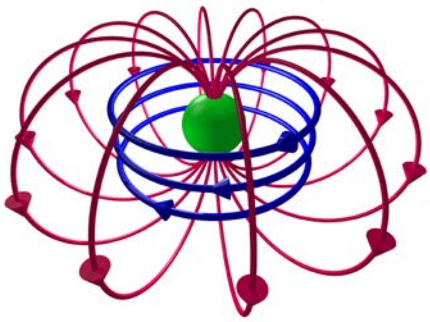

Figure 1: The e XMχD signal at K-edge provides information on the atomic orbital toroidal currents (drawn in red), or orbital anapole, while XMCD is indicative of the orbital dipolar moment (in blue)..

The magneto-chiral dichroism has an unusual symmetry, it is odd with respect to both parity and time-reversal symmetry but is invariant with respect to their product. It is closely related to the anapole moment, which in this particular case is originated from the toroidal orbital currents of the cobalt atoms, as depicted in Figure 1. Orbital toroidal currents are of relevance for many phenomena, ranging from multiferroicity to superconductivity.

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