Magnetic properties and spin-state transitions in the Cobaltates:

The importance of intra-atomic orbital-orbital, spin-spin and spin-orbital correlations

M.W. Haverkort
II. Physikalisches Institut, Universität zu Köln, Germany

Transition metal compounds with partially filled d-shells show a large variety of interesting properties, like metal insulator transitions, colossal magneto resistance and superconductivity. One reason for the complex behavior of these materials is the strong interplay between the orbital, charge, spin (magnetic), and lattice degrees of freedom. On top of these degrees of freedom that determine the rich physics in many of the transition metal compounds, for the cobaltates an extra degree of freedom exists. The 3+ cobalt ion can be in a Low-Spin configuration (S=0, t_{2g}^6), in a High-Spin configuration (S=2, t_{2g}^4 e_{g}^2) and in an Intermediate-Spin configuration (S=1, t_{2g}^5 e_{g}^1). This property of the cobaltates has caused considerable confusion within the literature.

Based on parameters derived from x-ray absorption spectroscopy, magnetic circular dichroism and magnetic susceptibility measurements, we show several models describing the magnetism and spin-state of $LaCoO_3$, $LaSrCoO_4$, and $Ca_3Co_2O_6$.

As we will show, low energy orbital excitations (d-d excitations) are important in these materials and knowledge about their energies is crucial in describing the magnetic properties. We therefore will conclude with some recent progress made in non-resonant inelastic x-ray scattering and show how this technique can be used to measure these excitations.