Polarization dependent X-ray absorption

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X-ray absorption is a local probe for studying magnetic, electronic and structural properties of a variety of materials. Its main appeal is the element selectivity, which makes it a unique tool for some applications. The technique was developed and significantly improved with the advent of synchrotron sources, since it requires a bright source with tunable energy. X-ray absorption is used in widely different research topics such as catalysis, organic and inorganic systems, biochemistry, magnetism. The lecture will focus on the use of x-ray absorption in complex oxides, starting from basic concepts and relating to examples from the literature.

In this lecture the students will learn about the basics of x-ray absorption spectroscopy and how the use of the x-ray polarization can probe different quantities, such as charge distribution or magnetic moment.

The main goal of the lecture is that students learn how to apply x-ray absorption for studying certain materials and to critically think whether this technique can be used in their research project.

The lecture is divided in two parts. During these two lectures the following topics will be covered:

- Production of x-rays in synchrotron sources and its polarization properties.
- Interaction of x-rays with matter. The dipole approximation of the transition operator will be discussed and its consequence, namely the dipole selection rules. It will be shown how the x-ray absorption cross section relates to the density of electronic states.
- It will be shown how x-ray absorption by different electronic core levels probes different states and therefore gives different types of information. It will be discussed how electronic and local structural information can be obtained from K-edge (transition $1s \rightarrow np$) spectra of transition metals. Focus will be given then to $L_{2,3}$-edges (transition $2p \rightarrow nd$), where the valence band of the 3d transition metal is probed. In this context we will discuss the spectral differences between metals and oxides and its relation to electronic correlations.
- In order to further understand the information contained in a spectrum, theoretical simulations are often needed. It will be discussed the different theoretical approaches available and which one is more appropriate to which measurement.
- Examples of experimental setup will be shown and how that differs depending on the energy scale of the x-rays. Various detection methods and their different probing depths will be discussed.
- Finally, the use of x-ray polarization in absorption will be included, which gives rise to linear and circular dichroism techniques. We will discuss which quantities are probed when linear or circularly polarized x-rays are used, which quantitative or qualitative information can be obtained and what are the limitations. Examples from the literature will be given in order to relate to real problems.

Bibliography:

[1] J. Stöhr and H. C. Siegmann, *Magnetism: From Fundamentals to Nanoscale Dynamics* (Springer, 2006).

[2] P. Willmott, *An Introduction to Synchrotron Radiation* (John Wiley & Sons, 2011).