Order and its decay: Resonant x-ray diffraction from transition-metal oxides

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Resonant x-ray diffraction, in particular in the soft x-ray range (RSXD), combines spectroscopic with momentum resolution to a highly selective probe for different electronic and structural degrees of freedom. In particular for spin, charge or orbital order in transition-metal oxides and complex magnetic systems this technique is very well suited. A recent development is to use RSXD to study dynamics. RSXD with coherent photons allows probing domain dynamics in real time. In a pump-probe RSXD experiment the dynamic response of different degrees of freedom to an external stimulus reveals coupling mechanisms.

In a series of experiments from magnetite (Fe_3O_4) we studied the local symmetry of the Fe-3d states that form the orbital order in this material. In a pump-probe RSXD experiment we found a strong coupling between orbital order and low-temperature lattice distortion, which both decay on time scales of less than 200 fs after an infrared laser pulse. For intermediate pump fluences a novel transient state is formed, which is characterized by orbital order in the presence of a drastically reduced band gap.

For stripe order in layered nickelates and cuprates intriguing differences to more bulk-sensitive neutron or hard x-ray results are found: In the near surface region charge order in 1/8 Sr-doped La_2CuO_4 is found, which does not exist in the bulk of the material. In the nickelates a loss of spatial coherence occurs at low temperatures, apparently due to a locking-in of the stripes to the crystalline lattice. Pump-probe resonant diffraction from a nickelate sample shows drastic differences between spin and charge order.