Time-resolved structure research aims at revealing basic processes which change the spatial arrangement of atoms and the electronic charge distributions in condensed matter.

X-ray methods with a femtosecond time resolution hold a particular potential for determining transient structures at atomic length scales and have been implemented with both accelerator- and laser-driven x-ray sources [1]. This talk combines basic concepts of femtosecond x-ray diffraction and absorption with recent results from laser-based experiments.

A combined x-ray diffraction/absorption study of the hydrogen-storage material LiBH4 addresses field-induced charge relocations and the extremely small elongations of coherent phonons in the crystal lattice [2,3]. The virtual transition state in the Raman excitation process of phonons is characterized in detail.

A second experiment demonstrates ferroelectric switching driven by soft-mode excitations in ammonium sulfate. The time-dependent charge density maps derived from diffraction data allow for establishing a link between microscopic currents and the macroscopic electric polarization, thus providing new insight into a longstanding problem [4].