AKjDPG 3: Time-resolved Spectroscopy

Time: Sunday 14:00–15:40 Location: HS 5+6

Tutorial AKjDPG 3.1 Sun 14:00 HS 5+6

Ultrafast spectroscopy — •Anchit Srivastava — Max Planck Institute for the Science of Light, Staudstrasse 2, 91058 Elangen, Germany.

Ultrafast spectroscopy has become a powerful tool for unravelling fundamental interactions in molecules, nanostructures, and solids. It enables the observation of processes on timescales from picoseconds to attoseconds. In this tutorial, I will introduce three pivotal techniques in modern ultrafast science: pump-probe, dual-comb, and field-resolved spectroscopy. We begin by discussing the pump-probe method, which monitors transient states by exciting a sample with an ultrashort pump pulse and tracking its dynamics with a temporally delayed probe pulse. Next, we explore dual-comb spectroscopy, emphasizing how two precisely stabilized frequency combs yield rapid, high-resolution data over broad spectral ranges. Lastly, we delve into field-resolved spectroscopy, a novel approach that allows direct measurement of the electric field of light pulses in ambient conditions. Through technological developments, field-resolved methods now extend from the terahertz to the petahertz domain, providing unprecedented temporal resolution down to the attosecond regime. By combining these techniques, researchers can thoroughly characterize ultrafast processes in a variety of materials, thereby deepening our understanding of energy transfer, charge dynamics, and fundamental light-matter interactions. This tutorial aims to equip students with the essential knowledge to tackle these rapidly evolving methodologies.

Tutorial AKjDPG 3.2 Sun 14:50 HS 5+6

Ultrafast spectroscopy: probing and controlling quantum dynamics on the fastest timescales — •Gergana D. Borisova — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

The fundamental processes in atoms, molecules, and solids occur on remarkably fast timescales – from picoseconds down to attoseconds. The rapid development of ultrafast physics and attosecond science, driven by advances in the generation of shorter and more intense laser pulses, has opened new frontiers in accessing these timescales. We can now measure, understand, and even control electron and nuclear dynamics within natural quantum systems at a fundamental level.
In this tutorial, we will explore the principles of ultrafast light-matter interactions using short and intense laser fields. Key tools of ultrafast spectroscopy, including table-top high-harmonic sources for generating attosecond pulses and large-scale free-electron lasers, will be introduced. We will get to know two prominent time-resolved spectroscopic techniques in the extreme ultraviolet (XUV) regime – time-delay spectroscopy and photoelectron-photoion spectroscopy – and examine their applications in probing and manipulating ultrafast dynamics in quantum systems. Through practical examples, participants will gain insight how ultrafast spectroscopy advances our understanding of dynamical quantum phenomena.