Experimentelle Physik 2

Seminar Festkörperphysik (CMP Seminar)

Aktuelle Probleme der Festkörperphysik für Studenten und Mitarbeiter
020236 Kolloquium/Seminar SS 26
Vorlesungszeit: 16.04.2026 – 16.07.2026

Thursday, 23.04.2026
12:10 – P1-02-110

Polarization- and Time-Resolved Nonlinear Multi-Photon Spectroscopy

Nikita Siverin

Experimentelle Physik 2, Technische Universität Dortmund, 44227 Dortmund, Germany

We present a versatile confocal microscopy platform for polarization- and time-resolved nonlinear multi-photon spectroscopy, developed for symmetry-sensitive studies of semiconductor systems. The setup combines broadly tunable femtosecond and picosecond excitation, full linear polarization control in both excitation and detection, spectral detection with high energy resolution, and time-domain pump–probe capability. This integrated approach enables a wide range of nonlinear optical experiments within a single instrument, providing access to polarization-, spectral-, spatial-, and temporal characteristics of excitonic and other nonlinear optical responses. In the first part of the seminar, I will introduce the experimental platform and illustrate its capabilities with selected examples, including polarization-resolved SHG spectroscopy, SHG microscopy of layered and twisted structures, and time-resolved measurements of coherent dynamics.

In the second part, I will focus on polarization- and time-resolved two-photon-excitation difference-frequency-generation (2P-DFG) spectroscopy of coherent exciton dynamics. As a model material, this approach was applied to Cu_2O, where it resolves the coherent dynamics of dipole-forbidden excitons as well as polarization-controlled, magnetic-field-induced quantum beats. Owing to its well-defined symmetry and exceptionally narrow exciton resonances, Cu_2O provides an ideal benchmark system for establishing 2P-DFG as a sensitive tool for coherence-resolved exciton spectroscopy. Building on this concept, I will then discuss new results obtained for bulk ZnSe, where time-resolved 2P-DFG reveals coherent exciton dynamics together with magnetic-field-induced quantum-beat signatures. In combination with resonant SHG spectroscopy, these measurements provide direct insight into the interplay between coherence, symmetry, and nonlinear optical response channels in semiconductor exciton systems.

[1] N. V. Siverin, A. Farenbruch, D. R. Yakovlev, D. J. Gillard, X. Hu, A. I. Tartakovskii, and M. Bayer, *Rev. Sci. Instrum.* **97**, 023905 (2026).
[2] A. Farenbruch, N. V. Siverin, G. Uca, D. Froehlich, D. R. Yakovlev, and M. Bayer, *arXiv*:2507.22717 [cond-mat.mtrl-sci] (2025).