SYAD 1: SAMOP Dissertation Prize

Time: Tuesday 11:00–13:00 Location: e415

Invited Talk SYAD 1.1 Tue 11:00 e415

Electron Pulse Control with Terahertz Fields — •Dominik Ehberger — Ludwig-Maximilians-Universität München — Max-Planck-Institut für Quantenoptik, Garching

Ultrashort pulses of free electrons enable the visualization of ultrafast processes in complex specimen on the atomic level via time-resolved diffraction and microscopy techniques. However, the temporal resolution of these techniques has been limited by the duration of the probing electron pulses, suffering from Coulomb repulsion and dispersion.

In my talk, I will show how all-optical methods for manipulating electron beams promise to overcome these limitations. Using laser-generated, single-cycle terahertz transients, we compress electron pulses from a duration of hundreds of femtoseconds to below 30 fs and detect them with few-femtosecond accuracy by means of terahertz-based streaking. This method further allows us to retrieve electron spectra with few-eV resolution and potentially beyond. Also, we can tilt electron pulses along their propagation axis in a controlled fashion. Data from this experiment indicates a fundamental link between angular dispersion and tilt angle of an electron pulse, which is well known for optical pulses, but now observed for matter waves, too. Terahertz pulses or, more generally, the cycles of light are therefore instrumental to control and shape ultrafast electron pulses to almost any desire.

With these advancements, time-resolved imaging with electrons approaches a new regime, namely that of ultrafast dynamics on sub-nanometer and sub-femtosecond length and time scales, the primary dimensions of fundamental light-matter interaction.

Invited Talk SYAD 1.2 Tue 11:30 e415

Laser-Based High-Voltage Metrology with ppm Accuracy — •Kristian König[1,2], Christopher Geppert[3], Phillip Imgram[2], Jörg Krämer[2], Bernhard Maass[2], Johann Meisner[4], Ernst Otten[3], Stephan Passon[4], Tim Ratajczyk[2], Johannes Ullmann[2], and Wilfried Nörtershäuser[2] — [1]Michigan State University, East Lansing, USA — [2]TU Darmstadt, Darmstadt — [3]Johannes Gutenberg-Universität, Mainz — [4]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

The ALIVE experiment at the TU Darmstadt is a new collinear laser spectroscopy setup that has been designed, constructed and commissioned particularly for the measurement of high voltages in the range of 10 to 100 kV. An accuracy of at least 1 ppm is targeted which is of high interest for metrology as well as for scientific applications like, e.g., the KATRIN experiment. Earlier attempts with this technique were limited by the uncertainty of the optical frequency measurement or the uncertainty of the real starting potential of the ions in the ion source. In the ALIVE (Accurate Laser Involved Voltage Evaluation) experiment, a two-stage laser interaction for optical pumping and probing is combined with a highly accurate frequency determination with a frequency comb to overcome these limitations. We will present the results we achieved with $^{40}Ca^+$ ions where the well-known $4s_{1/2} \rightarrow 4p_{3/2}$ and the $3d_{3/2} \rightarrow 4p_{3/2}$ transitions were used to identify post-acceleration voltages between -5 kV and -19 kV. We demonstrated a 5-ppm accuracy and further improvements of the apparatus are ongoing to reach sub-ppm accuracy.

Invited Talk SYAD 1.3 Tue 12:00 e415

Structured singular light fields — •Eileen Otte — Institute of Applied Physics, University of Muenster, Germany

Structured singular light fields are characterized by a spatially varying amplitude, phase and/or polarization, enabling the occurrence of singularities. These singularities are particularly interesting because, as structurally stable units of the light field, they determine its topology. In wave optics, singularities may occur in phase or polarization. Phase singularities are locations of undefined phase, causing intensity to vanish. In polarization singularities certain properties of polarization ellipses are undefined - as the oscillation direction of light.

Structured singular light is a ubiquitous phenomenon, not only observable in shallow water, but also the blue daylight sky. However, its artificial creation and especially customization of all its properties represents a major current challenge. If this succeeds comprehensively, singular light could revolutionize many applications.

I will present novel approaches finally enabling the full customization, detailed analysis, and application of structured singular light fields. The developed methods facilitate the fundamental investigation of, e.g., the fields' propagation behavior or the creation of an additional dimension by tight focusing. These fundamental results have opened innovative application perspectives: novel classical and quantum information technologies and tailored optical manipulation. Further, we developed a pioneering nanotomographic approach enabling the identification of typically invisible non-paraxial field properties, unlocking the huge potential of nano-structured light for applied optics.

Invited Talk SYAD 1.4 Tue 12:30 e415

Coherent Coupling of a Single Molecule to a Fabry-Perot Microcavity — •Daqing Wang — Institute of Physics, University of Kassel, 34132 Kassel, Germany

Efficient coupling of light with a quantum emitter is a central concept in the fundamentals of light-matter interaction and it is a prerequisite for deterministic quantum information transfer between distant nodes in a quantum network.

In this talk, we present the experimental realization of nearly perfect coupling of light with an organic molecule enabled by a Fabry-Perot microcavity. The microcavity consists of a planar mirror, and a curved micromirror fabricated using focused-ion-beam milling with a radius of curvature (ROC) in the order of 10 μm. The small ROC allows the operation of an open, tunable and scannable microcavity with a mode volume as small as $4\lambda^3$.

As a result, we observe a strong, coherent interaction of the 00-zero-phonon-line (00ZPL) transition of a dibenzoterrylene molecule with the cavity mode at 4.2 Kelvin. The coupling accelerates the 00ZPL transition by a factor of 38, gives rise to several unprecedented effects in the molecular system. First, the resonant scattering of the molecule interferes destructively with the cavity field in the forward direction, attenuating the cavity transmission by more than 99%. Second, the system responds nonlinearly at the level of single-photons, introducing strong correlations to the photons traversing the system. Furthermore, we demonstrate the efficient interaction of the system with single antibunched photons emitted by a second molecule.