SYAS 1: Award Symposium

Time: Tuesday 14:30–17:00 Location: Paulussaal

14:30 SAMOP Dissertation Prize 2024 award ceremony

14:45 Herbert-Walther-Prize 2024 award ceremony

Prize Talk SYAS 1.1 Tue 15:00 Paulussaal
Quantum Simulations with Atoms, Molecules and Photons — •Immanuel Bloch — Ludwig-Maximilians-Universität — Max-Planck-Institut für Quantenoptik — Munich Center for Quantum Science and Technology — Laureate of the Stern-Gerlach-Medal 2024

40 years ago, Richard Feynman outlined his vision of a quantum simulator for carrying out complex calculations of physical problems. Today, his dream has become a reality and a highly active field of research across different platforms ranging from ultracold atoms and ions, to superconducting qubits and photons. In my talk, I will outline how ultracold atoms in optical lattices started this vibrant and interdisciplinary research field 20 years ago and now allow probing quantum phases in- and out-of-equilibrium with fundamentally new tools and single particle resolution. Novel (hidden) order parameters, entanglement properties, full counting statistics or topological features can now be measured routinely and provide deep new insight into the world of correlated quantum matter. I will introduce the measurement and control techniques in these systems and delineate recent applications regarding quantum simulations of strongly correlated electronic systems, experiments on new dynamical phases of matter, novel quantum optical light matter interfaces and progress towards the realization of ultracold quantum matter of polar molecules.

Prize Talk SYAS 1.2 Tue 15:30 Paulussaal
Spectroscopy of molecules with large amplitude motions: a journey from molecular structure to astrophysics. — •Isabelle Kleiner — Laboratoire Interuniversitaire des Systèmes Atmosphériques, CNRS, Université Paris Cité et Université Paris Est Créteil, France — Laureate of the Gentner-Kastler-Prize 2024

The topic of my talk will concern molecules containing Large Amplitude Motions with one or two methyl (CH_3) internal rotors. Internal rotors are present everywhere in our environment, and are important indicators of the physico-chemical conditions which exist in it. They are also excellent *sensors* for molecular structure determinations.

The high resolution microwave or infrared spectra of those molecules cannot be treated by traditional Hamiltonian methods. Dedicated theoretical methods and codes have been developed to calculate the energy levels, and then to fit the observed line positions for internal rotors. First I will briefly review those approaches. By combining the theory with state-of-the-art experimental data, reliable predictions for the line positions and intensities of astrophysical molecules containing one or two internal rotor(s) can be provided. Internal rotation splittings can be also used to acquire knowledge on structural properties for small organic molecules or biomimetic molecules, which can serve as benchmark, and be compared to quantum chemical calculations. In this talk, I will show results for internal rotors which are prototype for odorant molecules and phytohormones, as well as on methyl derivatives of five or six-membered aromatic rings of biological interest.

Prize Talk SYAS 1.3 Tue 16:00 Paulussaal
Quantum x-ray nuclear optics: progress and prospects — •Olga Kocharovskaya — Texas A&M Univ., College Station, US — Laureate of the Herbert-Walther-Prize 2024

Quantum x-ray nuclear optics is a fast-developing branch of quantum optics dealing with hard x-ray photons and nuclear ensembles. Main advantages of hard x-ray photons are high efficiency of the single photon detectors, possibility of a tight focusing, deep penetration into medium and potentially broad bandwidth. Main advantage of nuclear ensembles in comparison to atomic ones is lower sensitivity to electric and magnetic perturbations. This opens prospects for superior clocks, quantum memories and other quantum technologies. We will discuss several recent advantages in this field. It includes successful resonant excitation of Sc-45 isomer at 12.4 keV with x-ray pulses from EuXFEL [1]. While the only candidate studied so far for nuclear clock was Th-229 isomer [2], resonant excitation of Sc-45 establishes this isomer as another promising candidate for nuclear clock. It also includes recently predicted [3] and experimentally demonstrated [4] quantum storage of the hard x-ray photons in ensemble of nuclei, coherent control of the single gamma-ray waveforms [5] and phenomenon of acoustically induced transparency for hard x-ray photons, an analogue of the EIT and Autler-Towns effects in optics. It was shown that propagation of photons within the transparency window can occur at low group velocity about 10 m/s. [1] Yu. Shvydko et al., Nature 622, 471 (2023). [2] S. Kraemer et al., Nature 617, 706 (2023). [3] X. Zhang et al., PRL 123, 250504 (2019). [4] S. Velten et al., Nature Photonics (submitted). [5] F. G. Vagizov et al., Nature 508, 80 (2014).

Prize Talk SYAS 1.4 Tue 16:30 Paulussaal
3D printed complex microoptics: fundamentals and first benchmark applications — •Harald Giessen — 4. Physikalisches Institut, Universität Stuttgart — Laureate of the Robert-Wichard-Pohl-Prize 2024

We introduce 3d printed complex microoptics, spanning a range between a few micrometers up to 5 mm. Our lens system consist of aspherical multiplet lens systems which can give high numerical apertures with simultaneously excellent imaginag properties over the entire field of view, even directly on an optical fiber tip. Combining several printed materials with different refractive indices and dispersions and the combination with diffractive elements allows for realization of micro-optical achromats or even apochromats which are aplanatic (no first- and third-order aberrations such as spherical aberration, astigmatism, coma, distortion etc.) and achromatic for 3 wavelengths (red, green, blue). We also demonstrate the direct printing of black resists, which results in aperture stops and blackened hulls. Atomic layer deposition yields antireflection coatings on all optical elements. Confocal surface profiling and wavefront interferometry demonstrate accuracies far better than lambda/20. In combination with high-resolution nanostructuring, also 3D holograms and metasurfaces can be included. We utilize these methods to demonstrate the smallest endoscope in the world, passing through a root canal of a tooth, as well as ultracompact sensors. Coupling single quantum emitters or single photon detectors to single mode fibers is demonstrated. Furthermore, single-fiber optical trapping of live cells or atomic systems becomes possible.