# SYAS 1: Award Symposium

Time: Tuesday 14:30–16:35 Location: E415

**SAMOP Dissertation Prize 2023 awarding ceremony**

**Prize Talk** SYAS 1.1 Tue 14:35 E415

**The Reaction Microscope: A Bubble Chamber for AMOP** — •Joachim Ullrich — 69256 Mauer, Germany — Laureate of the Stern-Gerlach-Medal 2021

Reactions Microscopes developed in 1994 revolutionised the experimental study of atomic and molecular break-up reactions and provided unprecedented insights into many-particle quantum dynamics. They enabled for the first time the coincident detection of the momentum vectors of several electrons and ions after (multiple) ionisation of atoms or molecules with high resolution and coverage of a large part of the final-state many-body momentum space. The talk will highlight the technology and its development, illustrate benchmark experiments and focus on the rich future potential of the method.

**Prize Talk** SYAS 1.2 Tue 15:05 E415

**Quantum Computation and Quantum Simulation with Strings of Trapped Ca+ Ions** — •Rainer Blatt — Inst. f. Experimentalphysik, Univ. Innsbruck, Austria — Inst. f. Quantenoptik u. Quanteninformation Innsbruck, ÖAW, Innsbruck, Austria — Laureate of the Herbert-Walther-Prize 2023

The state-of-the-art of the Innsbruck trapped-ion quantum computer [1] is briefly reviewed. We present an overview on the available quantum toolbox and discuss the scalability of the approach. With up to 50 fully controlled ion qubits we perform quantum simulations investigating quantum transport [2] and emerging hydrodynamics features [3]. Employing the quantum toolbox for entanglement-enhanced Ramsey interferometry, we find optimal parameters for quantum metrology [4]. Quantum computers can be protected from noise by encoding the logical quantum information redundantly into multiple qubits using error-correcting codes. Manipulating logical quantum states by imperfect operations requires that all operations on the quantum register obey a fault-tolerant circuit design to avoid spreading uncontrolled errors. We demonstrate a fault-tolerant universal set of gates on two logical qubits in the trapped-ion quantum computer [5].

[1] I. Pogorelov et al., PRX Quantum 2, 020343 (2021) [2] C. Maier et al., Phys. Rev. Lett. 122, 050501 (2019) [3] M. K. Joshi et al., Science 376, 720 (2022) [4] C. D. Marciniak et al., Nature 603, 604 (2022) [5] L. Postler et al., Nature 605, 675 (2022)

**Prize Talk** SYAS 1.3 Tue 15:35 E415

**Amplitude, Phase and Entanglement in Strong Field Ionization** — •Sebastian Eckart — Institut für Kernphysik, Max-von-Laue-Str. 1, 60438 Frankfurt am Main — Laureate of the Gustav-Hertz-Prize 2023

We report on experiments with highly intense femtosecond laser pulses with tailored polarization. The electric field of the laser bends the atomic potential and leads to tunnel ionization of single atoms and molecules. The momenta of the liberated electrons and the ions are measured in coincidence using cold-target recoil-ion momentum spectroscopy (COLTRIMS) reaction microscopes.

We explore properties of the amplitude [1] and the phase [2] of the wave function of the liberated electron. For example, this allows us to measure the Wigner time delay of the electron which is liberated from molecular hydrogen as a function of the electron's emission direction with respect to the molecular axis. Moreover, we prepare two spatially separated atoms from a single oxygen molecule. We probe this pair of atoms on femtosecond time scales and show that the valence electrons of the two atoms are entangled [5].

References:
[1] S. Eckart et al. Nat. Phys. 14, 701 (2018)
[2] S. Eckart et al. Phys. Rev. Lett. 121, 163202 (2018)
[3] S. Eckart, Phys. Rev. Research 2, 033248 (2020)
[4] D. Trabert et al. Nat. Commun. 12, 1697 (2021)
[5] S. Eckart et al. arXiv:2108.10426

**Prize Talk** SYAS 1.4 Tue 16:05 E415

**All-optical Nonlinear Noise Suppression in Mode-locked Lasers and Ultrafast Fiber Amplifiers** — •Marvin Edelmann — Center for Free-Electron Laser Science CFEL, Deutsches Elektronen-Synchrotron DESY, Notkestr. 85, 22607 Hamburg, Germany — Department of Physics, Universität Hamburg, Jungiusstr. 9, 20355 Hamburg, Germany — Laureate of the Georg-Simon-Ohm-Prize 2023

Optical pulse trains with ultra-low intensity noise are highly desirable for a variety of cutting-edge scientific and industrial applications including nonlinear microscopy, frequency-metrology, and photonic microwave generation.

In this work, new investigations regarding all-optical noise suppressing mechanisms in state-of-the-art Kerr-type fiber oscillators and amplifiers are presented. The highly efficient noise-transfer dynamics resulting from the nonlinear interaction of input intensity fluctuations with artificial transmission-functions enable the construction of versatile ultrafast laser systems with quantum-limited noise performance and ultra-stable laser working points.

The underlaying mechanism is further generalized to show that self-amplitude modulation with saturable absorbers, the physical effect fundamentally enabling the generation of ultrashort laser pulses via mode-locked steady-states, inevitably results in strong intra-pulse intensity noise shaping. Resulting intra-pulse noise distributions of an ultrafast laser system are utilized to demonstrate shot-noise limited intensity noise suppression via tailored optical filtering.