# Q 57: Poster VIII

Time: Thursday 17:00–19:00 Location: Aula Foyer

Q 57.1 Thu 17:00 Aula Foyer

**Implementation of a laser system for alkali vapor MEMS cell activation** — •Janice Wollenberg[1], Jenichi Clairvaux Felizco[2], Julien Kluge[1,2], Daniel Emanuel Kohl[1,2], Kai Gehrke[2], Andreas Thies[2], Klaus Döringshoff[1,2], Olaf Krüger[2], and Markus Krutzik[1,2] — [1]Institut für Physik - Humboldt-Universität zu Berlin — [2]Ferdinand - Braun-Institut, Leibniz - Institut für Höchstfrequenztechnik

We present a laser system designed for activating and characterizing Rubidium vapor MEMS cells. These mm-size cells are intended for use in chip-scale optical frequency references utilizing two-photon spectroscopy of Rubidium at 778 nm.

Our approach involves employing a high-power laser at 1064 nm to release elementary Rb from a dispenser pill within the MEMS cell. Within the dual-chambered MEMS cell, one chamber contains the Rb dispenser pill, which gets activated by the 1064 nm laser and releases Rb vapor into the second spectroscopy chamber via micro-channels. There, we use Doppler-free saturation spectroscopy of the D2 transition at 780 nm to characterize the quality of the cells. The outcomes of this work are expected to contribute to the development of optical frequency references, expanding their potential applications, e.g., in optical atomic clocks based on two-photon spectroscopy of Rubidium.

This work is supported by the German Space Agency (DLR) with funds provided by the Federal Ministry for Economic Affairs and Climate Action (BMWK) due to an enactment of the German Bundestag under grant numbers 50RK1971.

Q 57.2 Thu 17:00 Aula Foyer

**Status of a modern Michelson Morley experiment using ultrastable cryogenic cavities and shot noise limited cryogenic detectors** — •Erich Günter Leo Pape, Evgeny Kovalchuk, and Achim Peters — Newtonstr. 15, 12489, Berlin, Humboldt Universität zu Berlin, Institut für Physik

We present advancements in cryogenic experiments, showcasing an optical sapphire cavity setup for a Michelson-Morley experiment on Lorentz violations with a target frequency stability of $10^{-16} Hz/\sqrt{Hz}$. Furthermore, we present our cryogenic detectors using a cryogenic MESFET preamplifier for high bandwidth shot noise-limited performance at $10\mu W$ laser power, contributing to enhanced precision in signal detection.

Q 57.3 Thu 17:00 Aula Foyer

**Optofluidic lasing within a fiber-based microresonator** — •Mustafa Gerdan, Shalom Palkhivala, Larissa Kohler, and David Hunger — Karlsruhe Institute of Technology, Karlsruhe, DE

Most biochemical processes which are of interest to biological examinations occur in aqueous environments and require sensitive measurement techniques. The process of laser generation is highly sensitive to subtle changes in environmental conditions, making a lasing-based sensor a promising candidate for biosensing. As a first step towards optofluidic lasing-based sensing, we have demonstrated a dye microlaser in a fiber-based Fabry-Perot optical resonator [1] using rhodamine 6G as a gain medium. The resonator is integrated into a microfluidic system, allowing reactions within the gain medium to directly influence the lasing of the microlaser. By monitoring the lasing output, e.g. via the lasing threshold, small changes in the vicinity can be investigated. We shall report work towards constructing an optofluidic microlaser using europium-based molecules [2] as the gain medium. Europium presents distinct advantages in contrast to organic dyes, including its resistance to bleaching, precisely defined energy levels of the 4f-states, narrow linewidth of f-f transitions, and long lifetime. Such a device shows promise as a sensitive method in the monitoring of biochemical processes, such as small concentration changes or cell dynamics in a solution phase.

[1] Kohler, L. et al. Nat Commun 12, 6385 (2021)
[2] Kuzmanoski, A. et al. Zeitschrift für Naturforschung B, Vol. 69 (Issue 2), pp. 248-254 (2014)

Q 57.4 Thu 17:00 Aula Foyer

**Status of Laser Cooling at the FAIR SIS100** — •Denise Schwarz[1], Jens Gumm[1], Benedikt Langfeld[1], Sebastian Klammes[2], Danyal Winters[2], and Thomas Walther[1,3] — [1]TU Darmstadt — [2]GSI Darmstadt — [3]HFHF Darmstadt

Bunched relativistic ion beams with a narrow momentum distribution are key for precision experiments at accelerator facilities. To reduce the relative momentum distribution, the principle of laser cooling can be utilized.
Past experiments conducted at the Experimental Storage Ring (ESR) at GSI have demonstrated the advantage of both cw and pulsed UV laser in decreasing the relative momentum distribution of bunched relativistic ion beams.
To achieve even better result, the integration of three laser systems, one cw and two pulsed laser, has been proposed for laser cooling at the FAIR SIS100. To implement this new scenario, overlap in space, time and energy of the three laser beams with the ion beam needs to be optimized.
This work presents the specifics of laser cooling with the integration of three laser systems and focuses mainly on creating good spatial overlap between ion and laser beams, also taking into account the need for active laser beam stabilization.

Q 57.5 Thu 17:00 Aula Foyer

**Utilizing coupled mode theory for surrogate modeling with 3D FDTD simulations of GaAs-based surface Bragg grating** — •Yasmin Rahimof, Igor Nechepurenko, Sten Wenzel, Reza Mahani, and Andreas Wicht — Ferdinand-Braun-Institut (FBH)

Diode lasers with remarkably narrow linewidths, like Extended Cavity Diode Lasers (ECDLs), are vital components for photonic systems which have various applications in quantum computing, optical atomic clocks and quantum sensors based on atom interferometry. The monolithic ECDL (mECDL) represents an advanced photonic device, integrating electro-optical efficiency and compactness onto a single GaAs chip. This study introduces a surrogate model for the Bragg gratings in mECDL.

Recent mECDL improvements focus on optimizing Bragg gratings to reduce frequency noise. Achieving this goal involves utilizing Finite-Difference Time-Domain (FDTD) simulations to investigate the reflectance spectra. However, conducting these simulations is computationally complex. This complexity presents challenges, particularly in the context of large-scale structure simulations. To overcome this problem, we have employed a more efficient approach by integrating 3D FDTD with 1D coupled mode theory. This "hybrid" method created an accurate surrogate model for predicting Bragg grating's reflectance spectrum, drastically reducing simulation time. In summary, our research introduces a robust surrogate model for mECDL Bragg grating, enabling precise performance predictions instead of implementing time-consuming 3D simulations.

Q 57.6 Thu 17:00 Aula Foyer

**Tunability of a Pulsed UV Laser System for Laser Cooling of Relativistic Bunched Ion Beams** — •Tamina Grunwitz, Benedikt Langfeld, and Thomas Walther — Technische Universität Darmstadt

The usage of laser cooling as the only cooling method at FAIR's new synchrotron SIS100 promises a narrow momentum distribution of the relativistic bunched ion beams. In order to address a wide range of ion velocities, the pulsed laser system used for cooling must have the ability to be tunable at the cooling wavelength in the UV region.

In this contribution, we present our tunable pulsed laser system at a center wavelength of 257 nm. For tunability of the whole system, the seed wavelength can be tuned over a range of 3 nm around the center wavelength of 1030 nm. To ensure that this change in wavelength is converted to the UV region at maximum performance, both angle adjustments of the fiber amplifiers ASE filters and phase matching of the second SHG stage (critical phase matching) must be automated. In this work, we will present recent progress on these automations and their performance.

Q 57.7 Thu 17:00 Aula Foyer

**Generation of cw UV radiation using elliptical focusing enhancement cavities** — •Jens Gumm[1], Daniel Preissler[1], and Thomas Walther[1,2] — [1]TU Darmstadt — [2]HFHF Darmstadt

Long term cw laser operation with high output power in the UV spec-

tral range is of great interest in many scientific and commercial applications.
Generation of cw-UV light is often realized by resonant second harmonic generation employing $\beta$-Barium Borate (BBO) as the nonlinear optical medium. A known parasitic effect in BBO is the degradation of the crystal due to two-photon absorption.
We theoretically showed that elliptical focusing can lead to higher conversion efficiencies compared to the spherical optimum and decreases the peak intensity in the nonlinear crystal.
Experimentally, we demonstrated UV powers in excess of 2W.

Q 57.8 Thu 17:00 Aula Foyer

**Defect Dynamics and Microstructure in Colloidal Glasses Using Holographic Optical Tweezers** — •Rhuthwik Sriranga[1,2], Ratimanasee Sahu[1], Diptabrata Paul[1], GV Pavan Kumar[1], Vijayakumar Chikkadi[1], and Patrick Windpassinger[2] — [1]Indian Institute of Science Education and Research Pune, India — [2]Institute of Physics, Johannes Gutenberg-Universität Mainz

This study delves into the intricate relationship between plastic activity and microstructure in amorphous materials using optical tweezer techniques. Shear fields in a colloidal monolayer are generated using holographic optical tweezers with a Laguerre-Gaussian beam and a spatial light modulator. With this setup, we examine the relationships between defect dynamics and microstructure in a quasi-2D system of colloidal glasses, including the orientation of defects with respect to the shear direction. Using time-shared optical tweezers to trap more than 250 particles, we investigate the effect of random pinning on the phonon modes in colloidal crystals and glasses. Through these optical techniques, we aim to bridge the gap in understanding the behaviour of disordered solids and their response to external stimuli, providing valuable insights into the fundamental mechanics of amorphous substances.

Q 57.9 Thu 17:00 Aula Foyer

**Advancing Fiber Cavity QED with Precision Mirror Fabrication** — •Nick Theilacker, Patrick Maier, Gregor Bayer, Selene Sachero, Robert Berghaus, David Opferkuch, and Alexander Kubanek — University Ulm , Institute for Quantum Optics, Albert-Einstein-Allee 11, 89081 Ulm, Germany

In quantum photonic applications, achieving efficient single-photon exchange requires high-quality resonators. Researchers focus on reducing mode volume (V) and increasing quality factor (Q) in Fabry-Pérot resonators. This involves crafting concave structures with a small radius of curvature (ROC) and low surface roughness (Osc). Here, we report on our latest effort to optimize the ratio of Q over V to estabish concave mirrors for next generation F.-P. microcavities.

Q 57.10 Thu 17:00 Aula Foyer

**Noise cancelling in solid-state lasers** — •Thomas Konrad[1], Tobias Steinle[1], Roman Bek[2], Michael Scharwaechter[2], Matthias Seibold[2], Andy Steinmann[1], and Harald Giessen[1] — [1]4th Physics Institute and Research Center SCoPE, University of Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart — [2]Twenty-One Semiconductors GmbH, Allmandring 3, 70569 Stuttgart

Ultra-low-noise laser sources are key for fast and precise measurements, for instance in the fields of bioimaging, near-field optical microscopy, and gravitational wave detection. Besides efficient detection, the laser noise figure is the dominating factor that should be exploited to the fundamental limit demarked by the shot noise. Higher laser noise can be compensated by longer averaging, but the penalty in measurement time scales with the square of the excess noise. Especially with biological samples a significant longer measurement time can alter the results. Therefore, noise reduction of the system itself is more beneficial than longer measurement durations.

In this work we investigate an active noise cancelling scheme in solid state lasers, which are commonly used in many high precision applications. Instead of reducing the noise after the laser, we investigate approaches to reduce the laser noise at its source, namely the laser cavity itself. Due to a resonant coupling between the lifetime of the gain medium and the intracavity laser field, relaxation oscillations are one dominating noise phenomenon in solid-state lasers. Our approach is to actively modulate the absolute gain in a solid-state laser against the relaxation oscillations to achieve wide-band ultra-low intensity noise.

Q 57.11 Thu 17:00 Aula Foyer

**Machine-aided Autonomous Dispersion Compensation of Femtosecond Pulses in a Fiber-Integrated System** — •Mehmet Müftüoglu, Bennet Fischer, and Mario Chemnitz — Leibniz-Institute of Photonic Technologies, Albert-Einstein-Str. 9, 07745 Jena, Germany.

Dispersion compensation is crucial for optical communication and nonlinear optics. Typical compensation methods rely on bulky dispersive elements such as prisms and gratings or dispersive compensating fibers(DCFs). In this work, we compensated 6-meter fiber system dispersion to achieve transform-limited femtosecond pulses at the lead fiber's distal end. Wave shaping manipulates individual frequencies in the frequency domain, enhancing control over the phase profile. Our setup consists of a laser, an amplifier(EDFA), a waveshaper, an autocorrelator, and a computer. Our methodology incorporates a feedback loop between the autocorrelator and the waveshaper to optimize the phase of an ultrashort pulse autonomously. For unsupervised system control, we implement the Particle Swarm Optimization algorithm to compensate for target system configuration (e.g. fiber lengths or pump power). The swarm algorithm optimizes the seven free parameters of a polynomial Taylor expansion in 6th order. In our experiments, we consistently approached transform-limited pulses in various scenarios, achieving durations of 120 fs at lower power and 72 fs at higher power. Our machine-assisted compression method is applicable to supercontinuum spectra excitation in highly nonlinear fibers.

Q 57.12 Thu 17:00 Aula Foyer

**Coherent control in V-type systems: Simulation insights using intense two-dimensional coherent spectroscopy** — •Rishabh Tripathi, Krishna Kumar Maurya, and Rohan Singh — Indian Institute of Science Education and Research, Bhopal

Our study investigates coherent control in V-type three-level systems using high-intensity, ultrafast laser pulses, explored through two-dimensional coherent spectroscopy (2DCS). Employing numerical solutions of the optical Bloch equations, we analyze the response of a V-type system to Gaussian pulses of 10 fs and 120 fs. The research reveals that shorter pulses induce uniform Rabi oscillations, whereas longer pulses result in complex quantum interference and state-specific population dynamics. This distinction underscores the pivotal role of pulse duration and spectral properties in modulating quantum interactions.

Our 2DCS simulations, utilizing phase-cycling methods, provide insights into the system's spectral response in both perturbative and non-perturbative regimes. These simulations reveal the manipulation of spectral peak amplitudes and phases by adjusting the pulse areas, demonstrating control over the system.

This work contributes to the understanding of light-matter interactions in quantum systems and highlights the potential of tailored laser pulses for advanced coherent control, with implications for atomic vapors, semiconductor nanostructures, and photonics research.

Q 57.13 Thu 17:00 Aula Foyer

**Towards frequency comb Raman spectroscopy for quantum logic** — •Elyas Mattivi — Institut für Experimentalphysik, Universität Innsbruck, Technikerstr. 25, A-6020 Innsbruck, Austria

One of the most attractive quantum computing platforms is that of atomic ions. We aim to investigate an alternative approach that substitutes atomic ions with molecular ions, which allows for the utilization of rotational degrees of freedom for quantum information encoding. However, due to the complex internal structure of molecules, advanced methods are required to manipulate and readout their quantum states. In order to prepare, control, and characterize molecules at the quantum level, we are developing a setup for two-beam frequency comb Raman spectroscopy.

The two-beam frequency comb Raman setup allows precise control over driving rotational transitions in molecular ions. We will drive two-beam frequency comb Raman carrier transitions between the electronic D-levels in Ca+. The same system will be used for driving rotational state transitions in CaH+ and CaOH+. The possibility of directly driving sideband transitions with the frequency comb will also be explored. Driving rotational transitions in molecules, especially sideband transitions, requires higher intensities, necessitating the use of an amplifier. Dispersion in the optical path also decreases Raman efficiency. My project focuses on the amplification and dispersion compensation of the comb light used in this Raman setup.

Q 57.14 Thu 17:00 Aula Foyer

**Towards state preparation, readout, and control of polyatomic molecular ions using quantum logic spectroscopy** — •Mariano Isaza-Monsalve — University of Innsbruck, Innsbruck,

Austria

Molecular ions offer more degrees of freedom than atomic ions. These larger Hilbert spaces are rich and interesting landscapes to explore, possibly enabling quantum information applications such as quantum error correcting (QEC) schemes not available in atomic ions. This requires efficient and precise control of the molecular ion states. Co-trapping a molecular ion with an atomic ion facilitates state preparation and readout via quantum logic spectroscopy. Our group aims to use calcium-based molecules, e.g., CaH+ or CaOH+, co-trapped with a 40Ca+ ion for exploring these applications in QEC and precision spectroscopy. Coherent control within a rotational manifold of a molecular ion can be achieved by driving two-beam Raman transitions, as direct transitions between the sublevels in the same manifold are forbidden by selection rules.

Q 57.15 Thu 17:00 Aula Foyer

**Enhancing multi-electron event reconstruction for delay line detectors using deep learning** — •Tobias Volk[1], Marco Knipfer[1], Stefan Meier[1], Jonas Heimerl[1], Sergei Gleyzer[2], and Peter Hommelhoff[1] — [1]Department of Physics, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), 91058 Erlangen, Germany — [2]Department of Physics and Astronomy, University of Alabama, Tuscaloosa, AL 35487, USA

Accurate detection of multiple, closely spaced electrons is of utmost interest for correlation experiments [1, 2]. However, the reconstruction of individual electrons becomes particularly challenging if multiple electrons arrive closely confined in space and time. One possibility for a multi-hit capable detector system are so-called delay line detectors, where the core aspect of electron event reconstruction is the detection of voltage peaks. While classical methods work well on single electron events, they fail to reconstruct multiple close electrons arriving within a narrow time window. The result is a profound dead zone hindering the evaluation of especially interesting, close electron events. To address this challenge, we introduce a deep learning approach for the spatio-temporal reconstruction of multi-electron events [3]. We achieve a dead radius of 2.5 mm, reducing the classical limit by a factor of 8 while improving the overall resolution. Based on this, already existing delay-line setups can be improved posterior, not limited to electrons.

[1] S. Meier et al., Nature Physics 19, 1402-1409 (2023)
[2] R. Haindl et al., Nature Physics 19, 1410-1417 (2023)
[3] M. Knipfer et al., arXiv:2306.09359 (2023)

Q 57.16 Thu 17:00 Aula Foyer

**Optical coherence tomography of encapsulated two-dimensional materials using extreme ultraviolet radiation from high-harmonic generation sources** — •Felix Wiesner[1], Julius Reinhard[1,2], Johann J Abel[1], Martin Wünsche[1], Gerhard G Paulus[1,2], and Silvio Fuchs[1,2,3] — [1]Institute of Optics and Quantum Electronics, Friedrich Schiller University Jena, Jena, Germany — [2]Helmholtz Institute Jena, Jena, Germany — [3]University of Applied Sciences Mittweida, Laserinstitut (LHM, Mittweida, Germany

Atomically thin materials, such as graphene or transition-metal dichalgonides (TMDs), demonstrate exciting physical properties. For the majority of applications, the monolayers must be encapsulated for passivation, protection, or functionalization. Although many techniques exist to characterize the monolayers themselves, methods for imaging encapsulated monolayers are lacking.

Coherence tomography with extreme ultraviolet light (XCT) is a high resolution, high sensitivity technique for axial imaging. The high spatial resolution is enabled by the use of broadband extreme ultraviolet (EUV) light produced by high-harmonic generation (HHG). Consequently, XCT promises to provide important information on the structure of samples containing encapsulated monolayers.

This study applies XCT to the investigation of graphene layers in a silicon encapsulation. Mono-, bi-, and trilayers of encapsulated graphene can be differentiated. Furthermore the interface roughness and the thickness of native oxide layers can be reconstructed. We discuss the applicability of the method to additional types of samples.

Q 57.17 Thu 17:00 Aula Foyer

**Evolution of Floquet topological quantum states in drivensemiconductors** — Andreas Lubatsch[1] and •Regine Frank[2,3] — [1]Physikalisches Institut, Rheinische Friedrich Wilhelms Universitaet Bonn — [2]College of Biomedical Sciences, Larkin University, Miami, Florida, USA — [3]Donostia International Physics Center, 20018 Donostia-San Sebastian, Spain

Spatially uniform excitations can induce Floquet topological bandstructures within insulators which have equal characteristics to those of topological insulators. We demonstrate the evolution of Floquet topological quantum states for electromagnetically driven semiconductor bulk matter. We show the direct physical impact of the mathematical precision of the Floquet-Keldysh theory when we solve the driven system of a generalized Hubbard model with our framework of dynamical mean field theory (DMFT) in the non-equilibrium with physical consequences for opto-electronic applications. [1] A. Lubatsch, R. Frank, Eur. Phys. J. B (2019) 92: 215 [2] A.Lubatsch, R. Frank, Symmetry 2019, 11, 1246 [3] P.-C. Chang, J.G.Lu, Appl. Phys. Lett. 2008, 92, 212113