



# **GREENHORN 2026**

## **HAMBURG**

Annual meeting of early-career researchers in quantum optics,  
atomic physics and related fields

**PROGRAMME &  
BOOK OF ABSTRACTS**

**5 – 8 October 2026**

Institute for Quantum Physics · Hamburg

# WELCOME



## Welcome to Hamburg, and welcome to Greenhorn 2026!

The Greenhorn Meeting is an annual conference organised *by* and *for* early-career researchers in quantum optics, nano-optics, atomic physics, ultracold gases and related fields. It gives young scientists a stage to present their work early in their careers: every participant contributes both a talk and a poster.

This year, around 30 of us meet at the Institute for Quantum Physics on the DESY campus. The small size is intentional. It leaves room for real discussion, curious questions and open feedback among peers, so please ask, comment and discuss: that is what this meeting is for.

Beyond the sessions, a tour of DESY, lab tours at the IQP, an excursion to Schäfter + Kirchhoff, a barbecue and the conference dinner give you plenty of chances to connect across groups and cities. The conference language is English, which makes this a friendly place to practise international scientific communication.

This booklet has everything you need for the week: a campus map, the full programme, the poster sessions and all abstracts. We look forward to four inspiring days with you!

## ORGANISING COMMITTEE

### Till Schacht

Group of Prof. Sengstock

### Constantin Lescow

Group of Prof. Moritz

### Leo Michel

Group of Prof. Moritz

### Hannah Koeth

Group of Prof. Riedinger

## PRACTICAL INFORMATION

# GOOD TO KNOW

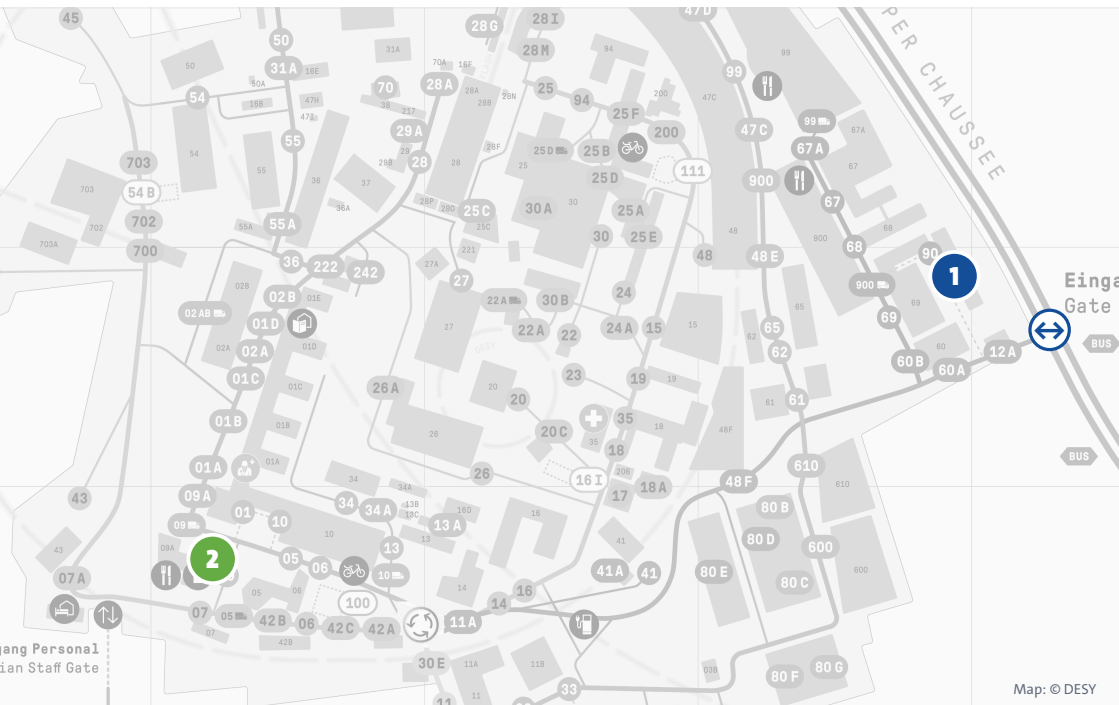
|                   |                                                                                                                                                                                                                       |
|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| VENUE             | <b>Institute for Quantum Physics (IQP)</b> , ZOQ · Building 90<br>DESY campus, Luruper Chaussee 149, 22761 Hamburg                                                                                                    |
| TALKS & POSTERS   | All talks take place in the ZOQ seminar room. Coffee breaks and poster sessions are in the ZOQ foyer.                                                                                                                 |
| LUNCH             | At the Mensa on the DESY campus. See the map on the next page.                                                                                                                                                        |
| WI-FI             | eduroam                                                                                                                                                                                                               |
| BARBECUE          | Monday, 18:00, in front of the ZOQ                                                                                                                                                                                    |
| EXCURSION         | Wednesday, 13:45<br><b>Schäfter + Kirchhoff</b> , Kieler Str. 212, 22525 Hamburg-Eimsbüttel<br>We go there together by public transport.                                                                              |
| CONFERENCE DINNER | Thursday, 18:00<br><b>Il Cortile Bistro &amp; Weine</b><br>Theodorstraße 41Z, 22761 Hamburg-Altona<br><a href="http://il-cortile.de">il-cortile.de</a>                                                                |
| CONTACT           | <a href="mailto:conference-greenhorn26.phys@uni-hamburg.de">conference-greenhorn26.phys@uni-hamburg.de</a><br><a href="https://conferences.uni-hamburg.de/e/greenhorn26">conferences.uni-hamburg.de/e/greenhorn26</a> |

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FINDING YOUR WAY

# CAMPUS MAP



Map: © DESY

- 1 ZOQ · Building 90: conference venue**  
Institute for Quantum Physics. Talks, coffee breaks and poster sessions all happen here.
- 2 Mensa**  
Lunch every day, on the other side of the campus. About a 10-minute walk from the ZOQ.
- ↔ Side entrance Lurper Chaussee**  
The closest gate to the ZOQ. Bus stops are right outside on Lurper Chaussee.

## OVERVIEW

# PROGRAMME AT A GLANCE

|       | MONDAY<br>5 October                      | TUESDAY<br>6 October                            | WEDNESDAY<br>7 October                          | THURSDAY<br>8 October                |
|-------|------------------------------------------|-------------------------------------------------|-------------------------------------------------|--------------------------------------|
| 10:00 | Welcome                                  | Invited Talk                                    | 10:00–11:00<br>Quantum Optics and Spectroscopy  | Invited Talk                         |
| 11:00 | 10:30–11:15<br>Optics and Tweezer Design | 10:30–11:30<br>(Quantum) Mechanical Oscillators | Coffee Break                                    | 10:30–11:15<br>Trapped Ions          |
|       | Coffee Break                             | Coffee Break                                    | Quantum Simulation                              | Coffee Break                         |
| 12:00 | Optics and Tweezer Design                | 11:45–12:30<br>Quantum Simulation               | 12:00–13:45<br>Lunch                            | 11:45–12:30<br>Quantum Communication |
|       | Rydberg Excitations                      | 12:30–13:45<br>Lunch                            |                                                 | 12:30–13:45<br>Lunch                 |
| 13:00 |                                          |                                                 |                                                 |                                      |
| 14:00 | 13:45–14:30<br>Rydberg Excitations       | Research at the IQP                             | 13:45–18:45<br>Excursion to Schäfer + Kirchhoff | Quantum Communication                |
|       | Introduction to DESY                     | 14:05–16:30<br>Lab Tours                        |                                                 | Quantum Optics                       |
| 15:00 | 15:00–18:00<br>DESY Tour                 |                                                 |                                                 | 15:00–18:00<br>Poster Session II     |
| 16:00 |                                          | 16:30–18:30<br>Poster Session I                 |                                                 |                                      |
| 17:00 |                                          |                                                 |                                                 |                                      |
| 18:00 | 18:00–20:20<br>Barbecue                  |                                                 |                                                 | 18:00<br>Conference Dinner           |
| 19:00 |                                          |                                                 |                                                 |                                      |
| 20:00 |                                          |                                                 |                                                 |                                      |

■ Talks
 ■ Invited talk
 ■ Posters
 ■ Tours & social
 ■ Breaks

TALKS, TOURS AND MORE

# PROGRAMME

## MONDAY

5 October

10:00–10:30 **Welcome**

### 10:30–11:15 OPTICS AND TWEEZER DESIGN

- 10:30 **Developing a Hybrid Tweezer Array of Dipolar Molecules and Rydberg Atoms** p. 14  
*Erik Geesmann · Leibniz Universität Hannover*
- 10:45 **Cavity array microscope for fast, scalable readout of a dual-element atom array** p. 15  
*Bahar Öztürk · uni-muenchen*
- 11:00 **Fast, dynamic and three-dimensional SLM holography for optical tweezers** p. 17  
*Maximilian Kob · 5th Institute of Physics, University of Stuttgart*

11:15–11:45 **Coffee Break**

### 11:45–12:15 OPTICS AND TWEEZER DESIGN

- 11:45 **Design of an Objective for a Single Atom Optical Tweezer** p. 18  
*Nessa Baum*
- 12:00 **Toward Near-Unity Photon Collection with a High-NA Solid-Immersion Lens System** p. 19  
*Jan Erik Axmann · Leibniz Universität Hannover*

### 12:15–12:30 RYDBERG EXCITATIONS

- 12:15 **Strong Light–Matter Coupling in a Rectangular Ring Cavity Integrated with a Rydberg-Atom Platform** p. 20  
*Thomas Benedikt Beck · University Bonn*

12:30–13:45 **Lunch** · Mensa

**13:45–14:30 RYDBERG EXCITATIONS**

- 13:45 **Reducing decoherence in single-photon Rydberg excitation** p. 21  
*Jule Brosig · Universität Tübingen*
- 14:00 **Dynamical Decoupling for Realising Time Reversal in Dipole–Dipole-Interacting Rydberg Systems** p. 22  
*Moritz Linnebacher*
- 14:15 **Effect of small interaction terms in a time-reversal protocol for a Rydberg quantum simulator** p. 23  
*Varad Dhodapkar · Heidelberg University*

**14:30–15:00 Introduction to DESY****15:00–18:00 DESY Tour****18:00–20:20 Barbecue** · in front of the ZOQ**TUESDAY****6 October****10:00–10:30 INVITED TALK**

- 10:00 **Giacomo Valtolina**  
*Fritz Haber Institute, Berlin*

**10:30–11:30 (QUANTUM) MECHANICAL OSCILLATORS**

- 10:30 **Inter-Mode Correlations in a Quantum Optomechanical System** p. 24  
*Sofia Kokhanska · Institute of Spintronics and Quantum Information, Faculty of Physics and Astronomy, Adam Mickiewicz University*
- 10:45 **Towards Remote Quantum Coherent Coupling of Atoms and a Mechanical Oscillator via Light** p. 25  
*Andreas Weber · Department Physik, Universität Basel*
- 11:00 **Coherent feedback cooling of a mechanical oscillator** p. 26  
*Alexandre Huot de Saint-Albin · Basel University*
- 11:15 **Implementation of a Simple Neural Network using a Neuromorphic Linear Wave-Scattering System** p. 27  
*Paula Turkiewicz · Adam Mickiewicz University*

**11:30–11:45 Coffee Break****11:45–12:30 QUANTUM SIMULATION**

- 11:45 **Towards imaging of 6Li using near-resonant tweezers** p. 28  
*Magnus Michael Rusch · Universität Tübingen*

- 12:00 **Towards high-resolution manipulation of a fermionic lithium-6 quantum gas** p. 29  
*David Gopalan · RPTU Kaiserslautern-Landau*
- 12:15 **Controlled preparation of double Well eigenstates with high fidelities** p. 30  
*Om Pote · Johannes Gutenberg Universität-Mainz*

12:30–13:45 **Lunch** · Mensa

13:45–14:05 **Research at the IQP**

14:05–16:30 **Lab Tours**

16:30–18:30 **Poster Session I**

## WEDNESDAY

7 October

### 10:00–11:00 QUANTUM OPTICS AND SPECTROSCOPY

- 10:00 **Mid-infrared sensing with induced coherence in Rb vapor ensemble** p. 32  
*Kaveri Jagtap · Leibniz Universität Hannover*
- 10:15 **Integration of Flip-Chip Photodiodes on Lithium Tantalate on Insulator (LTOI) Photonic Chips** p. 33  
*Luise Heiland*
- 10:30 **Probing the Standard Model with Atomic Deuterium** p. 34  
*Sudhir Suresh Babu · Max Planck Institute of Quantum Optics*
- 10:45 **Performance Evaluation of a Vacuum-Fluctuation Quantum Random Number Generator According to AIS 20/31** p. 35  
*Mehrzad Firoozi · Leibniz Universität Hannover*

11:00–11:30 **Coffee Break**

### 11:30–12:00 QUANTUM SIMULATION

- 11:30 **Characterizing RF-Induced Pressure Variations in Glass-Cell Vacuum Systems** p. 36  
*Vicente Yael Baca Montero · RPTU Kaiserslautern Landau*
- 11:45 **The superradiant phase transition driven by squeezed light** p. 37  
*Juan Antonio Luna Gutierrez · RPTU Kaiserslautern and University of Hamburg*

12:00–13:45 **Lunch** · Mensa

**13:45–18:45** **Excursion to Schäfter + Kirchhoff** · by public transport

## THURSDAY

8 October

### 10:00–10:30 INVITED TALK

10:00 **Ralf Riedinger**  
*University of Hamburg*

### 10:30–11:15 TRAPPED IONS

10:30 **Towards optical excitation of a spin-forbidden clock transition with structured light using a photonic-integrated ion trap** p. 38

*M. Ludwig*

10:45 **Towards Scalable Trapped-Ion Quantum Computing with an X-junction Trap** p. 39

*Christian Miguel Karres · Johannes Gutenberg Universität-Mainz*

11:00 **Cooling dynamics of  $C_{60}^+$  in an RF Paul trap: deep ion–atom wells and RF collisional heating** p. 40

*Yu Wang · University of Ulm*

**11:15–11:45** **Coffee Break**

### 11:45–12:30 QUANTUM COMMUNICATION

11:45 **Exploring Nickel Vacancies for Improved Quantum Repeaters** p. 41

*Florian Rickert · Universität Hamburg*

12:00 **Telecom-to-Visible Fiber-Integrated Quantum Frequency Conversion** p. 42

*Felix Rohe · Universität des Saarlandes*

12:15 **Investigation of Tin-Vacancy Centers in Diamond for Quantum Repeater Applications** p. 43

*Linus Ehre · Saarland University*

**12:30–13:45** **Lunch** · Mensa

### 13:45–14:15 QUANTUM COMMUNICATION

13:45 **Optical Memory in a Microfabricated Rubidium Vapor Cell** p. 44

*Joscha Locher · Universität Basel*

14:00 **Towards consumer-level quantum-secure cryptography using entanglement-based short-range quantum-key-distribution** p. 45

*Marco Arnds · Universität Hamburg*

**14:15–14:30** QUANTUM OPTICS AND SPECTROSCOPY

14:15

**Decoding Quantum Mechanics Textbooks: A Roadmap for Learners, Researchers and Young Educators**

p. 46

*Yajie Liang***15:00–18:00** Poster Session II**18:00** Conference Dinner · Il Cortile Bistro & Weine, Altona

## POSTER SESSIONS

Every participant presents a poster in the poster session after their talk. Most posters are on the same topic as the talk. Posters on a new topic are marked **NEW TOPIC**.

**Tuesday 16:30–18:30**

### POSTER SESSION I

**Erik Geesmann** · Leibniz Universität Hannover

p. 14

Developing a Hybrid Tweezer Array of Dipolar Molecules and Rydberg Atoms

**Bahar Öztürk** · uni-muenchen **NEW TOPIC**

p. 16

Quantum matter interfaces based on rubidium–ytterbium dual-element arrays

**Maximilian Kob** · 5th Institute of Physics, University of Stuttgart

p. 17

Fast, dynamic and three-dimensional SLM holography for optical tweezers

**Nessa Baum**

p. 18

Design of an Objective for a Single Atom Optical Tweezer

**Jan Erik Axmann** · Leibniz Universität Hannover

p. 19

Toward Near-Unity Photon Collection with a High-NA Solid-Immersion Lens System

**Thomas Benedikt Beck** · University Bonn

p. 20

Strong Light–Matter Coupling in a Rectangular Ring Cavity Integrated with a Rydberg-Atom Platform

**Jule Brosig** · Universität Tübingen

p. 21

Reducing decoherence in single-photon Rydberg excitation

**Moritz Linnebacher**

p. 22

Dynamical Decoupling for Realising Time Reversal in Dipole–Dipole-Interacting Rydberg Systems

**Varad Dhodapkar** · Heidelberg University

p. 23

Effect of small interaction terms in a time-reversal protocol for a Rydberg quantum simulator

**Sofia Kokhanska** · Institute of Spintronics and Quantum Information, Faculty of Physics and Astronomy, Adam Mickiewicz University

p. 24

Inter-Mode Correlations in a Quantum Optomechanical System

**Andreas Weber** · Department Physik, Universität Basel

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Towards Remote Quantum Coherent Coupling of Atoms and a Mechanical Oscillator via Light

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- David Gopalan** · RPTU Kaiserslautern-Landau p. 29  
Towards high-resolution manipulation of a fermionic lithium-6 quantum gas
- Om Pote** NEW TOPIC p. 31  
Quantum Simulation with trapped rydberg ions in Penning traps

**Thursday 15:00–18:00 POSTER SESSION II**

- Kaveri Jagtap** · Leibniz Universität Hannover p. 32  
Mid-infrared sensing with induced coherence in Rb vapor ensemble
- Luise Heiland** p. 33  
Integration of Flip-Chip Photodiodes on Lithium Tantalate on Insulator (LTOI) Photonic Chips
- Sudhir Suresh Babu** · Max Planck Institute of Quantum Optics p. 34  
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Performance Evaluation of a Vacuum-Fluctuation Quantum Random Number Generator According to AIS 20/31
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Characterizing RF-Induced Pressure Variations in Glass-Cell Vacuum Systems
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The superradiant phase transition driven by squeezed light
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Optical Memory in a Microfabricated Rubidium Vapor Cell

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Towards consumer-level quantum-secure cryptography using entanglement-based short-range quantum-key-distribution

**Yajie Liang**

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Decoding Quantum Mechanics Textbooks: A Roadmap for Learners, Researchers and Young Educators

## ABSTRACTS



MON 10:30 • OPTICS AND TWEEZER DESIGN

### Developing a Hybrid Tweezer Array of Dipolar Molecules and Rydberg Atoms

Erik Geesmann, Kai Voges

*Leibniz Universität Hannover*

Hybrid tweezer arrays of molecules and atoms represent a novel and promising platform for quantum science and technology. Optical tweezers enable highly flexible and dynamic trapping configurations. With their rich internal level structures and long rotational state coherence times, molecules are well suited for storing quantum information and can serve as excellent qubits. Their interactions can be significantly enhanced by employing Rydberg atoms to mediate long-range dipole–dipole interactions. This hybrid platform therefore offers an intriguing approach to quantum simulation [1] and quantum computing [2,3].

I will present our approach and conceptual design for constructing a new apparatus for hybrid tweezer trapping of ultracold SrF molecules and Sr atoms. I discuss the advantages of the SrF+Sr species combination, as well as the associated experimental challenges. Furthermore, I outline our design for the dual-species apparatus, including the source based on a cryogenic buffer-gas cell, the magneto-optical traps, and the optical tweezer trapping region.

Our planned hybrid architecture has the potential to open new pathways toward scalable quantum technology, especially with regards to quantum computing and simulation with trapped single particles.

[1] J. Dobrzyniecki et al., PRA 108, 052618 (2023)

[2] C. Zhang et al., PRX Quantum 3, 030340 (2022)

[3] K. Wang et al., PRX Quantum 3, 030339 (2022)

#### NOTES



**MON 10:45 • OPTICS AND TWEEZER DESIGN**

## Cavity array microscope for fast, scalable readout of a dual-element atom array

Bahar Öztürk<sup>1</sup>, Adrien Bouscal<sup>2</sup>, Johannes Zeiher<sup>3</sup><sup>1</sup>uni-muenchen; <sup>2</sup>Postdoctoral Researcher; <sup>3</sup>Professor

In atom-cavity platforms, fast readout of individual atom states remains a key bottleneck for scalability of the system. We implement a cavity array microscope — a parallel atom-cavity interface for simultaneous, cavity-enhanced readout and atom-photon interfacing in a rubidium-ytterbium Rydberg array — to improve readout times and networking rates. Rather than pursuing a short, high-finesse Fabry-Pérot, the cavity uses an intracavity telescope to focus the collimated cavity mode to a waist of  $w_0 \approx 1.5 \mu\text{m}$  at the atom plane, while the mirrors remain macroscopically separated. This lens-based geometry places most of the optics out of vacuum, relaxes mirror tolerances, and reaches a useful single-atom cooperativity of  $C > 1$  at only modest finesse. The cavity enables fast, non-destructive state readout and mid-circuit measurement via state-selective coupling, and provides an atom-photon interface for networking via fiber arrays.

## NOTES

## POSTER • POSTER SESSION I

## Quantum matter interfaces based on rubidium–ytterbium dual-element arrays

Bahar Öztürk<sup>1</sup>, Adrien Bouscal<sup>2</sup>, Johannes Zeiher<sup>3</sup>, Markus Fuhrmann<sup>4</sup>, Maximilian Gewald<sup>4</sup>, Mullai Sampangi, Pit Steinmetz<sup>4</sup>

<sup>1</sup>uni-muenchen; <sup>2</sup>Postdoctoral Researcher; <sup>3</sup>Professor; <sup>4</sup>Master's student

We present the design and construction of a dual-element neutral-atom platform combining Rb-87 and Yb-171 for scalable quantum information processing and distribution. Encoding data and ancilla qubits in distinct atomic species suppresses optical crosstalk, enables faster two-qubit gates, and yields functionally specialized qubits within a single array. The apparatus pairs a compact dual-element source that continuously reloads a tweezer array via a conveyor-belt lattice, with a cavity array microscope reaching cooperativity of  $C > 1$ . Coupling Rydberg-interacting atoms to this cavity provides a versatile atom–photon interface for fast, non-destructive cavity-enhanced readout, mid-circuit measurement, and entanglement distribution for distributed computing and networking. The rich Yb-171 level structure supplies ground-state, metastable, and optical qubits, while rubidium offers Raman-addressed encodings. Together these ingredients target high-fidelity universal gates and efficient light–matter interfaces in a continuously operated dual-species Rydberg array.

### NOTES

**MON 11:00 • OPTICS AND TWEEZER DESIGN**

## Fast, dynamic and three-dimensional SLM holography for optical tweezers

Maximilian Kob, Manuel Morgado, Govind Unnikrishnan, Achim Scholz, Ralf Berner, Jiachen Zhao, Tilman Pfau, Florian Meinert

5th Institute of Physics, University of Stuttgart

We report on progress towards a fully dynamical optical tweezer platform employing a fast, phase-only spatial light modulator (SLM) within the QRYdDemo experiment, a neutral-atom quantum computing demonstrator based on the Strontium fine-structure qubit [1,2]. Due to intensity flickering along sequences of Gerchberg–Saxton-based holograms, smooth transitions between frames are generated using the Linear Phase Interpolation (LPI) method. This mitigates losses during transport through light-field phase control and allows for on-SLM sorting of stochastically loaded tweezer arrays [3]. In our control software, we extend the demonstrated framework to allow for arbitrary two-dimensional trajectories. Additionally, we implement the generation of arbitrary dynamic 3D holograms, evaluating their usability for neutral atom experiments. This forms the basis for direct assembly of trap geometries interesting for quantum simulation & computation and atom transport along arbitrary 3D trajectories, which we implement based on the LPI technique. We show optical generation & volumetric imaging of 3D holograms, and perform first characterizations of the transient behavior of the sequences.

[1] G. Unnikrishnan et al., Phys. Rev. Lett. 132, 150606 (2024).

[2]F. Meinert, T. Pfau, C. Hölzl: EU Patent Application No. EP20214187.5 and US Patent Application 18/267,066

[3] I. H. A. Kottner et. al., SciPost Phys. 19, 118 (2025).

## NOTES

MON 11:45 • OPTICS AND TWEEZER DESIGN

# Design of an Objective for a Single Atom Optical Tweezer

Nessa Baum, F. Horlacher, L. Granert, S. Burgardt, S. Hiebel, J. Feß, J. Gutsche, A. Widera

Optical tweezers are a powerful tool for the manipulation of neutral atoms in ultracold quantum gases. In particular single atom optical tweezers have become an established technique in state of the art quantum gas experiments. Thus retrofitting existing experimental setups with single atom tweezers allows for exploration of novel physics beyond original experimental capabilities. However, in contrast to systems purpose-built from the ground up, preexisting experiments impose additional geometrical and optical constraints that complicate such an upgrade.

Here, I present ongoing development toward a single atom optical tweezer for an existing Rb based Bose-Einstein condensate experiment with singular Cs impurities as a case study. First, the requirements for single atom trapping are considered in conjunction with limitations imposed by the existing apparatus in order to asses the feasibility of different solutions. This analysis motivates the development of a custom microscope objective tailored to the experimental geometry. The objective is designed via ray tracing based on lens layouts from comparable objectives. Furthermore, a simple optical test setup utilizing the knife edge method is constructed in order to characterize assembled objectives.

This work demonstrates a relatively low cost route towards integrating optics for a single atom tweezer tailored to an experiment's preexisting constraints without commissioning an expensive custom objective.

## NOTES

**MON 12:00 • OPTICS AND TWEEZER DESIGN**

## Toward Near-Unity Photon Collection with a High-NA Solid-Immersion Lens System

Jan Erik Axmann

Leibniz Universität Hannover

Photon collection plays an important role in super-resolution microscopy, where localization precision strongly depends on the number of detected photons. Here, we present a new lens system combining a semi spherical solid immersion lens with an aspherical relay lens, designed to achieve an effective numerical aperture above 2.0 and near-unity collection efficiency. In addition to improving photon collection and spatial resolution in microscopy, the system is particularly suited for efficient collection from single-photon emitters. The presented design combines diffraction-limited performance with a high degree of adaptability while accounting for manufacturing constraints and the cryogenic environment required for the experiments.

## NOTES

## MON 12:15 • RYDBERG EXCITATIONS

## Strong Light–Matter Coupling in a Rectangular Ring Cavity Integrated with a Rydberg-Atom Platform

Thomas Benedikt Beck

*University Bonn*

Optical cavities are among the most powerful tools for enhancing atom–light coupling and constitute a key building block for future quantum technologies based on light–matter interfaces. Rydberg atoms, with their strong and tunable interactions, are a particularly attractive non-linear medium for such interfaces. We present the design and construction of a low-finesse, rectangular, traveling-wave (“ring”) cavity integrated with our existing  $87\text{Rb}$  Rydberg experiment operating on the D2 line at 780 nm, with the goal of enhancing the atom–light interaction and decreasing the decoherence rate of the existing setup. The resonator is a macroscopic cavity located outside the vacuum chamber and consists of four planar mirrors and two intra-cavity lenses that form the cavity waist. This design is straightforward to implement and avoids the astigmatism that arises from a non-zero angle of incidence on spherical mirrors. The traveling-wave geometry removes the standing-wave modulation of a linear resonator, while the lenses ease the alignment procedure and can be placed close to the existing vacuum chamber to create a tight focus of about  $5\text{ }\mu\text{m}$ . The non-planar geometry additionally allows independent control of the transverse-mode structure and the polarization eigenmodes, enabling nearly circularly polarized eigenmodes. The cavity is actively stabilized to a 787 nm laser that is in turn locked to an ultra-stable Fabry–Perot reference cavity. Based on our current design and data from the existing experiment, we anticipate a collective cooperativity of about 100. This platform opens a route toward cavity-mediated interactions between Rydberg atoms, combining the enhanced coupling of a small-waist ring cavity with the strong, long-range interactions of Rydberg states.

### NOTES

**MON 13:45 • RYDBERG EXCITATIONS**

## Reducing decoherence in single-photon Rydberg excitation

Jule Brosig

Universität Tübingen

Quantum simulation with single Rydberg atoms in an optical tweezer array is a powerful tool for investigating complex quantum systems. During the excitation of the atoms, however, technical and physical imperfections lead to decoherence in the system. In our case, a limiting technical imperfection is the phase noise of the laser used for the single-photon Rydberg excitation. A physical imperfection is the black-body-induced decay of the excited state into nearby states. To address these imperfections, we implemented a feedforward correction scheme based on the Pound-Drever-Hall method to reduce the phase noise and set up a laser system that depumps the contaminating Rydberg states and thereby counteracts the black-body-induced losses.

## NOTES

MON 14:00 • RYDBERG EXCITATIONS

## Dynamical Decoupling for Realising Time Reversal in Dipole–Dipole-Interacting Rydberg Systems

Moritz Linnebacher, E. Braun, G. Zürn, M. Lotze, M. Menashes, M. Weidemüller, V. Dhodapkar

*Physikalisches Institut, Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany*

Isolated, dipole–dipole-interacting Rydberg atoms realise effective pseudospin Hamiltonians dominated by exchange interactions. Reversing the sign of the exchange term enables time-reversal protocols and thus provides a route towards measuring out-of-time-order correlators (OTOCs). However, additional higher-order terms in the effective Hamiltonian, arising from couplings to off-resonant atomic states, prevent an exact inversion of the Hamiltonian and therefore an exact reversal of the dynamics. We investigate how global pulse sequences can be used to average out these unwanted contributions while preserving, or controllably transforming, the desired exchange interaction.

### NOTES

**MON 14:15 • RYDBERG EXCITATIONS**

## Effect of small interaction terms in a time-reversal protocol for a Rydberg quantum simulator

Varad Dhodapkar, Eduard Braun, Gerhard Zürn, Matthias Weidemüller, Meny Menashes,  
Moritz Linnebacher

Heidelberg University

Our time-reversal protocol is implemented in a dipolar interacting, isolated many-body spin system represented by Rydberg states in an atomic gas. This protocol can be used in measurement of out-of-time-order correlators (OTOCs) since time reversal is essential for an OTOC which requires backward evolution of a system which can then be used to measure the extent of information scrambling in the system. However, the dipole-dipole interaction Hamiltonian yields certain second order, perturbative interaction terms which effect the efficiency of our protocol and the fidelity of our measurement. Our goal is to experimentally realize pre-existing theoretical models like a 1-D spin chain to better understand the effect these terms have on our time reversal protocol.

## NOTES

TUE 10:30 • (QUANTUM) MECHANICAL OSCILLATORS

## Inter-Mode Correlations in a Quantum Optomechanical System

Sofia Kokhanska<sup>1</sup>, Anna Kowalewska-Kudłaszyk<sup>1</sup>, Joanna K. Kalaga<sup>2</sup>

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Nonclassical correlations between different bosonic modes constitute one of the key signatures of quantum behavior in hybrid quantum systems and play an important role in quantum information processing, quantum communication, and quantum sensing. In particular, inter-mode quantum correlations provide valuable insight into the transfer and redistribution of quantum excitations in coupled light–matter systems.

In this work, we investigate a driven quantum system consisting of a superconducting microwave resonator capacitively coupled to a quantum micromechanical resonator and interacting with a two-level atom. To describe the coupled dynamics, we introduce a hybrid photon-phonon supermode by applying a balanced linear transformation to the photonic and phononic fields. This representation enables a direct comparison of the quantum statistical properties of the photonic, phononic, and hybrid excitations.

To characterize the correlations between different modes, we evaluate the second-order two-mode correlation functions  $g_{ab}^{(2)}(0)$ ,  $g_{ac}^{(2)}(0)$ , and  $g_{bc}^{(2)}(0)$ . In addition, we calculate the corresponding two-mode principal squeeze variances and perform a comparative analysis of the correlation properties in all mode pairs. Particular attention is devoted to the influence of hybridization on the emergence of nonclassical inter-mode correlations and quantum noise reduction.

Our results demonstrate that the hybrid mode modifies the quantum statistical behavior of the system, leading to enhanced nonclassical correlations and stronger two-mode squeezing over extended parameter regions compared with the purely photonic and phononic modes. These findings provide further insight into the role of hybrid photon–phonon excitations in engineering multimode quantum states and may be relevant for future applications in quantum information processing and quantum metrology.

Keywords: second-order two-mode correlation functions, two-mode principal squeezing, hybrid photon-phonon modes, nonclassical states.

### NOTES

**TUE 10:45 • (QUANTUM) MECHANICAL OSCILLATORS**

## Towards Remote Quantum Coherent Coupling of Atoms and a Mechanical Oscillator via Light

Andreas Weber, Alexandre Huot de Saint-Albin, Gian-Luca Schmid, Manel Bosch Aguilera, Philipp Treutlein, Álvaro Mitchell Galvão de Melo

Department Physik, Universität Basel

Hybrid quantum systems that combine complementary physical platforms offer a promising route toward devices capable of simultaneously storing, processing, and transmitting quantum information.[1] In our experiment, we combine a spin-polarized ultracold atomic ensemble and a membrane optomechanical system to realize such a hybrid platform. We engineer coherent interactions between the two systems over a macroscopic distance of 2 meters, mediated by a free-space laser beam in a loop geometry.[2] The collective atomic spin couples to light via the Faraday interaction, while the membrane couples via radiation pressure, together enabling a bidirectional long-distance coupling. Having recently achieved quantum noise limited interactions for both systems individually,[3] the platform is now within reach of exploring quantum coherent coupling and the execution of protocols such as state swaps, ground-state cooling of the mechanical oscillator, and EPR entanglement generation.

1. Kurizki, G. et al. Quantum technologies with hybrid systems. *Proceedings of the National Academy of Sciences* 112, 3866–3873 (2015).
2. Karg, T. M. et al. Light-mediated strong coupling between a mechanical oscillator and atomic spins 1 meter apart. *Science* 369, 174–179 (2020).
3. Schmid, G.-L. et al. Squeezing light with optomechanical and spin-light quantum interfaces. *Comptes Rendus Physique* 26, 641–657 (2025).

## NOTES

TUE 11:00 • (QUANTUM) MECHANICAL OSCILLATORS

Coherent feedback cooling of a mechanical oscillator

Alexandre Huot de Saint-Albin, Alvaro Mitchell Galvao de Melo, Andreas Weber, Gian-Luca Schmid, Manel Bosch Aguilera, Philipp Treutlein

Basel University

Quantum feedback is a powerful technique for controlling quantum systems. The conventional strategy relies on quantum-limited measurements followed by classical processing and feedback actuation onto the system. However, quantum mechanics also allows coherent feedback of quantum signals. Such coherent feedback may exploit the information stored in non-commuting observables, while circumventing the decoherence and backaction noise associated with a measurement. Coherent feedback has thus the potential to improve quantum control and provide new capabilities in a broad range of physical systems. We experimentally demonstrate coherent feedback control of a mechanical oscillator with a quality factor of 46 million. Using this scheme, we demonstrate cooling of the mechanical oscillator’s motion to its quantum ground state.

NOTES

TUE 11:15 • (QUANTUM) MECHANICAL OSCILLATORS

## Implementation of a Simple Neural Network using a Neuromorphic Linear Wave-Scattering System

Paula Turkiewicz

Adam Mickiewicz University

Neuromorphic computing aims to perform machine-learning tasks directly in physical hardware, exploiting the system's own dynamics instead of digital simulation. Wanjura and Marquardt recently proposed realizing neural networks in a physical system based on linear wave scattering, showing that a nonlinear activation function can emerge from purely linear optics [1]. Here, we test this idea by implementing a simple neural network, based on linear wave scattering, that performs a binary classification task: the XOR logic operation, a classic example of a non-linearly separable problem.

[1] C. C. Wanjura, F. Marquardt, Nat. Phys. 20, 1434–1440 (2024).

## NOTES

TUE 11:45 • QUANTUM SIMULATION

## Towards imaging of ${}^6\text{Li}$ using near-resonant tweezers

Magnus Michael Rusch*Universität Tübingen*

We present the current status of our experimental setup for imaging  ${}^6\text{Li}$  atoms in near-resonant optical tweezers.

The tweezers are generated using light at a wavelength of 674.6 nm, close to the  ${}^6\text{Li}$  *D*-line resonance at 671 nm. This configuration provides a promising platform for combination with an optical lattice operating at 841 nm. The chosen lattice wavelength corresponds to the tune-out wavelength of  ${}^{166}\text{Er}$ , which is used for sympathetic cooling of  ${}^6\text{Li}$ . Our aim is to achieve a tweezer distance equal to twice the lattice spacing.

The two-dimensional optical tweezer array is generated using a spatial light modulator (SLM), with the phase pattern being defined via the Gerchberg-Saxton (GS) algorithm and employing both numerical and camera-based feedback to optimise the phase. We provide insight into the optical setup around the SLM and the tweezer generation process.

The small required spacing between the tweezers introduces technical challenges to the tweezer generation process. We discuss these challenges and present their respective solutions.

As the employed light is tuned close to the *D*-line of  ${}^6\text{Li}$ , the atoms are expected to experience stronger optical excitations than in far-off-resonant optical tweezers. We therefore present an overview of the planned implementation of  $\Lambda$ -enhanced gray molasses cooling, which is used for continuous cooling of the  ${}^6\text{Li}$  atoms during trapping and imaging.

### NOTES

**TUE 12:00 • QUANTUM SIMULATION**

## Towards high-resolution manipulation of a fermionic lithium-6 quantum gas

David Gopalan

RPTU Kaiserslautern-Landau

Ultracold quantum gases are versatile model systems for quantum simulation, since both the quantum gas itself and its surrounding potential landscape can be controlled with high precision [1]. The generation of nearly arbitrary optical potentials is made possible through Digital Micromirror Devices (DMDs), which consist of arrays of individually tiltable micrometer-sized mirrors. Here, I present an investigation of the suitability of a DMD for high-resolution manipulation of a fermionic quantum gas of lithium-6 atoms. For this purpose, I designed and constructed a modular optical test setup to characterize the device's diffraction properties. Furthermore, I compared the timing behavior of the device's operating modes and identified the uninterrupted projection mode as the most suitable option for generating stable optical potentials. To compensate for optical distortions in the desired potentials, I implemented an iterative feedback loop. Testing the feedback loop on a variety of target potentials yielded corrected intensity patterns with root-mean-square deviations below 3%.

[1] I. Bloch, J. Dalibard and S. Nascimbène, Quantum simulations with ultracold quantum gases, *Nature Phys.* 8, 267–276 (2012).

## NOTES

TUE 12:15 • QUANTUM SIMULATION

## Controlled preparation of double Well eigenstates with high fidelities

Om Pote

*Johannes Gutenberg Universität-Mainz*

### ABSTRACT

The preparation of excited many-body eigenstates is a central challenge in quantum simulation. In the Fermi–Hubbard model, the double well constitutes a local building block of a many body extended system. In this thesis, a controlled scheme for preparing two-particle eigenstates of a repulsively interacting fermions in a double-well system is developed and experimentally characterised using ultracold 40K atoms in an optical superlattice.

The preparation protocol exploits the use of varying Potential offset between the double well sites dynamically to prepare target eigenstates of the tilted double-well spectrum which is achieved by ramping the superlattice lattice phase and controlling optical lattice depths. This approach enables the preparation of the ground state  $|E_1\rangle$ , the antisymmetric doublon  $|E_3\rangle$ , which corresponds to a local  $\eta$ -pair, and the symmetric doublon  $|E_4\rangle$ .

To quantify the quality of the preparation, a detection scheme based on resolved site occupation combined with dedicated reference measurements to account for detection offsets and residual imperfections. Repeated traversals of the avoided crossings amplify small preparation errors, while bootstrap resampling is used to determine the statistical uncertainties of the resulting fidelity estimator. The measured per-ramp fidelities are close to unity for all four investigated ramp configurations. The resulting state-preparation fidelities are  $0.998 \pm 0.001$  for  $|E_1\rangle$ ,  $0.994 \pm 0.002$  for  $|E_3\rangle$ , and  $0.996 \pm 0.002$  for  $|E_4\rangle$ . These results demonstrate high-fidelity control of two-particle eigenstates in the repulsive double-well system and establish the double-well eigenstates as well-controlled local building blocks for future preparation of extended  $\eta$ -paired states in optical lattices.

### NOTES

## Quantum Simulation with trapped rydberg ions in Penning traps

We report on the development of a quantum simulation platform based on Rydberg-excited  $^{40}\text{Ca}^+$  ions confined in a Penning trap [1,2]. The platform is designed to study long-time quantum dynamics, collective behavior, and nonequilibrium phenomena in open many-body systems on timescales far beyond those accessible with conventional trapped-ion simulators [3]. Exciting ions to Rydberg states offers a distinct advantage for engineering spin interactions: the resulting dipolar couplings between neighboring ions are up to two orders of magnitude stronger than those achievable through standard laser coupling to vibrational modes [1,6]. Rydberg states' huge polarizability makes them sensitive to the oscillating confining field of a Paul trap. This leads to mixing and broadening the Rydberg spectrum through Floquet sidebands which is an unavoidable effect in Paul traps [8]. The Penning trap architecture removes this obstacle entirely, as confinement is achieved through a static electric field combined with a strong static magnetic field, eliminating micromotion associated Floquet mixing, and is expected to support trapping lifetimes of up to several days in combination with a cryogenic enclosure [7]. Microwave dressing of the Rydberg states is used to tune and control the resulting dipole-dipole interactions, allowing state-dependent coupling strengths to be engineered directly and enabling simulation of tailored spin models on a planar ion crystal with a high degree of control [5]. The current developmental stage of the project focuses on the magnetic confinement, achieved using an in-house permanent magnet Halbach array configuration [4]. This has been fully assembled and characterized, with field simulations and Hall-probe measurements at room temperature and liquid nitrogen temperatures confirming homogeneity of around 2600 ppm across the ion trapping region. References:

- [1] A. Mokhberi et al., *Adv. Atom. Mol. Opt. Phys.* 69, 233–306 (2024)
- [2] A. Polloreno et al., *arXiv:2203.05196* (2022)
- [3] C. Chen et al., *Nature* 616, 691 (2023)
- [5] H. Bao et al., *Europhys. Lett.* 151, 55003 (2025)
- [6] W. S. Martins et al., *arXiv:2601.01626* (2026), in prep. for PRX
- [7] J. Andrijauskas et al., *Phys. Rev. Lett.* 127, 203001 (2021)
- [8] W. S. Martins, J. W. P. Wilkinson, M. Hennrich, I. Lesanovsky, *Phys. Rev. A* 111, 043106 (2025)

## NOTES

## WED 10:00 • QUANTUM OPTICS AND SPECTROSCOPY

**Mid-infrared sensing with induced coherence in Rb vapor ensemble**Kaveri Jagtap<sup>1</sup>, Ilja Gerhardt<sup>2</sup><sup>1</sup>Leibniz Universität Hannover; <sup>2</sup>Institute of Solid-State Physics, Leibniz University Hannover

Measurements are the cornerstone of physics. Precision measurements and sensing at mid-infrared (MIR) wavelengths remain complicated by the limited availability of low-noise detectors between 1000 and 10000 nm. Warm alkali metal vapors have long served as a versatile, low-cost platform for spectroscopy and nonlinear optics.

Here we explore hot atomic rubidium vapor to drive the Doppler-free two-photon transition  $5S_{1/2} - 5P_{3/2} - 5D_{5/2}$  with 778nm light, which emits the cascaded  $5.2\ \mu\text{m}$  and 420nm (blue fluorescence).

Induced coherence is a technique, which allows to interfere two independently generated light beams, which originate from a non-linear optical process. Historically, two independently pumped photon pair sources were used to produce signal and idler beams. When the generated idler photons are aligned and rendered indistinguishable, coherence is induced between the otherwise independent signal photons. Naturally, the wavelength of signal and idler can be vastly different, such the detection of one testifies the interference of the other. This scheme has been extended to application including imaging with undetected photons, nonlinear interferometry and infrared spectroscopy. This positions the undetected idler beam as a means of encoding information that is only retrieved through the detected visible signal. Meanwhile, atomic vapors have proven to allow for highly non-linear optical transitions and paired photon generation. In hot rubidium vapor, a strong pump field around 778nm results in ( $5.2\ \mu\text{m}$ ) MIR and visible (420nm) fluorescence, which emerges from the consecutive decay steps of the cascade. In our experiment, we overlap the mid-infrared emission with the pump field and record interference of the 420nm component. This testifies the interaction on the near-infrared wavelength.

## NOTES

**WED 10:15 • QUANTUM OPTICS AND SPECTROSCOPY**

## Integration of Flip-Chip Photodiodes on Lithium Tantalate on Insulator (LTOI) Photonic Chips

Luise Heiland, Florian Pausewang, Wolfram Pernice

Quantum computers based on neutral atoms hold great potential for revolutionary discoveries across research and industry. However, scaling these systems requires precise, real-time control of laser power to manipulate atomic qubits reliably. Integrated photonics – especially based on electro-optically active materials such as LTOI – has emerged as a platform to pulse laser light used to control atoms. Yet LTOI lacks integrated photodetectors, so on-chip optical signals cannot be monitored directly on the same chip.

In my master's thesis project, I address this by hybrid-integrating low-noise photodiodes, fabricated on a separate platform, directly onto LTOI photonic chips via flip-chip bonding to realize closed-loop feedback for setting the working point of light modulators.

Working principle: A small fraction of the on-chip optical power is tapped off and guided to the flip-chip bonded photodiode via a 3D-nanoprinted out-of-plane coupler. The resulting photocurrent is processed by a PID control system that continuously adjusts the modulator's working point, laying the foundation for compact, self-regulating photonic modules.

In this work, I present the complete process from optical design and simulation, through chip fabrication, to the micro-assembly challenges of combining these two heterogeneous photonic platforms into a single functional device.

## NOTES

## WED 10:30 · QUANTUM OPTICS AND SPECTROSCOPY

**Probing the Standard Model with Atomic Deuterium**

Sudhir Suresh Babu<sup>1</sup>, Alexander Wilzewski<sup>1</sup>, Derya Taray<sup>1</sup>, Omer Amit<sup>1</sup>, Randolph Pohl<sup>2</sup>, Theodor Hänsch<sup>1</sup>, Thomas Udem<sup>1</sup>, Vincent Weis<sup>1</sup>, Vitaly Wirthl<sup>1</sup>

<sup>1</sup>Max Planck Institute of Quantum Optics; <sup>2</sup>Johannes Gutenberg-Universität Mainz

Hydrogen-like systems have a unique advantage for probing bound-state QED, as their energies can be computed from first principles. By comparing the transition frequencies of various energy levels, one can test the consistency of QED and also extract fundamental quantities, such as the Rydberg constant and nuclear radii, that are not accessible by other experiments to such high precision. This is particularly interesting due to the “Deuteron Radius Puzzle” and “Proton Radius Puzzle” where the nuclear radii extracted from the measured Lamb shift in muonic hydrogen [1] and deuterium [2] were discrepant from that of their electronic counterpart by more than  $3\sigma$ . Although one could say that the Proton radius puzzle is resolved, as the recent electronic hydrogen measurement agrees with the muonic hydrogen data [3, 4], the deuteron radius puzzle remains, as there have been no recent measurements in electronic deuterium. Here, we present the working of our hydrogen/deuterium spectrometer used to measure the dipole-allowed  $2s$ - $6p$  transition frequency in atomic deuterium, highlighting key differences from our  $2s$ - $6p$  measurement in atomic hydrogen [4], and present a preliminary analysis from our ongoing measurement campaign.

1. R. Pohl et al., Nature 466: 213-216, 2010
2. R. Pohl et al., Science 353(6300) : 669-673, 2016
3. A. Beyer et al., Science 358(6359):79-85, 2017
4. L. Maisenbacher et al., Nature 650:845-851, 2026

**NOTES**

<sup>1</sup>Leibniz Universität Hannover; <sup>2</sup>Fraunhofer Institute for Photonic Microsystems IPMS

## NOTES

WED 11:30 • QUANTUM SIMULATION

## Characterizing RF-Induced Pressure Variations in Glass-Cell Vacuum Systems

Vicente Yael Baca Montero

RPTU Kaiserslautern Landau

In recent years, radio-frequency (RF) magnetic fields have become increasingly important tools in ultracold-atom and quantum-gas experiments. Because many of these experiments rely on glass-cell vacuum chambers, where stable ultra-high vacuum (UHV) is critical, it is essential to verify that the presence of an RF coil (or any source of time-dependent magnetic fields) does not compromise vacuum integrity. In the present work a tunable RF coil was placed near a quartz glass-cell attached to a vacuum pumping system at near UHV pressures and driven over the MHz regime while monitoring the chamber pressure in real time. We observe frequency dependent pressure variations correlated with the magnitude of the applied RF field. The results contribute to understanding RF-induced perturbations in UHV environments and enhance the design of vacuum systems that incorporate RF fields.

## NOTES

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## The superradiant phase transition driven by squeezed light

<sup>3</sup>RPTU Kaiserslautern

## NOTES

THU 10:30 • TRAPPED IONS

## Towards optical excitation of a spin-forbidden clock transition with structured light using a photonic-integrated ion trap

M. Ludwig, G. Du, C. Grimpe, F. Salahshoori, M. Hesse, G. Beck, K. K. Mehta, E. Jordan, M. Kromrey, A. P. Kulosa, T. E. Mehlstäubler

Trapped ions are widely used for optical clocks [1], quantum computing [2], and tests of fundamental physics [3], offering optical transitions from the ultraviolet to the infrared. However, conventional free-space optics limit alignment stability and scalability, constraining the full exploitation of these systems. Photonic integration addresses these limitations by replacing bulky free-space optics with compact, robust on-chip components, while also opening new opportunities for tailored beam shaping.

We present a surface ion trap with integrated photonic waveguides and grating couplers designed to deliver all wavelengths required for  $^{172}\text{Yb}^+$  clock spectroscopy. To efficiently drive the forbidden E3 transition, an on-chip mode converter transforms the 467 nm light into a Hermite–Gaussian HG<sub>01</sub> mode. The characteristic intensity minimum of this mode allows the ion to be positioned at the central dark region, strongly suppressing AC Stark shifts while maintaining efficient excitation with appropriate polarization [4]. We report on the current status of the setup and discuss the technical challenges specific to room-temperature operation.

[1] Tara M. Fortier, Andre N. Luiten, and Helen S. Margolis, “Optical atomic clocks: defining the future of time and frequency metrology,” *Optica* 13, 143-163 (2026)

[2] Colin D. Bruzewicz, John Chiaverini, Robert McConnell, Jeremy M. Sage; Trapped-ion quantum computing: Progress and challenges. *Appl. Phys. Rev.* 1 June 2019; 6 (2): 021314

[3] L. S. Dreissen, et al. *Nat Commun* 13, 7314 (2022)

[4] A. A. Peshkov et al, Excitation of Forbidden Electronic Transitions in Atoms by Hermite–Gaussian Modes. *ANNALEN DER PHYSIK* 2023, 535, 2300204.

### NOTES

## Towards Scalable Trapped-Ion Quantum Computing with an X-junction Trap

<sup>1</sup>Johannes Gutenberg Universität-Mainz; <sup>2</sup>Johannes Gutenberg University Mainz

[1] A. Conta *et al.* “Toolchain for shuttling trapped-ion qubits in segmented traps”, [AVS Quantum Sci. 8, 023801 \(2026\)](#)

## NOTES

THU 11:00 • TRAPPED IONS

## Cooling dynamics of $C_{60}^+$ in an RF Paul trap: deep ion–atom wells and RF collisional heating

Jesús Pérez-Ríos<sup>1</sup>, Saajid Chowdhury<sup>2</sup>, Yu Wang<sup>3</sup>, Zhongqi Liang<sup>2</sup><sup>1</sup>Stony Brook; <sup>2</sup>Stony Brook University; <sup>3</sup>University of Ulm

Buckminsterfullerene  $C_{60}$  is a benchmark large molecule — highly symmetric, rigid, and readily sublimed and ionized — making its cation  $C_{60}^+$  one of the most accessible large molecular ions to produce. It is also the first identified molecular carrier of the diffuse interstellar bands, assigned through cold gas-phase spectroscopy, so buffer-gas cooling of  $C_{60}^+$  in RF traps directly underpins such measurements. Yet for large ions the relevant collision dynamics — transient complex formation in deep ion–atom wells and RF-driven collisional heating — remain poorly characterized. We present classical molecular-dynamics simulations of a single trapped  $C_{60}^+$  ion (720 amu;  $\Omega/2\pi = 0.75$  MHz) buffer-gas cooled by helium or cadmium, using ab initio ion–atom potential-energy surfaces (well depths  $D_e \approx 102$  K for He, 3971 K for Cd) and a moving-bubble buffer-atom injection scheme. Over trajectory ensembles we track the single-ion temperature (including micromotion), cooling curves, and complex-formation statistics. Contrasting a light, warm gas (He, 4 K) with a heavy, ultracold one (Cd, 6.4 mK), the ion cools toward the bath on ms–s timescales, its steady-state temperature set by competition between collisional cooling and RF micromotion heating — enhanced during long-lived captures in the deep Cd well [He  $\sim 6.8$  K; Cd  $\sim 12$  mK]. These stiff capture dynamics are resolved with a well-period-adaptive symplectic integrator benchmarked against embedded Runge–Kutta. We discuss prospects for cooling large molecular ions toward the mK regime.

### NOTES

THU 11:45 • QUANTUM COMMUNICATION

## Exploring Nickel Vacancies for Improved Quantum Repeaters

Florian Rickert<sup>1</sup>, Caius Niemann, Lena Zimmer, Leonie Eggers<sup>2</sup>, Nick Brinkmann<sup>2</sup>, Ralf Riedinger<sup>1</sup>, Rikhav Shah

<sup>1</sup>Universität Hamburg; <sup>2</sup>Universität Hamburg

As quantum computers advance, the need for quantum networks becomes more apparent. In order to realize a quantum internet, we need to connect processors over long distances. With quantum cryptography, security levels in communication could then be raised to unprecedented levels.

Due to the exponential loss of photons in fibers over long distances, an optical quantum network relies on quantum repeaters that allow for qubit storage with sufficiently long coherence times. A thoroughly investigated platform for such repeaters is the silicon-vacancy (SiV) color center in diamond. At temperatures below 100 millikelvin, this defect exhibits spin memory long enough to enable entanglement over a distance of 500 kilometers. The major drawback of this platform, despite its impressive performance, is the extremely low temperature requirement which demands expensive dilution refrigeration.

A promising candidate to overcome this limitation is the NiV color center in diamond. Due to stronger spin-orbit coupling, the ground state splitting of Nickel is larger, making the spin qubit stable at temperatures up to ~2K. These temperatures are reached with a much more affordable and transportable setup.

Here we present recent efforts for chip integration of NiV color centers.

## NOTES

THU 12:00 · QUANTUM COMMUNICATION

# Telecom-to-Visible Fiber-Integrated Quantum Frequency Conversion

Felix Rohe, Marlon Schäfer, David Lindler, Tobias Bauer, Jannis Sode, Christoph Becher

Universität des Saarlandes

Telecom quantum light sources such as quantum dots, as well as weak coherent laser pulses have recently been gaining importance for quantum repeater applications, by entangling the photons with quantum memory nodes, possessing long spin coherence times [1]. However, since most of the quantum memories exhibit an optical interface in the visible or near-infrared, telecom-to-visible quantum frequency conversion is crucial for long-distance quantum entanglement distribution. Here, we present a two-stage conversion scheme to tune single telecom photons to resonance with the tin-vacancy (SnV) center in diamond in a fiber-integrated design using a solid-core photonic crystal fiber (PCF) coupled to a periodically-poled lithium niobate (PPLN) waveguide. The signal photons at 1550 nm are converted to 619 nm in a two-step sum-frequency generation process using a strong pump field at 2062 nm. This fiber-integrated design offers increased robustness against fluctuations of ambient conditions, paving the way for operation outside of a controlled lab environment. We show results on fiber-to-waveguide coupling as well as conversion efficiencies.

[1] Knaut, C.M. et al., Nature 629, 573–578

## NOTES



## THU 12:15 · QUANTUM COMMUNICATION

## Investigation of Tin-Vacancy Centers in Diamond for Quantum Repeater Applications

Linus Ehre, Christoph Becher, Dennis Herrmann

Saarland University

Quantum networks play an important role in quantum information science as they promise secure communication as well as applications in distributed quantum computing and quantum metrology. To expand them over large distances, however, quantum repeaters based on entanglement distribution are required to minimize optical fiber losses. This increases the demand for efficient interfaces between photonic and stationary qubits as a source of entanglement. The negatively charged Tin-Vacancy color center in diamond ( $\text{SnV}^-$ ) is a promising candidate, as it offers Fourier-limited single photon emission and an optically accessible electron spin with millisecond coherence times [1]. To create a quantum repeater segment by entanglement swapping between two spin-photon interfaces, photonic Bell-State measurements are employed. These require a high indistinguishability of the single photon emission from the  $\text{SnV}^-$ , which has not yet reached sufficiently high regimes [2]. Here, we demonstrate a high indistinguishability of consecutively emitted photons from a  $\text{SnV}^-$  hosted by an  $^{12}\text{C}$  enriched diamond. By observing a raw Hong-Ou-Mandel Visibility of  $V_{\text{HOM}}^{\text{raw}} = 0.950^{+0.006}_{-0.008}$  and compensating for technical imperfections, an intrinsic indistinguishability up to 0.999 highlights the  $\text{SnV}^-$ 's suitability for quantum network applications. Further work aims to implement fast gate operations by investigating possibilities and limitations of all-optical coherent control of the  $\text{SnV}^-$ 's electron spin. Combination of its photonic properties with coherent spin control thus contributes to the development of an efficient source of spin-photon entanglement. [1] I. Karpatzakis et al., Phys. Rev. X 14, 031036 [2] J. A. Martínez et al., Phys. Rev. Lett. 129, 173603

### NOTES

THU 13:45 • QUANTUM COMMUNICATION

## Optical Memory in a Microfabricated Rubidium Vapor Cell

Joscha Locher, Gianni Buser, Philipp Treutlein, Roberto Mottola, Suyash Gaikwad

Universität Basel

Large-scale quantum networks require a scalable, mass-producible memory platform. Ground-state atomic vapor memories are a promising candidate: room-temperature operation makes them experimentally simple, and they have been shown to perform well across a range of figures of merit. Their noise performance is compatible with preserving the non-classical photon-number statistics of retrieved photons, and their acceptance bandwidth can be matched to high-quality single-photon sources such as semiconductor quantum dots or SPDC sources. Additionally, vapor cells can be microfabricated, using the same techniques already applied to compact quantum sensors such as atomic clocks, magnetometers, and gyroscopes. However, so far, no quantum memory has been realized in a MEMS vapor cell. Recently, we demonstrated for the first time an optical memory in a microfabricated vapor cell compatible with wafer-scale fabrication techniques, representing a crucial step towards scalability.

Our result relies on a novel memory scheme that engineers a “clean” atom-light interaction. A tesla-order static magnetic field brings the atomic vapor into the hyperfine Paschen-Back regime, where Zeeman degeneracies are lifted and the nuclear and total electronic spin are decoupled. This spectrally isolates a single  $\Lambda$ -system in the hot ensemble, enabling efficient, low-noise storage in the atomic ground states. In this proof-of-principle experiment, we stored and retrieved weak coherent pulses attenuated to the single-photon level, reaching an end-to-end efficiency of  $3.12(17)\%$  at an  $80\text{ ns}$  storage time, with a  $\text{SNR} = 7.9(8)$ . The memory preserves the pulses over a  $1/e$  lifetime of  $224(8)\text{ ns}$ . The SNR is currently limited by poor initial atomic polarization caused by radiation trapping. To address this, the cell geometry and filling have been optimized to improve state preparation, and a custom-built permanent magnet now provides the tesla-order field with ppm-level homogeneity on the centimeter scale. With these upgrades, we will attempt to interface the memory with a single-photon source. Such an optical interconnect, built from miniaturized room-temperature memories, would pave the way to more complex networking applications.

## NOTES

THU 14:00 • QUANTUM COMMUNICATION

## Towards consumer-level quantum-secure cryptography using entanglement-based short-range quantum-key-distribution

Marco Arnds, Luca Graf, Ralf Riedinger

Universität Hamburg

Quantum key distribution (QKD), which generates a cryptographic key via a quantum channel, has paved the way for physically secure communication. Over the last decades, most efforts in developing QKD focused on long-distance implementations, which are costly and challenging due to exponential losses of photons in quantum channels. An alternative approach is hybrid cryptography, where key distribution occurs over short distances, followed by quantum-secure classical encryption over long distances. Initially, an information-theoretically secure Root-of-Trust is exchanged via a quantum channel, which is stored on two end modules. Afterwards, this Root-of-Trust can be employed to generate encryption keys through a classical rekeying algorithm. In this approach, it is possible to spatially separate the end modules and communicate over existing classical infrastructure, since no quantum channel is required after initialisation. We present a compact source for entangled photon pairs that enables short-range QKD. In future work, we aim to implement low-cost end modules based on semiconductor electronics for the detection scheme of the experimental setup.

## NOTES

THU 14:15 • QUANTUM OPTICS AND SPECTROSCOPY

# Decoding Quantum Mechanics Textbooks: A Roadmap for Learners, Researchers and Young Educators

Stefan Heusler, Yajie Liang

Quantum mechanics (QM) textbooks shape our foundational understanding as students, serve as our primary references as researchers, and guide our strategies as teaching assistants. But how well do these texts actually reflect the modern quantum landscape? This study analyzes the didactic structures of university-level QM textbooks across nations and eras by mapping the placement of mathematical formalisms, physical systems, and interpretations. We reveal distinct pedagogical priorities, identifying a historical shift from traditional “wave-first” and “spin-first” trajectories toward more diverse, concept-oriented approaches that better connect formalism with modern experiments and applications - such as those in quantum optics and modern quantum technology. By comparing these structures, we map out how different texts balance conceptual understanding with formal competence. Ultimately, we propose a practical roadmap tailored for early-career researchers: whether you are looking for the best resource to independently study a new quantum sub-field, seeking effective examples for your next TA tutorial, or simply curious about how our generation is being taught to think about quantum physics. Given the interactive nature of the Greenhorn Meeting, this presentation also aims to spark an open discussion about our shared experiences with quantum education and what we, as the next generation of researchers, need from future textbooks.

## NOTES

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