29th
Young Atom Opticians Conference

Strasbourg, France

June 30 - July 16 2024

hosted by CESQ, ISIS, Fondation Jean-Marie Lehn

Conference Booklet

Strasbourg, June 2024

Welcome to YAO2024 in Strasbourg!

The YAO conference is a well-established annual international meeting. It has been organized by students since 1995 in many different scientific institutions around Europe. It is the largest student conference in the field of atomic and molecular optics. The main goal of the YAO conference is to strengthen scientific exchange among young students in the field in order to create a strong international community. It aims to offer an optimal platform for participants to obtain a broad overview of the state-of-the-art research, to expand their network and establish new contacts around the world and, for many, it is also the first opportunity to show their own results and discuss them among peers.

This year YAO takes place at the Centre Européen de Sciences Quantiques (CESQ) at the University of Strasbourg for its 29th edition, from the 30th of June to the 5th of July. As the organizer's of this YAO edition, it is our pleasure to welcome you and wish for you a fulfilling experience!

With kind regards,

YAO Organizing Committee

Contact Organising Committee

- E-mail: yao.strasbourg2024@gmail.com
- Website: https://yao2024.eu

Organisers:

Manuel Morgado, Maximilian Müllenbach, Amar Bellahsene, Swayangdipta Bera, Matteo Bergonzoni, Tatiana Bespalova, Ruben Daraban, Clément Gradziel, Tanul Gupta, Dr. Anuja Padhye, Laura Pecorari and Vineesha Srivastava.

Scientific Advisory Committee:

Prof. Guido Pupillo, Prof. Guillaume Schull and Prof. Shannon Whitlock.

We thank Anna Guyon and Laurence Schmitt for the administrative support in organising the conference. We thank the Fondation Jean-Marie Lehn for co-organizing together with us.

Conference Venue

The conference will take place in the main lecture hall of Institut de Science et d'Ingénierie Supramoléculaires (ISIS) in Esplanade, which is a Mixed Research Unit (UMR 7006) of CNRS and Université de Strasbourg.

Institut de Science et d'Ingénierie Supramoléculaires,
8 Allée Gaspard Monge,
67000 Strasbourg,
France

Hotels

We split the number of participants equally into two hotels. One of them is City Résidence Strasbourg Centre (1 Rue des Magasins, twin studios), the other one is Séjours and Affaires Strasbourg Kleber (16 Rue Hannong, twin studios).

City Résidence Strasbourg Centre,
1 Rue des Magasins,
67000 Strasbourg,
France

Séjours and Affaires Strasbourg Kleber,
16 Rue Hannong,
67000 Strasbourg,
France

Bed and breakfast are included from Sunday night until Friday morning.

Moving around

Strasbourg is not a very large city and many destinations can be reached comfortably on foot, however public transport (trams and buses) may be useful. Tickets can be purchased at the vendor machines located at many of the stops, or alternatively on the CTS Transports Strasbourg app. A single ticket costs 1,90€ and allows you to use both buses and trams for 1 hour after purchase, connections are authorised within that time range. Carnets of 10 single tickets are also available for 17,10€.

Airport - City centre:

The Strasbourg-Entzheim (SXB) airport is served up to 5 times an hour by a shuttle train, linking it to Strasbourg train station (Gare Centrale) in just 8 minutes, the cost of the TER ticket is 3,10€. A 4,90€ ticket is also available in which, in addition to the TER ticket, a single CTS ticket (for tram and buses in the city) is also included. The tram/bus ticket can be used within 1h30 after purchase. Both the two tickets can be purchased at the vendor machines. Then the station is about a 10 minutes walk away from the hotels, and 20 minute away from ISIS (the main lecture hall) by tramway (C line).

Hotel - ISIS:

From the hotel City Résidence Strasbourg Centre there is 30-40 minutes walk to ISIS (the main lecture hall) or 20 minutes by tram C (from Gare Centale to Université), other options are 2 or C9 buses. From the hotel Séjours and Affaires Strasbourg Kleber there is 20-30 minutes walk to ISIS (the main lecture hall) or 15 minutes by tram C or F (from Homme de Fer to Université).

Lunch restaurant - ISIS:
The Restaurant Universitaire de l'Esplanade (the lunch place) is less then 5 minutes walk away from ISIS (the main lecture hall).

You can find a map with the main locations of this conference at this link: map.

Social Activities

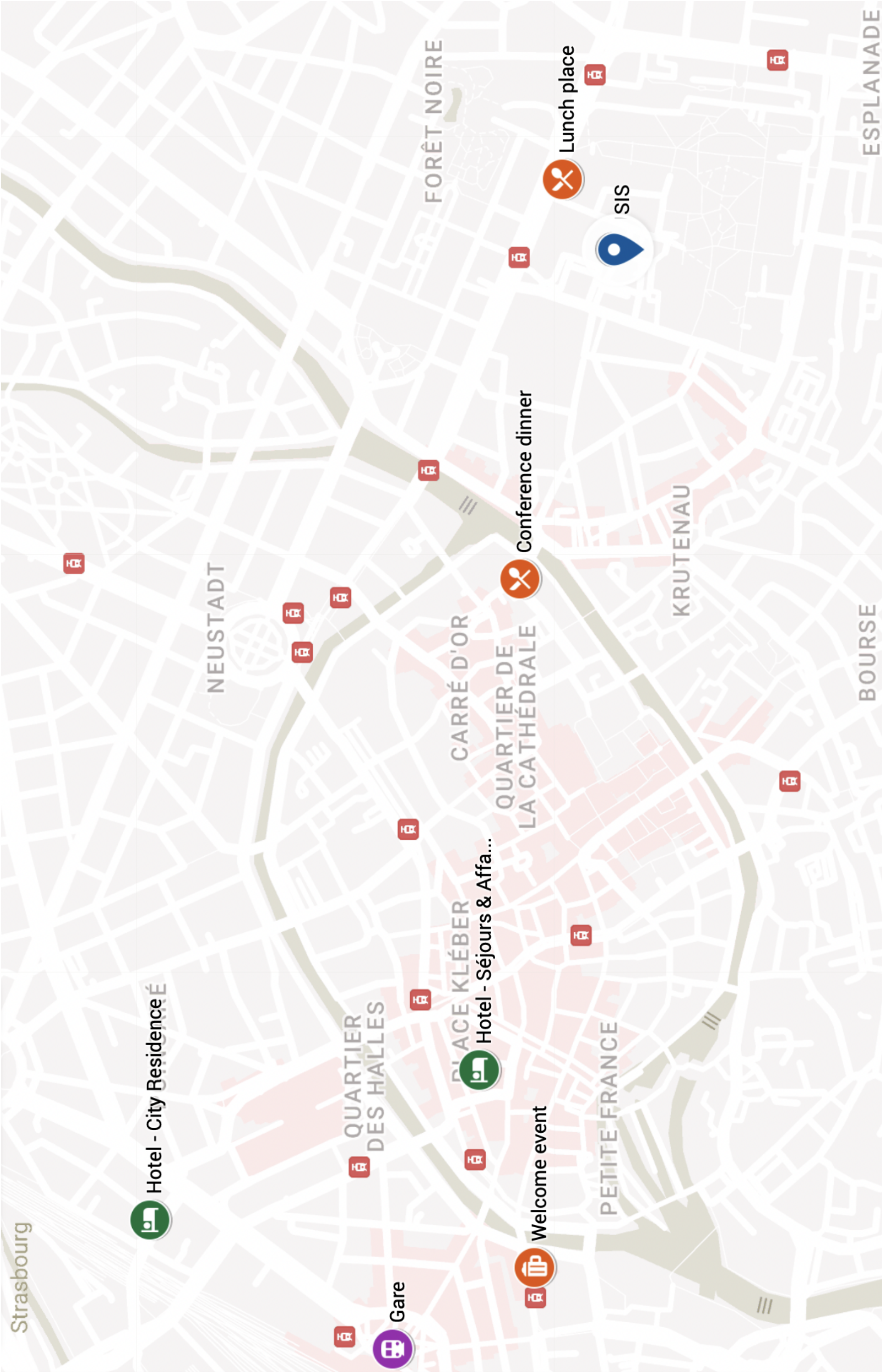
We prepared for you a range of non-scientific activities whose sole purpose is to make you socialize within and beyond the scientific context. Some people call it networking, but we think of it more as just having a fun time.

***Welcome event*:** On Sunday evening starting at 18 o'clock, we will welcome you in the historical brasserie Le Tigre (5 Rue du Faubourg National, 67000 Strasbourg). After registration, you will be able to meet and get to know eachother while enjoying varied foods (including tartes flambées) and Alsatian beers or wine.

***Boat Tour, European Parliament and Picnic*:** On Thursday July 4th, after the the lunch break, we will meet at the Embarcadère BATORAMA (Pl. du Marché aux Poissons, 67000 Strasbourg) just in front of Palais Rohan, by the Cathedral in the city center. The meeting time is 14:00 at Embarcadère. Here we will board a boat that will allow us to discover the beautiful city of Strasbourg from a unique perspective and learn more about its history. After a tour around the city island, we will then make our way up to one of the most famous buildings of Strasbourg: the European Parliament (about one hour for the total trip). Once landed, you can choose to visit the European Parliament, where an English group tour is reserved for the YAO participants, or spend some free time at the nearby Parc de l'Orangerie, where several activities will be waiting for you (music, beers, games...). Remember: if you choose to visit the European Parliament, bring a valid ID document with you!

***Conference Dinner*:** For the conference dinner, we'll do a deep dive into Alsatian cuisine. It will be held at Au Brasseur (22 Rue des Veaux, 67000 Strasbourg), a traditional restaurant still brewing their own beer, in the historic city center. We will meet there on Thursday at 19:00.

	June 30th	July 1st	July 2nd	July 3rd	July 4th	July 5th
	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
8:45:00		Welcome				
9:00:00		**Antoine Browaeys**	**Stuart Adams**	**Elisa Ercolessi**	**Christiane Koch**	**Katharina Kaiser**
9:30:00						
10:00:00		Coffee Break	Coffee Break	Coffee Break	Coffee Break	Coffee Break
10:30:00					Optimal Control	
11:00:00		Quantum Simulation	Rydberg Physics	Quantum Computing and Simulation Methods	Quantum Gas Microscopy	Cold Molecules and Hybrid Systems
11:30:00					Sponsor Talk: IonQ	
12:00:00						Farewell
12:30:00		Lunch	Lunch	Lunch	Lunch	
13:00:00						
13:30:00		**Giovanni Modugno**	Sponsor Talk: Q.ANT	**Patrick Maletinsky**		Lab Tours and Lunch
14:00:00			Ultracold Fermions			
14:30:00		Coffee Break	Coffee Break	Coffee Break		
15:00:00			Atom Interferomety			
15:30:00		Bose-Einstein Condensates		Quantum Technologies		
16:00:00					Social event & Free Time	
16:30:00			Cavities			
17:00:00		Poster Session I		Poster Session II		
17:30:00						
18:00:00						
18:30:00						
19:00:00	Welcome Event & Registration					
19:30:00					Conference Dinner	
20:00:00						
...						


Strasbourg
Hotel - City Residence
Gare
QUARTIER DES HALLES
PLACE KLÉBER
Hotel - Séjours & Affa...
Welcome event
PETITE FRANCE
NEUSTADT
CARRÉ D'OR
QUARTIER DE LA CATHÉDRALE
Conference dinner
KRUTENAU
BOURSE
FORÊT NOIRE
Lunch place
SIS
ESPLANADE

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Conference Schedule

Monday, 1 July

8:45 **Welcome**, Conference Venue: ISIS, 8 Allée Gaspard Monge

9:00 **Invited Speaker:**
Many-body physics with arrays of individual atoms and optical dipoles
Antoine Browaeys, Institut d'Optique, CNRS, France

10:00 **Coffee Break**

10:30 **Session - Quantum simulation**

Dipolar XY magnetism in a two-dimensional Rydberg atom array
Bastien Gély, Laboratoire Charles Fabry, Institut d'Optique Graduate School, Palaiseau, France

Experimental Observation of Quantum Criticality in a 4D Quantum Disordered System
Farid Madani, PhLAM (Laboratoire de Physique des Lasers, Atomes et Molécules)

Ground-state cooling of Yb atoms in hybrid lattice-tweezer quantum simulator
Leonardo Bezzo, Ludwig-Maximilians Universität München

Direct laser cooling of Rydberg atoms with an isolated-core transition
Alisée Bouillon, UCLouvain

Interacting Laser-Trapped Circular Rydberg Atoms for Quantum Simulation
Aurore Young, Laboratoire Kastler Brossel

Highly Scalable Quantum Processing Architecture using Neutral Atom Arrays in a Microlens-based Integration
Lukas Sturm, TU Darmstadt

12:00 **Lunch Break at Restaurant Universitaire de l'Esplanade**

13:30 **Invited Speaker:**
Exploring the supersolid phase of matter with dipolar quantum gases
Giovanni Modugno, LENS, Università di Firenze, Italy

14:30 **Coffee Break**

15:00 **Session - BEC**

Towards superfluids and supersolids in a ring
Niccolò Preti, Università degli studi di Firenze

Observation of superthermal correlations at the Superfluid to Mott transition with ultracold bosons
Géraud Dupuy, Laboratoire Charles Fabry

Observation of vortices in a dipolar supersolid
Eva Casotti, University of Innsbruck, IQOQI

Loss features in ultracold 162Dy gases : pairwise versus three-body processes
Maxime Lecomte, Laboratoire Kastler-Brossel, ENS-PSL, Collège de France

Active magnetic field stabilization for cold atom spin mixture experiments
Sara Tiengo, Institut d'Optique, Palaiseau, France

Measurement of the excitation spectrum of a recoil-resolved atom-cavity system at the boundary between the normal and self-organized phases
Anton Bölian, Universität Hamburg

16:30 **Poster Session I**

Tuesday, 2 July

9:00 **Invited Speaker:**
From atom optics to Rydberg quantum optics
Stuart Adams, Durham University, England

10:00 **Coffee Break**

10:30 **Session - Rydberg Physics**

Rydberg Blockade in Atomic Arrays
Felix Russo, TU Wien

Strong photon-photon interactions mediated by Rydberg polaritons in ultracold Ytterbium gases
Florian Pausewang, University Bonn

From one to two superatoms in an optical cavity
Antoine Covolo, Collège de France

Characterization of a state-insensitive optical trap for long coherence time of Rydberg superatoms
Jan de Haan, Institute of Applied Physics, University of Bonn

Multiparameter quantum sensing with a hybrid rf-dc optically pumped magnetometer at Earth's magnetic field
Diana Méndez Avalos, ICFO

Room Temperature Quantum Memory for light using the Atomic Frequency Comb protocol
Zakary Schofield, University of Southampton

12:00 **Lunch Break at Restaurant Universitaire de l'Esplanade**

13:30 **Sponsored talks** Industry Partner: Q.ANT (Company introduction and current research)

14:00 **Session - Ultracold Fermions**

Cooling of fermionic Lithium in a 2D optical lattice
Luca Muscarella, Max Planck Institute of Quantum Optics

Self-organisation dynamics in strongly interacting ultracold fermions
Gaia Stella Bolognini, IEcole Polytechnique Fédérale de Lausanne

14:30 **Coffee Break**

15:00 **Session - Atom Interferometry**

Multi- species cold atom interferometry for inertial measurements
Mal Landru, ONERA DPHY - SLM

Dark energy search using atom interferometry in the Einstein-Elevator
Magdalena Misslisch, Institut fur Quantenoptik, Hannover

High-performance two axis cold-atom gyroscope for rotational seismology
Nathan Marliere, LNE-SYRTE

Optimal Floquet Engineering for Large Scale Atom Interferometers
Léo Calmels, Laboratoire Collisions Agrégats Réactivité (LCAR), Université Toulouse III Paul Sabatier, Toulouse, France

16:00 **Session - Cavities**

Standard quantum limits for cavity-enhanced optical readout methods of hot atomic vapor quantum sensors
Hana Medhat, ICFO

Cavity-based non-destructive detection in ultracold gases
Gokul Vengillasery Illam, Raman Research Institute

An Optical Cavity-Atom Array System for Quantum Computing
Michelle Chong, Massachusetts Institute of Technology

A cavity-microscope for micrometer-scale control of atom-photon interactions
Ekaterina Fedotova, EPFL

Wednesday, 3 July

9:00 **Invited Speaker:**
Hybrid Variational Algorithms on a neutral atom platform
Elisa Ercolessi, University of Bologna, Italy

10:00 **Coffee Break**

10:30 **Session - Quantum computing**

Few-body Forster resonances in Rydberg atoms for quantum gate protocols
Ivan Ashkarin, Université Paris-Saclay, CNRS, Laboratoire Aimé Cotton, 91405 Orsay, France

Optimisation of weighted graphs using neutral atom arrays
Max Wells-Pestell, University of Strathclyde, Glasgow

Cryogenic strontium quantum processor
Valerio Amico, University of Tübingen

11:15 **Session - Numerical Methods and Simulations**

Continuous Coherent Quantum Feedback with Time Delays: Tensor Network Solution
Kseniia Vodenkova, University of Innsbruck

Lissajous figures in a quantum walk on a lattice
Grzegorz Jaczewski, University of Warsaw

Finite-temperature Rydberg atom systems: quantum phases and entanglement characterization
Nora Reinić, University of Padova, INFN Padova

12:00 **Lunch Break at Restaurant Universitaire de l'Esplanade**

13:30 **Invited Speaker:**
Photophysics and quantum optics of solid-state quantum sensors
Patrick Maletinsky, Universität Basel, Switzerland

14:30 **Coffee Break**

15:00 **Session - Quantum Technologies**

Strongly Interacting Photons in 2D Waveguide QED
Matija Tečer, University of Padua

Development of a transportable optical cavity for a portable trapped ion atomic clock
Rishabh Pal, Indian Institute of Technology Tirupati

Manufacturing Q-optimized polymer-based mechanical resonators for cavity optomechanics with 3D-direct laser writing
Daniel Stachanow, University of Bonn

Enabling atomic systems with fully integrated photonics from UV to IR
Sophie Cavallini, ETH Zurich

Shallow, optically coherent SiV centers in diamond nanopillars for quantum sensing
Marina Obramenko, University of Basel

Characterizing single photon from an atom array via optical fiber
Yuya Maeda, Osaka university

Thursday, 4 July

9:00 **Invited Speaker:**
Training Schrödinger's Cat: Quantum Control in Molecular Physics and Quantum Information Science
Christiane Koch, Freie Universität Berlin, Germany

10:00 **Coffee Break**

10:30 **Session - Optimal Control**

Fast and robust cat state preparation utilizing higher order nonlinearities
Suocheng Zhao, IIQMT, KIT

Optimal control of quantum systems: Applications to the control of Bose-Einstein Condensates
Etienne Dionis, Laboratoire Interdisciplinaire Carnot de Bourgogne

11:00 **Session - Quantum Gas Microscopy**

A strontium quantum-gas microscope
Carlos Gas Ferrer, ICFO

Towards a quantum gas microscope with programmable lattices
Sarah Jane Waddington, TU Wien

11:30 **Sponsored talks** Industry Partner: IonQ (Company introduction and current research)

12:00 **Lunch Break at Restaurant Universitaire de l'Esplanade**

13:30 **Social Event and Free Time** Batorama tour, European Parliament and picnic at Parc de l'Orangerie

19:30 **Conference Dinner** Au Brasseur, 22 Rue des Veaux

Friday, 5 July

9:00 **Invited Speaker:**
Optoelectronics on the atomic scale – what we can learn from STM on single molecules
Katharina Kaiser, Unversität Göttingen, Germany

10:00 **Coffee Break**

10:30 **Session - Molecules**

Compact high-precision microwave spectrometer based on FID measurements

Hemanth Dinesan, CNRS, Laboratoire de Physique des Lasers, Universite Sorbonne Paris Nord and CNRS, Laboratoire Aime Cotton, France

Experiments with ultracold atoms and molecules

Lukas Leczek, TU Wien

Ultracold molecules: how not to lose them - A step towards larger molecular quantum computers

Etienne Walraven, IMM, Radboud University

11:15 **Session - Hybrid Systems**

Vibrationally coupled Rydberg atom-ion molecules

Ilango Maran, Universiteit van Amsterdam

Trapped ions in optical tweezers

Nella Diepeveen, University of Amsterdam

Interfacing Rydberg atoms with an electromechanical oscillator in a cryostat

Julia Gamper, University of Bonn

12:00 **Farewell** Closing remarks

12:30 **Lab tours** At the laboratory of CESQ and IPCMS on the Cronenbourg Campus. Lunch is included.

Talks

The following chapter contains all the invited and contributed talks.

Links linking back either to the Table fo Content or to the long abstracts are provided in red.

Invited Speaker: Antoine Browaeys

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Many-body physics with arrays of individual atoms and optical dipoles

Antoine Browaeys - Laboratoire Charles Fabry, Institut d'Optique, CNRS, 2 avenue A. Fresnel, 91127 Palaiseau, France

This talk will present our recent work on the control of interactions between cold atoms to implement spin Hamiltonians useful for quantum simulation of many-body problems, or quantum optics situations. We rely on laser-cooled atomic ensembles of Rb, consisting either of individual atoms in tweezer arrays, or dense elongated atomic gases.
By exciting arrays of up to 100 atoms into Rydberg states, we make the atoms interact by the resonant dipole interaction. The system implements the XY spin ½ model, which exhibits various magnetic orders depending on the ferromagnetic or antiferromagnetic nature of the interaction. When the system is placed out of equilibrium, the interactions generate scalable spin squeezing. Analyzing the spread of correlations across the system, we measure the dispersion relation and observe the predicted anomalous behavior in the ferromagnetic case, a consequence of the dipolar interactions.
Using an elongated dense atomic ensemble driven on an optical transition, we rely on the collective coupling of many atoms to a single mode of the electromagnetic field to observe driven superradiance and demonstrate the generation of non-classical light.

Antoine Browaeys is an experimental physicist at the Laboratoire Charles Fabry , leading the group "Optique quantique – Atomes" and he is specialised in the laser manipulation of atoms. He received his Ph.D in 2000 at the Université Paris-Sud, now the Université Paris-Saclay (Charles Fabry Laboratory). In 2003 he joined CNRS - Research Fellow at the Charles Fabry Laboratory. In 2007 he received the Aimé Cotton Prize from the French Physical Society. In 2013 he became Research Director at the Charles Fabry Laboratory and in 2019 he co-found the start-up Pasqal.

Talks: Quantum Simulation

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Dipolar XY magnetism in a two-dimensional Rydberg atom array 10:30

Bastien Gély, *Laboratoire Charles Fabry, Institut d'Optique Graduate School, Palaiseau, France*

Quantum simulation of interacting many-body spin Hamiltonians with Rydberg atom array and construction of a new experiment.

Quantum simulation, Rydberg, Atomic array

Experimental Observation of Quantum Criticality in a 4D Quantum Disordered System 10:45

Farid Madani, *PhLAM (Laboratoire de Physique des Lasers, Atomes et Molécules)*

Anderson metal-insulator transition is one of the few known phenomena that maintain their non-mean-field character in high dimensions, posing great challenges for traditional theoretical approaches. In this work, engineering synthetic dimensions in an ultracold atoms experiment, we observe the Anderson transition in 4D and probe its critical behavior. We measure the critical exponents, which are in agreement with Wegner's scaling law, and confirm the non-mean-field character of the transition.

Ultracold Atoms, Bose-Einstein Condensate, Quantum Simulation, Anderson Transition, Quantum Phase Transition

Ground-state cooling of Yb atoms in hybrid lattice-tweezer quantum simulator 11:00

Leonardo Bezzo, *Ludwig-Maximilians Universität München*

Quantum gas microscopes offer crucial insights into quantum many-body systems, essential for validating theoretical models and exploring new phases of matter. Achieving the ground state, together with large, tunable tunnelling rates are key challenges, traditionally addressed through evaporative cooling and adiabatic loading in optical lattices, which lack the flexible and precise control over atoms offered by tweezers. By combining optical lattice and tweezer technologies, alongside novel state-dependent control methods, a hybrid quantum simulator is being developed using Yb atoms, promising alternative routes for simulating complex Hubbard-type models.

Quantum Simulation, Optical Lattice, Optical Tweezers, Ytterbium

Direct laser cooling of Rydberg atoms with an isolated-core transition

11:15

Alisée Bouillon, *UCLouvain*

We present a scheme to directly laser cool alkaline-earth metal Rydberg atoms, using an isolated-core transition. We show that, while the presence of the Rydberg electron complexifies the energy-level structure of the ion core compared to the isolated-ion case, a closed cooling cycle can be found and laser cooling achieved. The effects of a small magnetic field on the population dynamics are also detailed.

Rydberg physics, Cold atoms, Cold gases, Alkaline-earth atoms

Interacting Laser-Trapped Circular Rydberg Atoms for Quantum Simulation

11:30

Aurore Young, *Laboratoire Kastler Brossel*

Circular Rydberg atoms, atoms with maximal orbital momentum, have a natural lifetime 100 times longer than Rydberg atoms, which makes them well suited to the quantum simulation of the dynamics of interacting quantum systems. To benefit from it, we trap them in individual optical bottle beams, characterize their interactions and demonstrate the expected coupling between spin and motional degrees of freedom in a Rydberg-atom system.

Circular Rydberg atom, Quantum simulations

Highly Scalable Quantum Processing Architecture using Neutral Atom Arrays in a Microlens-based Integration

11:45

Lukas Sturm, *TU Darmstadt*

Tweezer arrays of neutral atoms provide a versatile platform for quantum information technologies. We realize an architecture with 3000 qubit sites and more than 1000 atomic qubits. Supercharging the array with reservoir atoms increases the initial filling fraction, enabling defect-free assembly of up to 441 qubits. Addressing atom loss, we implement a modular scheme that facilitates continuous operation. The presented results on highly scalable quantum arrays foster future advances in quantum science with tweezer arrays.

Optical Tweezer Arrays, Continuous Operation , Scalability, 1000 Atomic Qubits

Invited Speaker: Giovanni Modugno

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Exploring the supersolid phase of matter with dipolar quantum gases

Giovanni Modugno - LENS and Dipartimento di Fisica e Astronomia, Università di Firenze, and CNR-INO, Pisa

Supersolids are a fundamental quantum phase of matter combining properties of crystals and of superfluids. A supersolid phase was recently discovered in Bose-Einstein condensates of strongly magnetic atoms. I will discuss the exceptional properties of dipolar supersolids, spanning from double symmetry breaking to mixed superfluid and classical dynamics. I will in particular show how a supersolid can behave as a self-induced Josephson junction array, and how it is possible to deduce from the Josephson dynamics the superfluid fraction, which is the universal property quantifying the deviation of supersolids from both crystals and superfluids.

Monday

Giovanni Modugno has been conducting experimental research since 1999 aimed at studying fundamental physics phenomena with ultracold quantum gases. He has conducted frontier experiments in the fields of quantum mixtures, quantum transport, quantum disordered systems and quantum few-body phenomena. He received his Ph.D. in Physics with honours at the Scuola Normale Superiore in Pisa in 1999. In 1999 he became a Research Fellow and TD Researcher at the LENS laboratory of the University of Florence and CNR. In 2005 he become Associate Professor of Physics of Matter at the Department of Physics and Astronomy, University of Florence and from 2022 he is a Full Professor of Physics of Matter at the Department of Physics and Astronomy, University of Florence.

Talks: BEC

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Towards superfluids and supersolids in a ring 15:00

Niccolò Preti, *Università degli studi di Firenze*

I will report on an ongoing experiment regarding the superfluid nature of the supersolid. Our aim is to trap the supersolid in an optical potential shaped as a ring. Moving from the supersolid to a standard superfluid through a reversible quantum phase transition, we will be able to test for the first time the seminal theory by the Nobel laureate A. Leggett.

Supersolids, Superfluids, Dysprosium

Observation of superthermal correlations at the Superfluid to Mott transition with ultracold bosons 15:15

Géraud Dupuy, *Laboratoire Charles Fabry*

To accurately describe strongly-correlated quantum systems, one needs to account for the non-trivial correlations induced by interactions between individual particules. Our experiment aims to observe such correlations in momentum with an original electronic detection device using metastable ultracold helium-4. Here we report our observation of many-body correlation function becoming super-thermal at the Mott transition, suggesting the presence of non-gaussian correlations.

Ultracold atoms, Strongly-correlated systems, Non-Gaussian correlations

Observation of vortices in a dipolar supersolid 15:30

Eva Casotti, *University of Innsbruck/IQOQI*

We report on the theoretical study and experimental observation of vortices in a dipolar supersolid, an exotic phase of matter that spontaneously breaks two simmetries: phase and translational invariance. Our observations, revealing a fundamental difference between modulated and unmodulated quantum matter, open the way to study the peculiar properties of vortices in supersolids and further applications to the study of other systems with multiple broken simmetry, such as neutron stars.

Dipolar gases, Supersolidity, Vortices

Loss features in ultracold 162Dy gases : pairwise versus three-body processes 15:45

Maxime Lecomte, *Laboratoire Kastler-Brossel, ENS-PSL, Collège de France*

In (ultra)cold atomic gases experiments, Fano-Feshbach resonances turned out to be a major tool to tune the interactions between particles. Understanding their nature and properties allow a better control of such dilute systems. We investigated low-field Fano-Feshbach resonances in a dipolar gas, whose interactions are long-range and anisotropic.

Fano-Feshbach resonances, Pairwise, Three-body processes, Dipolar gas.

Active magnetic field stabilization for cold atom spin mixture experiments. 16:00

Sara Tiengo, *Institut d'Optique, Palaiseau, France*

The popularity of Feshbach resonances as a tool for manipulating atomic interaction strength has led to an increasing demand for generating large and highly stable magnetic fields. Our experiment, concerning the study of effective three-body interactions in radio-frequency coupled spin mixtures, requires magnetic field stability at the ppm-level. We propose an easy-to-implement active feedback method to stabilize the magnetic field, which has been proved via Ramsey spectroscopy on the K39 magnetic sub-levels to stabilize a magnetic field of 57 G with a rms noise reduced 2.5 ppm.

Magnetic field stabilization, Feedback loop circuit, Coupled spin-mixtures

Measurement of the excitation spectrum of a recoil-resolved atom-cavity system at the boundary between the normal and self-organized phases 16:15

Anton Bölian, *Universität Hamburg*

We study the exciation spectrum of a transversely pumped Bose- Einstein-condensate coupled to a single mode of a recoil-resolved cavity. We measure the softening of the lowest polariton mode induced by the external pump, and observe the emergence of an excitation gap when measuring with a pump near detuned to the cavity resonance, caused by the significant contribution of the long-lived cavity field to the polariton mode.

Cavity QED, Quantum phase transition, Bosonic quantum gases

Invited Speaker: Stuart Adams

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From atom optics to Rydberg quantum optics

C. Stuart Adams - Durham University, England

Three decades ago when the Young Atom Optics conference series began, atom optics, the control of atomic centre-of-mass was an emerging field [1]. In those three decades we have seen remarkable progress including developments such as Bose-Einstein condensation and optical tweezing of individual atoms. In this talk, I will focus on another unforeseen development, the flourishing of atomic and optical physics exploiting highly-excited Rydberg states [2]. In addition to the strong-switchable interactions that are useful for quantum simulation and quantum computation, Rydberg atoms allow us to connect six orders of magnitude in the electromagnetic spectrum [3]. For example, terahertz-to-optical conversion using Rydberg atoms enables fast imaging in the terahertz region for the first time [4]. The strong interactions between Rydberg atoms also have implication for sensing [5], and result in rich dynamics such as synchronisation [6].

[1] CS Adams, M Sigel and J Mlynek, *Phys Rep* **240**,143 (1994).

[2] CS Adams, JD Pritchard and J Shaffer, *J Phys B* **53**, 012002 (2019).

[3] G Allinson et al., arXiv:2311.11935, Phys Rev Res accepted (2024).

[4] L Downes et al., *Phys Rev X* **10**, 011027 (2020).

[5] DS Ding et al., *Nature Phys* **18**, 1447 (2022).

[6] K Wadenpfuhl and CS Adams, *Phys Rev Lett* **131**, 143002 (2023).

Charles Stuart Adams studied Physics at Hertford College, Oxford University, he obtained a Masters by Research from McMaster University in Canada followed by a PhD from Strathclyde University in Glasgow. After post doctoral work in Germany and the US, he began a research group at Durham in October 1995. His main interests are in experimental quantum optics, in particular light-matter interactions in strongly-interacting atomic systems. He was awarded the Thomson medal by the IOP in 2014 and the Holweck Prize by the French Physical Society and IOP in 2020 for pioneering work on quantum optics.

Tuesday

Talks: Rydberg Physics

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Rydberg Blockade in Atomic Arrays 10:30

Felix Russo, *TU Wien*

Subwavelength atomic arrays have emerged as a versatile platform for realizing strong light-matter coupling. I will discuss their potential to create quantum states of light via the Rydberg-blockade mechanism. Understanding the nonlinear dynamics of atomic Rydberg arrays is crucial for realizing their promising prospects, e.g., in photonic quantum information processing.

Rydberg blockade, Atomic arrays, Quantum nonlinear optics

Strong photon-photon interactions mediated by Rydberg polaritons in ultracold Ytterbium gases 10:45

Florian Pausewang, *University Bonn*

I present the progress towards the demonstration of strong interaction between photons, mediated by Yb-174 Rydberg excitations formed in a 1D ultracold Ytterbium gas. Our experimental apparatus has a two-chamber design featuring dispensers and a 2D MOT providing transversally cooled Yb atoms and a two-color 3D MOT and a dipole trap in the science chamber. Using a 2-photon excitation EIT scheme the interaction strength for Rydberg s-states in dissipative and attractive interaction regimes can be quantified.

Rydberg polaritons, Ytterbium, Two-color MOT

From one to two superatoms in an optical cavity 11:00

Antoine Covolo, *Collège de France*

For quantum simulations and computing, scalability in optics relies on deterministic photon gates. Our system utilizes a small atomic cloud within a cavity, driven to a Rydberg state, acting as a collective superatom. With 60% efficiency, we achieve deterministic preparation of non-Gaussian Wigner-negative optical quantum states. Expanding our setup, we incorporate an additional atomic cloud, laying the groundwork for advanced protocols and quantum optics applications.

Collective excitation, Rydberg, Optical cavity

Characterization of a state-insensitive optical trap for long coherence time of Rydberg superatoms 11:15

Jan de Haan, *Institute of Applied Physics, University of Bonn*

To increase the coherence time of Rydberg superatoms in our setup by reducing the motion of the constituent atoms and by reducing differential light shifts due to the confining trap, we have implemented a 1D-lattice state-insensitive optical trap for ground and Rydberg states. For different trap geometries, I present measurements of wavelengths giving the best coherence time in a photon storage experiment, and compare them to spectroscopic measurements of magic wavelengths.

Magic wavelength trap, Rydberg superatoms, Ponderomotive potential

Multiparameter quantum sensing with a hybrid rf-dc optically pumped magnetometer at Earth's magnetic field 11:30

Diana Méndez Avalos, *ICFO*

We describe a hybrid optically pumped magnetometer (hOPM) that simultanously measures the dc magnetic field and one quadrature of the rf magnetic field, operating around Earth's magnetic field with only one atomic spin ensemble. We demonstrate sub$-pT/Hz^{1/2}$ quantum-noise-limited sensitivity, for frequency and amplitude modulation schemes.

Magnetometers, Metrology, OPM, Multiparaneter estimation

Room Temperature Quantum Memory for light using the Atomic Frequency Comb protocol 11:45

Zakary Schofield, *University of Southampton*

Quantum memories are devices that allow for the on-demand storage and retrieval of photonic quantum information. The Atomic Frequency Comb (AFC) protocol is a rephasing memory based on the spectral shaping of an inhomogenoulsy broadened transition into a frequency comb with periodic spacing Δ. This is demonstrated with short pulses of light attenuated to the single photon level in warm Rubidium vapour with a storage time of 7.5ns and an efficiency of 9%.

Quantum Memory, Warm Rubidium Vapour, Frequency Comb

Talks: Ultracold Fermions

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Cooling of fermionic Lithium in a 2D optical lattice 14:00

Luca Muscarella, *Max Planck Institute of Quantum Optics*

We present our advancements towards achieving Raman cooling of Fermionic Lithium confined in a 2D optical lattice. Following trapping in a MOT, we proceed to direct loading into the lattice and we employ Raman cooling to drive the atoms into their motional ground state. In the future we aim to load this sample into a superlattice that we intend to use as a hybrid digital/analog quantum processor.

Laser cooling, Optical lattice, Lithium

Self-organisation dynamics in strongly interacting ultracold fermions 14:15

Gaia Stella Bolognini, *Ecole Polytechnique Fédérale de Lausanne*

The talk presents an experimental setup which combines a degenerate Fermi gas of 6Li with a high-finesse optical resonator, providing full control over both short and long range interparticle interactions. We study the dynamics of the superradiant phase transition which emerges upon driving the system from the side, for which the atoms self-organise into a crystalline structure. A universal response is observed, suggesting the existence of a new universality class emerging in far-from-equilibrium, strongly interacting systems.

Ultracold fermions, Cavity-Quantum Electrodynamics, Light induced Phase transitions

Talks: Atom Interferometry

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Multi- species cold atom interferometry for inertial measurements 15:00

Mal Landru, *ONERA DPHY - SLM*

Cold atom interferometry based on a single atomic species (usually Rubidium) can give rise to very stable and absolute gravity sensors, but this technology suffers from dead times and a limited measurement range. However, manipulating 3 atomic species instead of 1 reveals new potential of cold atom gravimeters. A triple-species gravimeter (Rb85, Rb87 and Cs133) could present fewer dead times and a better measurement range, or could even enable simultaneous 3D acceleration measurements.

Cold atoms, Atom Interferometry, Inertial sensor, Multi-species

Dark energy search using atom interferometry in the Einstein-Elevator 15:15

Magdalena Misslisch, *Leibniz Universitat Hannover*

Dark Energy Search using Interferometry in the Einstein-Elevator (DESIRE) studies the chameleon field model for dark energy using Bose-Einstein Condensate of 87-Rb atoms as a source in a microgravity environment. Multi-loop atom interferometry is used to search for phase contributions induced by chameleon scalar fields with a specially designed test mass that suppresses gravitational effects from self-mass and its environment.

Atom interferometry, Dark energy search, BEC, Microgravity

High-performance two axis cold-atom gyroscope for rotational seismology 15:30

Nathan Marliere, *LNE-SYRTE*

The SYRTE cold-atom gyroscope represents the state-of-the-art in atomic gyroscopes. Using atomic interferometry, it achieves measurements of the Sagnac effect with exceptional sensitivity and stability. I will present our recent work on enhancing sensitivity through no dead-time sequences, enabled by double diffraction. This aims to minimize noise and improve performance, ultimately reaching standard quantum projection noise levels.

Atomic Inferometry, Gyroscope, Sagnac effect

Optimal Floquet Engineering for Large Scale Atom Interferometers

15:45

Léo Calmels, *Laboratoire Collisions Agrégats Réactivité (LCAR), Université Toulouse III Paul Sabatier, Toulouse, France*

Atom interferometry is a very promising tool for metrology and exploration of quantum physics at the macroscopic scale, but requires highly efficient atom manipulations processes. We present a new method, based on Floquet's theory, for accelerating atoms in an optical lattice, resulting in the largest momentum transfer ever achieved in atom interferometry so far.

Atom interferometry, Large momentum transfer, Floquet engineering

Talks: Cavities

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Standard quantum limits for cavity-enhanced optical readout methods of hot atomic vapor quantum sensors 16:00

Hana Medhat, *Institut de Ciències Fotòniques (ICFO)*

We derive the standard quantum noise limits of different optical readout techniques for monitoring the collective spin variables of a hot atomic ensemble with high number density placed inside a resonant cavity structure. The techniques included in our analysis are Homodyne and Heterodyne interferometric readout methods as well as the Pound-Drever-Hall readout method.

Cavity-Enhancement, Optical readout methods, Standard quantum noise limits

Cavity-based non-destructive detection in ultracold gases 16:15

Gokul Vengillasery Illam, *Raman Research Institute*

To demonstrate rapid, continuous cavity-based measurement, we experimentally measure time evolution in a multilevel system and show the potential of cavity-based measurements for state detection, even when there are many participating energy levels. To illustrate the range of applications of the cavity-based detection scheme, we also use the cavity to detect photoassociation in a dark MOT where a direct fluorescence measurement is not possible and use this to determine PA rates in the system.

Cavity QED, Quantum optics, Non-destructive detection

An Optical Cavity-Atom Array System for Quantum Computing 16:30

Michelle Chong, *Massachusetts Institute of Technology*

Atom arrays are a promising platform for quantum computing but it will be difficult to scale system size using the standard readout technique of fluorescence imaging. We present cavity-mediated readout as a scalable alternative. We present progress on error detection and correction of an atom array using an optical cavity.

Optical cavity, Atom array, Quantum computing

A cavity-microscope for micrometer-scale control of atom-photon interactions 16:45

Ekaterina Fedotova, *EPFL*

We present our cavity-microscope device allowing for spatio-temporal programming of the light-matter coupling of atoms in a high finesse cavity, which provides a spatial resolution an order-of-magnitude lower than the mode waist. We illustrate this capability by engineering micrometer-scale coupling, using cavity-assisted atomic measurements and optimization. This technique opens a wide range of perspectives from ultra-fast, cavity-enhanced readout to the quantum simulation of quantum matter.

QED, microscope, aberration correction, SYK

Invited Speaker: Elisa Ercolessi

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Hybrid Variational Algorithms on a neutral atom platform

Elisa Ercolessi - University of Bologna, Italy

Quantum Computing is seen as a potential breakthrough for the study of hard classical problems as well as for quantum many body systems. However, we are in the era of NISQ devices and still far away from fault-tolerant machines.
This leads us to consider the possibility of hybrid classical-quantum protocols of variational type: they exploit quantum resources to efficiently prepare states that depend on a suitable chosen set of variational parameters, which can then be determined by means of optimization algorithms to be run on a classical computer. The choice of such classical optimizer schemes is to be guided by compatibility requirements with respect to current available quantum platforms.
To evaluate the feasibility of such an approach, we present an application of the Quantum Approximate Optimization Algorithm to a typical classical hard combinatorial problem, that has been emulated and tested on the Rydberg atom quantum machine Fresnel of Pasqal.

Elisa Ercolessi is an Associate professor of Theoretical Physics, Models and Mathematical Methods at the Department of Physics and Astronomy since 2005. After the Laurea Degree in Physics at the University of Bologna, she obtained the PhD in Physics at Syracuse University (NY, USA). Her research develops in the field of quantum statistical mechanics, working with several national and international groups, focussing mainly on models for many body systems in low-dimensions, which exhibit topological and exotic phases of matter, and on quantum information and computation theory. Author of more than 80 papers in international journals and of 3 books.

Talks: Quantum Computing

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Few-body F¨orster resonances in Rydberg atoms for quantum gate protocols 10:30

Ivan Ashkarin, *Université Paris-Saclay, CNRS, Laboratoire Aimé Cotton, Orsay, France*

Due to the dramatic size increase of available neutral-atom-based quantum registers, the implementation of long-range multi-qubit quantum gates is essential to maintain interconnectivity and improve computational efficiency in near-term NISQ devices. Stark-induced Förster transitions provide a promising approach for realizing multi-qubit gates between distant atomic qubits. We present results of research on the applicability of Förster interactions to Rydberg quantum computing applications, and propose high-fidelity three-qubit quantum gate protocols based on such transitions.

Multiqubit gate, Quantum gate, Förster resonance, RF induction

Optimisation of weighted graphs using neutral atom arrays 10:45

Max Wells-Pestell, *University of Strathclyde, UK*

Neutral atom quantum computers show promise in finding solutions for combinatorial optimisation problems. Here we show first experimental results of solving an optimisation problem on a weighted graph using local light-shifts, extending the class of problems that can be solved with neutral atom tweezers and providing a route to scaling to solutions of real-world problems. An example 2D MWIS problem was solved by coherent quantum annealing for the first time, where a five vertex graph was encoded into a nine qubit array.

Quantum information processing, Rydberg atoms, Quantum computing

Cryogenic strontium quantum processor 11:00

Valerio Amico, *University of Tübingen*

We work to realise an optical tweezer lattice in a cryogenic environment at 4K. This will allow us to shield the environment (black body radiation), reach stronger vacuum regimes, and thus get high-performance qubits.

Cryostat, Quantum computer, Strontium87, Rydberg atoms, Optical tweezers.

Talks: Numerical Methods and Simulations

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Continuous Coherent Quantum Feedback with Time Delays: Tensor Network Solution 11:15

Kseniia Vodenkova, *University of Innsbruck*

We present a new method for solving quantum optical systems with coherent feedback loops with time delays. We map these non-Markovian problems to Markovian quantum many-body problems, enabling efficient numerical solutions using tensor network methods. Our approach handles long time delays and arbitrary excitations in delay lines, providing solutions for real-time dynamics and steady states. We also propose a mean-field approach that offers semi-analytical solutions.

Quantum optics, coherent feedback, tensor networks

Wednesday

Lissajous figures in a quantum walk on a lattice 11:30

Grzegorz Jaczewski, *University of Warsaw*

The dynamics of a quantum particle on a square lattice subjected to an external constant force is numerically studied. In one dimension, if the wave packet is wide enough, the average position over time will evolve in an oscillatory manner, while the shape of the wave packet is pre- served. We mainly focus on showing that it is possible through a combination of Bloch oscillations in both directions to obtain trajectories of a wave packet center analogous to classical Lissajous figures.

Quantum walk, Bloch oscillations, Lissajous figures

Finite-temperature Rydberg atom systems: quantum phases and entanglement characterization 11:45

Nora Reinić, *University of Padova, INFN Padova*

Ultracold Rydberg atoms are a promising quantum computing and simulation platform. However, considering that a realistic experimental setup can never be cooled down to a zero temperature, it is important to understand how robust to the temperature these systems really are. For this purpose, we develop a tensor network algorithm for studying quantum many-body systems at thermal equilibrium, and use it to extract the finite temperature phase diagrams and entanglement properties of Rydberg chains.

Rydberg atoms, Tensor networks, Finite temperature, Entanglement

Invited Speaker: Patrick Maletinsky

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Photophysics and quantum optics of solid-state quantum sensors

Patrick Maletinsky - Department of Physics, University of Basel, Switzerland

Quantum two-level systems offer remarkable opportunities for sensing minute physical quantities and enabling high-resolution imaging at the nanoscale [1]. While atomic and molecular systems excel in quantum coherence and record sensitivities [2], solid-state quantum emitters are more conducive to device development [3] and provide access to nanoscale imaging in both physical and life sciences [4]. In this talk, I will present the foundational principles [5] and key engineering challenges in the field of solid-state quantum sensing [6]. I will describe their basic operational principles and highlight selected key applications in mesoscopic, condensed-matter physics [7]. The focus will then shift to the (quantum)-optical properties of solid-state quantum sensors. I will discuss the photophysics of a leading platform in quantum sensing - the Nitrogen- Vacancy center in diamond [8] - and present recent advancements towards utilizing coherent optical control of Silicon-Vacancy center spins for quantum sensing under extreme conditions [9]. The talk will emphasize the importance of spectroscopy and quantum optics in quantum sensing. An in-depth understanding of the (quantum)-optical properties of solid-state quantum centers is not only crucial for developing and optimizing such sensors, but also holds significant potential for discovering novel sensing modalities, which could unlock new scientific insights across various disciplines.

[1] B. Chernobrod and G. Berman, J. of Applied Physics 97, 014903

[2] M W. Mitchell and S. P. Alvarez, Rev. Mod. Phys. 92, 021001

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[4] G. Balasubmaranian et al., Nature 455, 644

[5] C. L. Degen, F. Reinhard, and P. Cappellaro RMP 89, 035002

[6] P. Appel et al., Rev. Sci. Instr. 87, 063703; N. Hedrich et al. Phys. Rev. App., 14, 064007

[7] L. Thiel et al., Science 364, 973 and Nature Nano. 11, 677

[8] J. Happacher et al., PRL 128, 177401 and PRL 131, 086904

[9] J. A. Zuber et al., Nano Lett. 23, 10901; Z.-H. Zhang et al., PRL 130, 166902

Patrick Maletinsky was born in 1979 in Baden, AG and grew up in the town of Schaffhausen, Switzerland. He studied Physics at ETH Zurich with stays at the Ecole Normale Supérieure Paris and at JILA in Boulder, Colorado. For his doctoral studies, he returned to ETH Zurich, where he graduated under the supervision of Prof. Atac Imamoglu on optical studies of hyperfine-interactions in individual, self-assembled quantum dots. His doctoral thesis was awarded the Schläfli-prize of the Swiss Academy of Sciences in 2010. From 2008 to 2011, he was a postdoc in the group of Amir Yacoby at Harvard University, where he developed and applied novel, highly precise methods for nanoscale magnetic field sensing. In 2012, Patrick Maletinsky assumed the Georg-H.-Endress-Professorship as an Assistant Professor at the Department of Physics of the University of Basel; he was promoted to Associate Professor in February 2017.

Talks: Quantum Technologies

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Strongly Interacting Photons in 2D Waveguide QED 11:30

Matija Tečer, *University of Padua*

The occurrence of strong photon-photon interactions in 1D waveguide quantum electrodynamics has been studied extensively in the last few decades. However, the question of its occurrence in higher dimensions is not trivial since photons can be emitted within a larger phase space. We positively answer this question for the case of a 2D square array of atoms coupled to the light confined into a 2D waveguide by demonstrating the existence of long-lived two-photon repulsive and bound states.

Quantum optics, Collective effects in atomic physics, Light-matter interaction, waveguide QED, Photonic Crystals

Development of a transportable optical cavity for a portable trapped ion atomic clock 11:45

Rishabh Pal, *Indian Institute of Technology Tirupati, India*

Portable all optical atomic clocks, reliant on dipole forbidden optical clock transition are crucial in modern applications. Coherent probing of optical clock transition necessitates ultra-stable narrow linewidth laser, feasible using ultra-stable high finesse cavity. Designing such cavity involves meticulous selection of cavity length and materials. This presentation focuses on Airy point identification of cavity and how cavity length and mirror curvature impact fundamental thermal noise floor.

High finesse cavity, Portable optical clock, Finite element analysis, Airy Point

Manufacturing Q-optimized polymer-based mechanical resonators for cavity optomechanics with 3D-direct laser writing 12:00

Daniel Stachanow, *University of Bonn*

Optomechanical platforms with high-quality mechanical and optical resonators have a wide application potential ranging from quantum limited sensing to long-lived storage of quantum information. Recent developments in polymer-based 3D direct laser-written structures allow for new paradigms in manufacturing micromechanical bridge-like resonators, but so far suffer from strong mechanical dissipation. We show viable routes for improving this platform.

Optomechanics, Nanoscribe, Direct Laser Writing, Fiber Cavity, Dissipation Dilution

Enabling atomic systems with fully integrated photonics from UV to IR

12:15

Sophie Cavallini, *ETH Zurich*

Integrated photonics have demonstrated substantial benefits in chip-scale atomic systems, including stability, convenience, and scalability. Recent advances in alumina waveguide fabrication have opened the door to trapped ion and neutral atom systems with all wavelengths of light integrated on chip. Our work targets more generally photonic integrated circuits, for example, structures like low-loss bends and power splitters, and we present ongoing work towards self-injection locking on a chip for a UV diode laser using a thermally tunable ring resonator.

Chip-scale atomic system, Integrated photonics, Aluminium oxide waveguides

Shallow, optically coherent SiV centers in diamond nanopillars for quantum sensing

12:30

Marina Obramenko, *Department of Physics, University of Basel, CH-4056 Basel, Switzerland*

In our work, we present a way of creating individual SiV centers at the depth of approximately 50 nm. We introduce a novel charge stabilization method through extended 445 nm laser exposure, which enables resonant excitation without a charge-repump pulse. Our results constitute a key step towards single SiV quantum sensing under extreme conditions and offer a powerful tool for charge stabilisation of various solid state spin.

Colour centers, Quantum sensing, SiV centers

Characterizing single photon from an atom array via optical fiber

12:45

Yuya Maeda, *Osaka University*

The system of atom arrays, containing a large number of computable qubits and offering the potential for photonic links, is also showing promising features as quantum nodes. In this talk, we report the experiment of fiber coupling of the photons emitted from a single site in an atom array and the measured results of nonclassical second-order correlation.

Atom arrays, Quantum communication, Quantum optics

Invited Speaker: Christiane Koch

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Training Schrödinger's Cat: Quantum Control in Molecular Physics and Quantum Information Science

Christiane Koch - Freie Universität Berlin, Germany

Control refers to the ability to steer a dynamical system using external fields; quantum control does so by exploiting quantum coherence. One way to think of it is in terms of constructive and destructive interference between different quantum pathways, all connecting the same initial and final states. The desired interferences can be designed spetrally, temporally, or using the picture of dressed states. If the dynamics of the quantum system is too complex to design the interferences by hand, optimal control theory comes to rescue. I will showcase recent applications of these concepts to chiral molecules and AMO platforms for quantum information.

Christiane Koch studied physics at the Humboldt University of Berlin from 1992 to 1998, during which she was a Fulbright Scholar at the University of Texas at Austin. She did her doctoral studies in chemical physics through Humbold University at the Fritz Haber Institute of the Max Planck Society, completing her Ph.D. in 2002. After postdoctoral study at the University of Paris-Sud and The Hebrew University of Jerusalem, she became an Emmy Noether Independent Junior Researcher at the Free University of Berlin in 2006. She became a professor at Kassel in 2010, and moved to the Free University of Berlin in 2019. Christiane's researches involve quantum mechanical versions of control theory, including the use of lasers to achieve coherent control of chemical reactions. She has also performed research on efficiently testing the accuracy of quantum computing devices.

Talks: Optimal Control

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Fast and robust cat state preparation utilizing higher order nonlinearities

10:30

Suocheng Zhao, *IQMT, KIT*

Coherent cat states can be prepared using multiple order nonlinearities and optimal control, protected from noise using optimal squeezing, and realized using Rydberg ensemble.

Cat state, quantum control, Rydberg atom, Squeezed cat state

Optimal control of quantum systems: Applications to the control of Bose-Einstein Condensates

10:45

Etienne Dionis, *Laboratoire Interdisciplinaire Carnot de Bourgogne*

Quantum control techniques applied to manipulate Bose-Einstein condensate in optical lattice. Demonstrated precise control using modified GRAPE algorithms to meet experimental constraints.

Optimal Control, Quantum Control, BEC

Talks: Quantum Gas Microscopy

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A strontium quantum-gas microscope 11:00

Carlos Gas Ferrer, *ICFO*

A quantum-gas microscope of strontium is introduced and results on single-atom imaging of a superfluid of bosonic strontium (^{84}Sr) are presented. Finally, efforts towards efficient cooling and single-atom imaging of the fermionic isotope (^{87}Sr) are described.

Quantum gas microscope, Strontium, Quantum simulation

Towards a quantum gas microscope with programmable lattices 11:15

Sarah Jane Waddington, *TU Wien*

Our poster will present the ongoing design and development of a Lithium quantum simulator. A reconfigurable lattice potential will allow site-resolved state preparation and evolution, and imaging will be achieved through a microscope objective. Research goals include the Fermi-Hubbard model, but also more unconventional phases allowed by the dynamic lattice shaping.

Lattice, Simulation, Microscope

Invited Speaker: Katharina Kaiser

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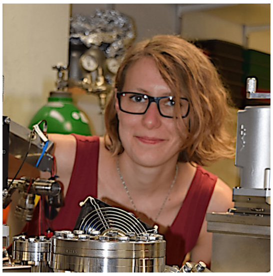
Optoelectronics on the atomic scale – what we can learn from STM on single molecules

Katharina Kaiser - Unversität Göttingen, Germany

When we talk about molecules in scanning tunneling microscopy (STM), we typically refer to a geometry that essentially consists of a molecule that is sandwiched between two tunnel barriers and metal electrodes. Basically, this corresponds to the geometry of an organic resonant tunnel diode, or photodiode, if dyes are used instead of just any molecule. Only in this case, instead of a huge ensemble of molecules arranged in a thin film, we have a single molecule. And instead of a plate capacitor-like arrangement of electrodes, one electrode is an atomically sharp tip that allows us to observe and manipulate the molecule with atomic resolution and precision.
In my talk, I will show you how this allows us to understand what happens during charge transport through a molecule and what possibilities there are to actively control the light emission from such a single-molecule tunnel photodiode.



Professor Katharina Kaiser studied physics at the Georg-August-Universität in Göttingen, Germany, and obtained her Ph.D. in 2022 from Regensburg University generating and characterizing single molecules by atomic force and scanning tunneling microscopy at IBM Research. Afterwards she continued her research on single molecules using scanning tunneling microscopy at IPCMS in Strasbourg. Since January she is a junior professor at the Georg-August-University in Göttingen and leads a group on atomic scale optoelectronics and STMs

Talks: Molecules

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Compact high-precision microwave spectrometer based on FID measurements 10:30

Hemanth Dinesan, *CNRS, Laboratoire de Physique des Lasers, Université Sorbonne Paris Nord, Villetaneuse, France and CNRS, Laboratoire Aimé Cotton,Orsay, Saclay, France*

We present a simple, compact, microwave spectrometer based on Free Induction Decay measurements of molecules confined in a microwave waveguide at room temperature. The test measurments on OCS the transition at 12.163 GHz yielded a notably high SNR ($> 10^7$) which is well above the state-of-the-art commercial instruments and laboratory measurements in this frequency range. Extending the technology to the measurements at cryogenic temperatures should allow us to significantly improve the SNR.

Free induction decay, Signal-to-Noise Ratio, Microwave

Experiments with ultracold atoms and molecules 10:45

Lukas Leczek, *TU Wien*

I will report on two experiments that use the unique properties of different atomic and molecular quantum gases. First, I present the design and realization of an optical system that combines an adjustable ring pattern created by axicon lenses and tailored light patterns created by a digital micro-mirror device, which will be used in an experiment with strongly interacting quantum gas of lithium-6 atoms. Second, I discuss a new experiment that aims to use ultracold calcium monofluoride molecules to study supersolid phases of matter.

Ultracold quantum gas, Axicon lens, Digital micro-mirror device, Ultracold molecules

Ultracold molecules: how not to lose them - A step towards larger molecular quantum computers 11:00

Etienne Walraven, *IMM, Radboud University*

Ultracold molecules trapped by an optical tweezer array are a powerful platform for quantum computing. However, the typical loading efficiency of 50% limits the scalability to larger systems. We propose a novel scheme to increase this efficiency to 80% by using rotationally excited states that show lower collisional loss.

Dipolar molecules, Optical tweezers, Ultracold collisions

Friday

Talks: Hybrid Systems

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Vibrationally coupled Rydberg atom-ion molecules 11:15

Ilango Maran, *Universiteit van Amsterdam*

We use a hybrid atom-ion system to create a linear ion crystal in a Paul trap with Rydberg atom ion molecules at its ends to generate ion-mediated Rydberg-Rydberg interactions. We propose a scheme that uses motional modes of the ion chain to enhance or suppress the formation of two RAIMs at its ends, effectively extending the blockade radius. We use detailed Floquet analysis and the Landau-Zener criterion to provide a qualitative test for the RAIM's survival in the Paul trap's rf potential.

Rydberg atom-ion molecules, Floquet formalism, Rydberg blockade

Trapped ions in optical tweezers 11:30

Nella Diepeveen, *University of Amsterdam*

We plan to combine 2-dimensional Yb+ ion crystals in a Paul trap with optical tweezers to create a novel platform for quantum simulations. Our experimental work demonstrates an optimisation routine for resonant tweezers and observation of coherent population trapping of the ion states. Looking ahead, since we need a deep trapping potential while minimising photon scattering for quantum simulation, we outline future plans to align and optimize non-resonant tweezers.

Quantum simulation, Optical tweezers, Trapped ions

Interfacing Rydberg atoms with an electromechanical oscillator in a cryostat 11:45

Julia Gamper, *University of Bonn*

We are interested in interfacing optically controlled Rydberg atoms with an electromechanical oscillator and will explore the possibility to cool a mechanical oscillator mode to its quantum mechanical ground state by extracting phonons via a coherent exchange of microwave photons with the atoms. Here, we present our design of how to implement this hybrid system and present our progress on the construction. Moreover, we show in detail the optimisation and characterisation of the atom preparation.

Rydberg Atoms, Hybrid System, Electromechanical Oscillator

Posters

Posters: Session Monday (1)

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Atom Interferometer Observatory and Network: towards enhancement of large momentum transfer for fundamental physics

Upasna Chauhan, *University of Birmingham*

The Atom Interferometer Observatory and Network (AION) project, is an atom interferometry project in the UK to detect ultra -light dark matter, mid-frequency gravitational waves and explore other fundamental physics. In my poster, I will provide an overview of the work towards AION at Birmingham, with a focus on both the laboratory progress and the theoretical exploration of LMT. An analysis of wavefront aberration effect in LMT atom interferometers, and a scheme for compensation will also be discussed.

Cold atoms, Quantum sensing, Atom interferometry, Atom optics, Large momentum transfer

High-resolution spectroscopy of the lowest energy levels in the b3Π0 potential of 87Rb133Cs for magic wavelength trapping

Albert Li Tao, *Durham University*

High-resolution spectroscopy of the lowest three rovibrational levels of the $b^3\Pi_0$ potential of ultracold RbCs molecule are conducted. Though this, the rotational constant, the partial linewidths, the natural linewidths and the magnetic moments of the excited states are measured. These parameters are crucial for an improved model of a rotationally magic wavelength of RbCs molecules.

Ultracold RbCs molecules, High-resolution spectroscopy, Magic trapping

A progress report on the isotopic comparison of parity violation in Yb

Iraklis Marios Papigkiotis, *University of Crete*

The development of our newly built precision measurement tabletop apparatus will serve as a novel platform for fundamental tests in nuclear and particle physics. By studying the isotopic variation of atomic parity violation in the ytterbium atom we aim to gain knowledge regarding the neutron distribution of neutron-rich nuclei and delve into physics that extend beyond the Standard Model.

Precision measurements, Atomic parity violation, Neutron skin distribution

Atom-light Crystals in Photonic Crystals: cold Rb atoms in Hollow Core Photonic Crystal Fibres (HCPCF)

Matteo Marchesini, *Alma Mater Studiorum - University of Bologna*

Atom interferometry allows to build gravimeters and gyroscopes of unprecedented precision. Our aim is to realise a setup that is more compact, economic and easily transportable compared to commercial instruments. Our experiment is composed of a Magneto Optical Trap of Rb atoms in proximity of the tip of a Hollow-Core Photonic Crystal Fiber, in which we plan to confine the cold atoms to reduce encumbrance while still attaining state-of-the-art sensitivities ($10^-7m/s^2$).

Laser cooling and trapping, Atom-ligh Crystals, Hollow Core Photonic Crystal Fibers, Quantum sensors, Magnetometry, Interferometry

Quantum interference measurement of the free fall of anti-hydrogen

Joachim Guyomard, *Laboratoire Kastler Brossel*

In order to improve the accuracy of the measurement of the gravitational force between matter and anti-matter, we are studying new interferometric schemes in the special case of a very small sample of atoms. Using optical analogies, we find for bouncing wave packets a behaviour similar to the caustic phenomenon. Finally, we study the resonances in the cavity created between the force of gravity and the bouncing potential.

Interferometry, Gravity

Floquet operator engineering for quantum state stroboscopic stabilization

Nicolas Ombredane, *Toulouse*

We use Quantum Optimal Control (QOC) to manipulate a Bose-Einstein condensate in a shaken optical lattice, and prepare a wide range of states (arbitrary momentum superpositions, squeezed gaussian states…). A complete state reconstruction is performed via tomographic measurements to certify the preparation with high fidelities and purities. We also report on the efficient design of QOC protocols to engineer a Floquet operator, allowing for the stroboscopic stabilization of any desired state.

Floquet, Stroboscopic

Scaling Beyond Grids of 1000 Optical Tweezers with Dynamic Manipulation in Real-time

Marcel Mittenbühler, *TU Darmstadt / Atoms - Photons - Quanta*

Optical tweezers have become the standard for moving atoms in stochastically loaded optical lattices and tweezer arrays to construct structures required for subsequent experiments. However, using a single tweezer becomes a bottleneck for scaling to ever larger systems. Our setup overcomes several challenges in controlling multiple tweezers with strict real-time requirements, achieving various movement patterns, including grids of up to 40x40 tweezers for atom transport.

Optical Tweezers, Scalable Atom Transport, Multi-tone Signal Generation, Real-time Control

Engineering Atomic Frequency Distributions for Atomic CQED Experiments

Clément Raphin, *Laboratoire Kastler Brossel*

The paradigm of N single neutral atoms coupled to the resonant mode of a Fabry-Perot cavity allows the study of transport properties in long-range interacting spin chains. When the emitter frequency distribution is inhomogeneous, the competition between light-matter coupling and disorder leads to a quantum phase transition. We discuss an experimental technique that allows controllable broadening of the atomic frequency distribution using elliptically polarized dipolar traps (optical tweezers).

Cavity Quantum Electrodynamics, Optical Tweezers, Light Shifts, Polaritons, Quantum Simulation, Single Atom Array

Microfabricated alkali cells for atomic devices

Linda Péroux, *Centrale Lille - IEMN*

Miniature atomic devices rely on microfabricated alkali vapor cells. We replicate the glass-blowing technique used in the fabrication of macro-cells on wafer-integrated microstructures. We report on our first results of migration of cesium inside the cells using this method.

Vapor cell, Atomic device, Microfabrication

Realising fast readout for Rydberg arrays

Mehmet Öncü, *Max Planck Institute of Quantum Optics*

In this work, we present our progress on an experimental platform aimed at achieving cavity-assisted, non-destructive, local readout of dual-element tweezer arrays. Long-range and tunable interactions between highly-excited Rydberg states make the platform suited to simulate spin models and form the architectural basis for the realisation of a scalable error-corrected quantum computing platform.

Neutral atom quantum computing, Rydberg atom arrays, Fast cavity readout, Dual-element tweezer arrays

Two-qubits entanglement and quantum gate operations using trapped neutral atom

Diksha Thapliyal, *Indian Institute Of Technology Roorkee, India*

This work thoroughly compares and analyses the impact of Doppler dephasing and decoherence originating due to the finite Rydberg state lifetimes across existing Rydberg protocols. These insights are crucial for designing a novel and robust gate protocol. Additionally, it presents a idea of implementing Controlled-Z and swap gates using amplitude and phase-modulated pulse waveform. Furthermore, it outline our experimental strategy to achieve the objective of high-fidelity gate implementation.

Trapped neutral atom, Quantum entanglement, High-fidelity quantum gates, Rydberg blockade

Picosecond imaging of both the phase and amplitude of an out of equilibrium 2D quantum gas

Kayce Ouahrouche, *Université de Lille*

We propose a new experimental scheme to investigate quantum turbulence at the picosecond time scale and perform single shot measurement of both the phase and amplitude of a turbulent polaritons fluid.

Quantum Turbulence, Polaritons Fluids, Ultrafast Imaging

Sensing Interactions in Atomic Quantum Systems

Luc Verwaal, *Eindhoven university of technology*

Hybrid ion-atom systems combine the well-controllable platforms of trapped ions and ultracold quantum gases and link them together by the intermediate-range ion-atom interaction. These quantum systems offer opportunities for buffer gas cooling, quantum simulation of many-body systems, as well as state-to-state quantum chemistry. At TU/e a new setup is being built to exploit the novel combination of Yb+ and Dy offering the opportunity to investigate the effects of dipole-dipole interactions in hybrid ion-atom systems.

Quantum sensing, Dipolar, Hybrid ion-atom system

Towards a Dual-Species Dipolar Quantum Gas Microscope

Clemens Ulm, *Institute for Quantum Optics and Quantum Information*

Ultracold atoms in optical lattices have been established as a powerful toolbox for quantum simulation, enabling the study of many-body physics and strongly correlated condensed matter. In the last decade, single-site imaging and addressing of these lattice-confined atoms has been achieved by the experimental realization of quantum gas microscopes. Here, we report on the progress towards a quantum gas microscope utilizing the highly dipolar species erbium and dysprosium, which will allow the study of both single- and dual-species physics on the single-atom level.

Ultracold, Dipolar Atoms, Quantum Gas Microscope

Cold Rydberg atoms for Strontium Optical Clock thermometry

Hugo Tortel, *SYRTE / Laboratoire Aimé Cotton - CNRS*

We propose a method for an in-situ, independent evaluation of the blackbody radiation frequency shift of the clock by exciting the clock atoms into a Rydberg state, therefore significantly increasing their BBR sensitivity.

Optical Lattice Clocks, Blackbody Radiation, Rydberg atoms.

Quantum simulation using Bose Einstein Condensates

Morten Strøe, *Aarhus University*

Using BECs as a quantum simulator for electron-phono quasiparticles (phonons) in a solid

Polarons, Quantum-Simulation, many-body physics

Studying Ultra-cold Collisions in Hg-Rb Mixture

Archita Sahu, *Nicolaus Copernicus University in Torun*

We developed an experimental set-up to perform ultra-cold collisions in sympathetically cooled ultra-cold Hg+Rb mixture in a two-species magneto-optical trap (MOT). We use the Time of Flight method and absorption imaging technique to measure the temperature of the atomic Rb cloud in the presence and absence of Hg atoms We also check the cooling efficiency for all five prominent Hg isotopes.

Ultra-cold atoms, Rubidium, Mercury, Collision, Sympathetic cooling, Magneto-optical trap

Exploring Kitaev model with Rydberg atoms: Probing exotic spin states through dipole-dipole interactions

Sakthikumaran Ravichandran, *Faculty of Physics, University of Warsaw*

We study the prospects for realizing Kitaev-type interactions through the utilization of Rydberg atoms, capitalizing their dipole-dipole interactions to engineer specific quantum spin dynamics. By combining theoretical analysis and numerical simulations, the research maps these interactions onto an effective spin-1/2 model, enabling the exploration of quantum phases with potential topological properties through precise control via external electromagnetic fields.

Rydberg atoms, Kitaev model, Quantum spin dynamics

Experimental setup to investigate fundamental interactions in ultra-cold mercury atoms.

Indrajit Nandi, *Nicolaus Copernicus University*

We developed an experimental system based on ultra-cold Hg atoms to explore the possibilities for new interactions beyond the Standard Model. Two-color photo-association spectroscopy will be performed at nm range near the dissociation threshold limit of Hg-Hg molecules. The Hg-Hg molecules will also be used to explore possibility of realization of optical molecular clock.

Ultra-cold mercury, Photo-association, Optical Feshbach resonance, Optical molecular clock

Toward microwave-induced Feshbach resonance

Bastien Mirmand, *Laboratoire de Physique des Lasers*

We are currently investigating a microwave-induced Feshbach resonance which has been theoretically predicted for all alkaline atoms in 2010. Relying on a coplanar waveguide, we induce a strong microwave field at the position of a sodium BEC, which is magnetically trapped on top of an atom chip. We have observed the different spin states of the molecular bound state involved in this Feshbach resonance and have obtained preliminary results on the modification of the interatomic interactions.

Feshbach-microwave-BEC

An accordion optical lattice for the realization of Hofstadter ladders with bosonic mixtures

Andreas Meyer, *ICFO - The Institute of Photonic Sciences*

Strong interactions among charged particles in two-dimensional lattices in the presence of a magnetic flux give rise to fractional quantum Hall physcis. We report on our progress in realizing a minimal representation of this many-body system with mixtures of Bose-Einstein condensates through the implementation of a two-dimensional accordion optical lattice.

Optical lattices, Synthetic gauge fields, Fraction qantum Hall effect, Bose-Einstein condensates

Chip-Scale Quantum Gravimeter

Julian Lemburg, *Leibniz Universität Hannover, Institut für Quantenoptik*

Atom interferometry with Bose-Einstein condensates promises very precise, absolute and drift-free measurements of gravity with residual uncertainties on the order of nm/s^2. To be applicable in ground or space-borne geodesy quantum gravimeters have to be compact, lightweight and energy-efficient . To tackle those challenges, we designed a novel atom chip that is equipped with a grating and a wavelength dependent mirror, which allows us to perform cooling and atom interferometry on a single axis.

Atom Chips, Gravimetry, Compactification

Quench induced chaotic dynamics of Anderson localized interacting Bose-Einstein condensates in one dimension

Swarup Sarkar, *Indian Institute of Technology, Guwahati*

In this work, we establish a possible connection between the delocalized condensate with temporal chaos, which is captured using the time correlator function as the post-perturbed dynamics of the condensate. Although, the dynamics in the delocalized region is chaotic with time but in the localized region the time correlator remain periodic, and quasiperiodic in nature. This investigation enables us to develop a characterization technique between localization and delocalization by studying the dynamics of the condensate, which remains consistent across various trap geometries.

Ultracold atoms: BEC, atomic clocks, Rydberg physics, ...

Posters: Session Wednesday (2)

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Emergence of Synchronisation in a Driven-Dissipative Hot Rydberg Vapour

Karen Wadenpfuhl, *Physikalisches Institut, Heidelberg University*

Synchronisation has first been studied by Huygens, who observed out-of-phase synchronisation of two pendula fixed to the same support, and has since been employed to explain a wealth of phenomena in nature, and physics in particular. We show theoretically that strong interactions via a Rydberg density mean field facilitates synchronisation in a thermal gas and report on the experimental observation of synchronisation emerging in a driven-dissipative hot Rydberg vapor. This system provides an ideal testbed for a fundamental study of synchronisation in ensembles of nonlinear, coupled oscillators due to the large number of constituent oscillators and tunability of the system's parameters.

Rydberg atoms, Hot vapour, Synchronisation, Nonlinear driven-dissipative system

Towards a Grating MOT for Calcium Atoms

Pavel Filippov, *Eidgenössische Technische Hochschule Zürich, ETH Zurich*

We present the latest results of our experiment with the goal of using circular Rydberg states of calcium as qubits. In particular, this work focuses on the implementation of a grating magneto-optical trap (gMOT). This technology allows for a simplified implementation into a cryogenic apparatus and opens new integration possibilities, such as waveguides integration into the grating and a compact source of quadrupole magnetic field.

Rydberg, MOT, Calcium

Driving Raman transitions using a nano-structured atom chip

Kai-Christian Bruns, *Leibniz Universität Hannover*

Grating atom chips simplify and enhance quantum sensing devices by trapping atoms in a MOT with a single beam. This advancement promises compact, portable, and efficient quantum sensors. The poster demonstrates Raman transition measurements on such a chip, supported by simulations. Utilizing the diffracted beams, multi-axis atom interferometers could be constructed, with implications ranging from fundamental research to practical geodesy applications.

Interferometry, Atom chips, Raman transitions

Closed loop correction for laser pulse envelope imperfections based on Compact-Optimized optical modulator

Shuzhe Yang, *University of Strasbourg*

Optimal pulses featuring specific amplitude and phase envelopes have been investigated to achieve high-fidelity quantum operation in neutral atom or ions trap based quantum processor. However, the generated laser pulse usually suffers from distortions induced by experimental devices, which will have a detrimental effect on fidelity of quantum operations. Here, we present a method to correct the distortion in laser's amplitude and phase simultaneously. By estimating the complex-value impulse response function characterized by the Volterra series, we are able to obtain pre-distorted amplitude and phase envelope from optimization algorithm , which enables us to compensate for the distortion induced from experimental devices. Our method is effective in addressing the errors that arise from the laser pulse envelope imperfections on ions trap or neutral atom-based quantum processor.

QI technology: quantum computers, Sensors, Simulators, Communications

Quantum Simulation and Quantum Computing using trapped ^{88}Sr atoms

Jan Geiger, *Max Planck Institute of Quantum Optics*

Here, we present the coherent excitation of the ultranarrow $^1S_0$–$^3P_2$ transition in ^{88}Sr with excitation fractions of 97(1)%. Building on these results, we demonstrate the implementation of a fine-structure qubit encoded in the metastable $^3P_2$ and $^3P_0$ states of ^{88}Sr promising fast single- and two-qubit gates. Our results pave the way for fast quantum information processing and highly tunable quantum simulators with two-electron atoms.

Quantum simulation, Quantum computing, Optical lattice, Strontium

A miniature atomic magnetometer prototype

Arthur Dewilde, *Centrale Lille - IEMN*

We report on the ongoing development of a miniature atomic magnetometer at IEMN. These sensors must contain a VCSEL, the optics (quarter-wave plate, lens and prisms), the alkali vapor cell and the coils, in the most compact design possible.

Atomic magnetometer, VCSEL, Vapor cell

Quantum computing with mixed qubit types in ^{137}Ba^{+}

Sophie Decoppet, *University of Oxford*

We present an initial toolbox for trapped ion quantum computing with mixed qubit types. In particular, we demonstrate a novel state preparation and measurement protocol and entangling gates between ground and metastable qubits.

Trapped ion quantum computers, omg architecture, Mixed qubit types

Cold ytterbium Rydberg atoms source

Jawad Cheayto, *Quantum Information Master- Laboratoire Aime Cotton*

Mounting a new atomic source constituted of an ytterbium oven, a Zeeman slower collecting most of the velocity classes, followed by a Magneto-Optical Trap (MOT) in 2 dimensions to redirect the atomic flux towards a 3D MOT.

Quantum Simulations, Rydberg Atoms, Quantum Computers

Quantum Simulations using potassium-40

Paul Catterson, *University of Strathclyde*

Quantum gas microscopes allow for single-atom-imaging within an optical lattice, allowing for the study of meany-body quantum systems with applications within solid state, and fundamental physics.

Quantum simulation, Quantum gas microscope, Optical lattices

Lowering entanglement in quantum trajectory unravelings of noisy quantum circuits

Ruben Daraban, *University of Strasbourg*

The evolution of quantum states quantum circuits subjected to dissipation can be simulated by unraveling the dynamics into quantum trajectories. Here, we introduce strategies to optimize those unravelings by leveraging the unitary degree of freedom in defining the Kraus operators. With analytical arguments and large-scale numerical simulations we demonstrate that standard representations of Kraus operators lead to almost worst-case scenario entanglement growth, and introduce a novel way to limit the entanglement growth.

Matrix Product States, Random quantum circuits, Monte Carlo wavefunction, Quantum Trajectories, Measurement induced phase transition

Energy levels in a 2D spin dependent optical lattice

Kamil Dutkiewicz, *University of Warsaw*

Investigation of energy levels in a 2D spin dependent, rectangular optical lattice. Type of boundary condition is discovered to influence the topological behavior of the energy levels as a function of the extertal magnetic field. Wave functions are investigated to show the difference in energy comes from interaction with the Dirichlet walls.

Optical lattices, Band structure, Edge states

Scale-invariant phase transition of disordered bosons in one dimension

Tanul Gupta, *University of Strasbourg*

This study investigates disorder-induced quantum phase transitions in one-dimensional bosonic systems, challenging the conventional expectation of a Berezinskii-Kosterlitz-Thouless (BKT) transition. Using hard-core lattice bosons with power-law hopping, a non-BKT continuous phase transition is revealed, contrary to expectations. Exact quantum Monte Carlo methods are employed to explore the phase diagram for different power-law exponents, highlighting scale-invariant behavior for $\alpha \leq 3$. Additionally, the data suggest a correlation length exponent consistent with the Harris bound, unveiling a new universal behavior for disordered bosons in one dimension.

Quantum Monte Carlo, Bose-Hubbard Model, Power-law hopping

Energy Damping of a Jones-Roberts Soliton: Analytical and Numerical Results

Nils Krause, *University of Otago*

We investigate the thermally induced decay of Jones-Roberts solitons in the framework of the stochastic projected Gross-Pitaevskii equation. Our findings suggest that the dominant damping mechanism is energy damping. While in the vortex dipole regime the characterising property of a Jones-Roberts soliton is the distance between the vortices, we identify the interaction energy as the relevant quantity in the rarefaction pulse regime.

Damping, BEC, Soliton

Assembled Arrays of Rydberg-interacting Atoms with Single-site Control

Justus Götzinger, *Technische Universität Darmstadt*

Neutral atoms in optical tweezer arrays are a well-controlled and scalable platform for quantum science. We extend the typical 2D setup to the third dimension at no additional cost, using a microlens-generated Talbot tweezer lattice. In-plane atom transport enables the deterministic preparation of defect-free configurations of naturally identical atomic qubits. We apply this platform to quantum sensing of magnetic fields and quantum information science with Rydberg-mediated interactions.

Optical tweezers, Quantum sensing, Rydberg interactions

Towards cavity-control of ultracold chemical reactions in molecular quantum gases

Marian Dürbeck, *Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin, Germany*

Understanding and controlling chemical reactions at ultralow temperatures is crucial for unlocking the potential of molecular quantum gases and for engineering new molecular species. We report on our efforts to create a Bose-Einstein Condensate of dysprosium atoms and preliminary spectroscopy characterization of the target dysprosium dimers.

Molecular quantum gases, Dysprosium, BEC, Ultracold chemistry, Cavity

Quantum Simulation of Ultra-Cold Atoms

Zoubair Daouma, *Université de Lille*

In my theoretical study, I explore the dynamics of the quantum kicked rotor, a fundamental system for studying quantum chaos and Anderson localization, by introducing spin-orbit coupling. This advanced model allows me to examine time-reversal symmetry and to develop an experimental protocol aimed specifically at studying the three Wigner-Dyson symmetry classes: symplectic, orthogonal, and unitary. A novel aspect of this work lies in the study of Hamiltonians belonging to the symplectic symmetry class, which, to our knowledge, have never been experimentally realized before.

Quantum kicked rotor, Ultracold atoms, Time-reversal-symmetry

Hydrodynamic Instabilities in Quantum Droplets

Luca Cavicchioli, *University of Florence*

We report on a hydrodynamic instability of a 41K-87Rb quantum droplet, which causes the break-up of the atomic cloud into smaller droplets. The phenomena seen can be explained by a conceptual framework analogous to that of the capillary instability in classical fluids, where the surface tension causes the fragmentation of a liquid filament. This opens new possibilities in the investigation of multicomponent superfluids.

Quantum droplets, Superfluids, Hydrodynamic Instability

Bragg-spectroscopy of a dissipation induced instability

David Baur, *ETH*

In our Experiment, we investigate two roton-like excitation modes, induced by the long-range interactions of our coupled BEC-cavity system. We make use of Bragg-Spectroscopy to simultaneously measure these two low-lying excitations and find the individual softening of the two modes as they approach their respective phase. We can explore a parameter regime, where the two modes coalesce, observing an exceptional point and the associated dynamical instability.

Cavity physics, Long-Range order, Roton-mode softening, Dynamical instability, Exceptional point

A new ytterbium experiment for single-atom resolved many body physics

Omar Abdel Karim, *Università degli Studi di Napoli, Federico II*

Neutral atoms trapped in arrays of optical tweezer microtraps have recently emerged as a promising platform for quantum science. Optical tweezers enable the manipulation, control, and detection at the single-atom level. Moreover, the dynamic rearrangement of tweezer traps allows the generation of large-scale defect-free atom arrays in arbitrary geometric configurations. This, together with the possibility of directly implanting reordered arrays in optical lattice traps allows to combine the precise control provided by tweezers and the versatility provided by optical lattices making possible the realization of new generation quantum simulators.

Tweezers, Ytterbium, Simulator

High-rate quantum LDPC codes for long-range-connected neutral atom registers

Laura Pecorari, *University of Strasbourg*

We discuss the possibility of realizing a family of high-rate Low-Density Parity-Check (LDPC) codes in neutral atom quantum computers. We present results for their encoding and error correction capabilities, by focusing on codes that may be realized in near-term experiments with Rydberg atoms trapped in a two-dimensional array. We conclude by discussing in what situations these codes offer advantages over the standard surface code approach.

Rydberg Physics, Quantum Error Correction, Quantum Computing

Towards optical dipole trapping of Feshbach molecules with infrared light near $2\mu m$

Viviana Lippolis, *University of Innsbruck*

We are building an optical parametric oscillator, realized with a periodically poled lithium niobate crystal (PPLN). This is used to generate a tunable infrared light beam, with wavelength around 2 μm, that can be used to realize an ODT trap for the Dy-K Feshbach molecules.

Ring Cavity, Infrared light, Optical Dipole Trap

Perfect ring-shaped Bose Einstein Condensation

Vishal Pathak, *ITE Heraklion*

Ring-shaped Bose-Einstein condensates are created using timme-averaged adiabatic potentials (TAAPs) trap from the application of oscillating magnetic fields to a rf dressed quadrapole trap. A study is carried out for the coherence and superfluidity nature of the atoms making a testbed for fundamental quantum physics. The stability of the ring-shaped BECs is being studied by analyzing the effects of perturbations and fluctuations and precise control over cooling and confinement. By controlled manipulation of the trapping potentials, the dynamic excitations of the condensates is also studied. Ring-shaped BECs also offer possibilities for mater wave interferometry, and in atomtronics.

BEC, Ring-shape, Superfluidity

About YAO

The Young Atom Opticians conference (YAO) is an annual meeting aimed at young PhD and master students in the field of atomic and molecular physics. Its goal is to provide participants with a platform to learn from and extend their network with peers from around the world.

YAO 2024 conference is arranged by PhD students from CESQ and will take place in Strasbourg from June 30th to July 5th 2024.

Since 1995 it has been hosted by different institutions all over Europe.

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1996:	Oxford, UK	2011:	Hannover, Germany
1997:	Parco dell'Orecchiella, Italy	2012:	Krakow, Poland
1998:	Gif-Sur-Yvette, France	2013:	Birmingham, UK
1999:	Potsdam, Germany	2014:	Barcelona, Spain
2000:	Brighton, UK	2015:	Zurich, Switzerland
2001:	Stuttgart, Germany	2016:	Munich, Germany
2002:	Volterra, Italy	2017:	Paris, France
2003:	Amsterdam, Netherlands	2018:	Glasgow, Scottland
2004:	Insbruck, Austria	2019:	Hamburg, Germany
2005:	Hannover, Germany	2020:	Cancelled due to COVID-19
2006:	Palaiseau, France	2021:	Aarhus, Denmark (online)
2007:	Durham, UK	2022:	Stuttgart, Germany
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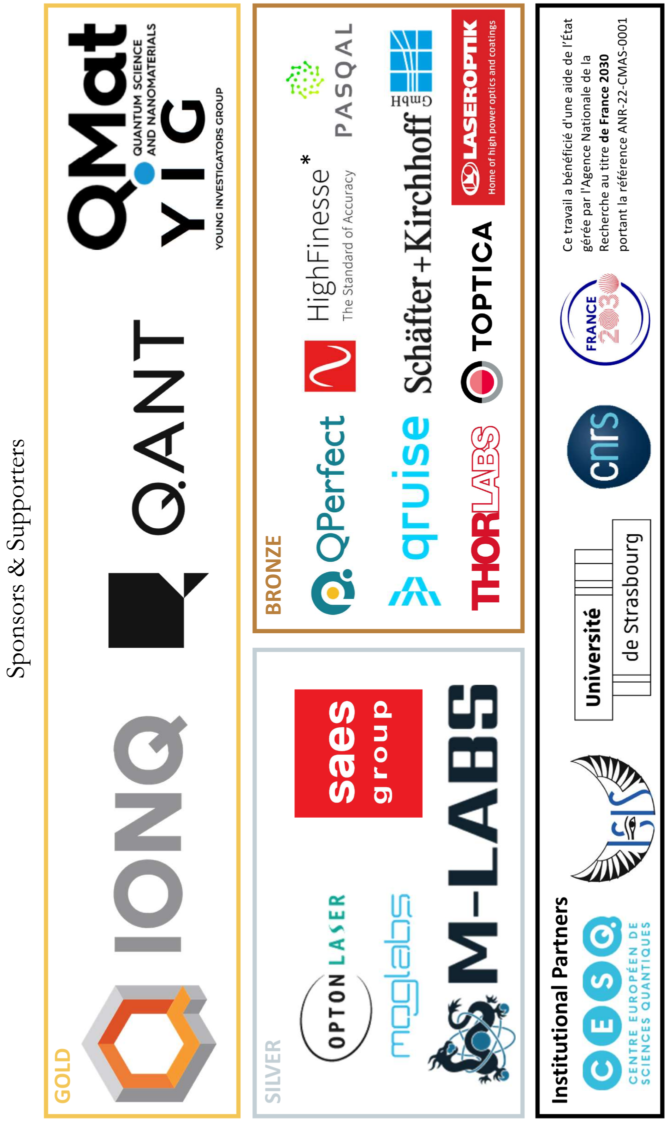

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