# Q 59: Ultra-cold atoms, ions, and BEC VII (joint session A/Q)

Time: Friday 11:00–13:00 Location: f303

**Invited Talk** Q 59.1 Fri 11:00 f303

**Interaction-induced lattices for bound states: Designing flat bands, quantized pumps and higher-order topological insulators for doublons** — •Grazia Salerno, Giandomenico Palumbo, Nathan Goldman, and Marco Di Liberto — Center for Nonlinear Phenomena and Complex Systems,Universit *e Libre de Bruxelles, CP 231, Campus Plaine, B-1050 Brussels, Belgium

Bound states of two interacting particles moving on a lattice can exhibit remarkable featuresthat are not captured by the underlying single-particle picture. Inspired by this phenomenon, weintroduce a novel framework by which genuine interaction-induced geometric and topological effectscan be realized in quantum-engineered systems. Our approach builds on the design of effectivelattices for the center-of-mass motion of two-body bound states, which can be created throughlong-range interactions. This general scenario is illustrated on several examples, where flat-bandlocalization, topological pumps and higher-order topological corner modes emerge from genuineinteraction effects. Our results pave the way for the exploration of interaction-induced topologicaleffects in a variety of platforms, ranging from ultracold gases to interacting photonic devices.

Q 59.2 Fri 11:30 f303

**Spectroscopy of interorbital dimers and pair states in Ytterbium-171** — •Oscar Bettermann[1,2], Nelson Darkwah Oppong[1,2], Giulio Pasqualetti[1,2], Luis Riegger[1,2], Immanuel Bloch[1,2], and Simon Fölling[1,2] — [1]Max-Planck-Institut für Quantenoptik, Garching, Germany — [2]Ludwig-Maximilians-Universität, Munich, Germany

An outstanding feature of alkaline-earth-(like) atoms is the existence of a metastable excited electronic state connected to the ground state via an ultranarrow "clock" transition. The interactions between atoms in the different electronic states are governed by the molecular interaction potentials between the atoms and the bound states formed inside these potentials.

Here, we report on the direct production and spectroscopy of the least bound state in Ytterbium-171 and characterization of the interactions between atoms in different electronic states. The dimers are produced by direct single-photon photoassociation via the clock line, in a deep three-dimensional optical lattice. In strong contrast to the shallow bound state present in Ytterbium-173, we find a much larger binding energy, with a much smaller molecular wavefunction therefore largely independent of the external potentials. We also show that the free-to-bound transition can be made insensitive to the depth of the trapping potential, an important aspect in the realization of optical molecular clocks.

Q 59.3 Fri 11:45 f303

**A subradiant two-dimensional atomic array forming an optical mirror** — •David Wei[1], Jun Rui[1], Antonio Rubio-Abadal[1], Simon Hollerith[1], Kritsana Srakaew[1], Simon Evered[1], Immanuel Bloch[1,2,3], and Christian Gross[1] — [1]Max-Planck-Institut für Quantenoptik, Garching, Germany — [2]Fakultät für Physik, Ludwig-Maximilians-Universität, München, Germany — [3]Munich Center for Quantum Science and Technology (MCQST), München, Germany

When quantum emitters are positionally structured on sub-wavelength scales, photon-mediated dipole-dipole interactions can strongly alter the spectral and directional radiative response. Tightly trapped atoms in optical lattices, only coupled to the electromagnetic vacuum, constitute ideal dipolar emitters to study such cooperative behaviour.

In our experiment, we probe the collective properties of a two-dimensional square array of atomic dipoles by performing spectroscopic absorption and reflection measurements. We directly observe considerably subradiant response and demonstrate that the array acts as a reflective mirror formed by a single mono-layer of a few hundred atoms. By varying the atom density within the array, we are able to control the influence of the dipolar interactions. By introducing positional disorder in the atomic ensemble, we analyze the role of the array structure. Its importance is emphasized by dynamically breaking and restoring the order using atomic Bloch oscillations to control the reflectivity of the atomic mirror.

Q 59.4 Fri 12:00 f303

**State-dependent optical lattices for the clock states of strontium** — •Annie Jihyun Park[1], Andre Heinz[1], Trautmann Jan[1], Neven Santic[1], Sergey G Porsev[2,3], Marianna S Safronova[2,4], Immanuel Bloch[1,5], and Sebastian Blatt[1] — [1]Max Planck Institute of Quantum Optics, Garching, Germany — [2]U. Delaware, Newark, USA — [3]Petersburg Nuclear Physics Institute, Gatchina, Russia — [4]JQI, NIST and U. Maryland, College Park, USA — [5]LMU, Munich, Germany

We demonstrate state-dependent optical lattice for the clock states in strontium at the tune-out wavelength for the 1S0 ground state, where its dipole polarizability vanishes. Using a novel spectroscopic method, we measure 689.222225(14) nm for this tune-out wavelength in Sr-88, one of the most precise and accurate measurements of a tune-out wavelength to date. Since our method does not require quantum degenerate gases, it is also suited for measuring tune-out wavelengths for atoms in metastable states, molecules, fermionic species and trapped ions. Furthermore, we measure the polarizability of the excited 3P0 clock state at the tune-out wavelength using high-resolution clock spectroscopy, demonstrating the first excited state polarizability measurement in an alkaline-earth-metal atom. In a proof-of-principle experiment, we trap 3P0 atoms in a one-dimensional optical lattice at the tune-out wavelength. Our measurements benchmark state-of-the-art atomic structure calculations and pave the way for state-dependent manipulations of strontium atoms for high-fidelity quantum simulations and quantum computation schemes.

Q 59.5 Fri 12:15 f303

**Atom number stabilization with single-atom precision** — Andreas Hüper[1], Cebrail Pür[1], •Mareike Hetzel[1], Jiao Geng[1], Mick Kristensen[2], Jan Arlt[2], and Carsten Klempt[1] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Germany — [2]Institut for Fysik og Astronomi, Aarhus Universitet, Denmark

The preparation and evaluation of quantum states for optimal entanglement-enhanced metrology relies on an accurate determination of the number of atoms. We present an accurate fluorescence detection of atoms trapped in a miniature magneto-optical trap. We utilize the accurate atom number detection for a number stabilization of a laser-cooled atomic ensemble. For a target ensemble size of seven atoms prepared on demand, we achieve a 92 % preparation fidelity and reach number fluctuation 18 dB below the shot noise level using real-time feedback on the magneto-optical trap.

Q 59.6 Fri 12:30 f303

**Continuous measurement of a quantum driven top** — •Jessica Eastman[1], Stuart Szigeti[2], Joseph Hope[2], and André Carvalho[3] — [1]Imperial College London, London, UK — [2]Australian National University, Canberra, Australia — [3]Q-CTRL, Australia

The need to understand many-body quantum chaos is motivated by a growing area of research with connections to topics such as random unitaries, holographic duality and information scrambling in black holes, nonequilibrium thermodynamics and quantum sensing. We theoretically investigate the effect that continuous weak measurement can have on the emergence of chaos in many-body quantum systems by looking at a system that can be easily realisable in ultra cold atom experiments: the Quantum driven top. The corresponding classical system in this case is a closed system with no dissipation. By adding weak coupling to a measurement device, we introduce decoherence to the system.

Q 59.7 Fri 12:45 f303

**Bulk topological proximity effect in multilayer systems** — Jaromir Panas[1], •Bernhard Irsigler[1], Jun-Hui Zheng[1,2], and Walter Hofstetter[1] — [1]Goethe-University Frankfurt, Germany — [2]NTNU, Trondheim, Norway

We investigate the bulk topological proximity effect in multilayer lattice systems. We show that one can introduce topological properties into a system composed of multiple trivial layers by coupling to a single nontrivial layer described by the Haldane model. This phenomenon depends not only on the number of layers but also on their arrangement, which can lead to the emergence of dark states in multilayer systems. The response of a trivial system to the proximity of a topological insulator appears to be highly nonlocal, in contrast to the proximity effect observed in context of superconductivity. We also find a range of parameters where our system is semimetallic with features similar to the ones observed in three-dimensional topological states. This is promising from the perspective of bridging two- and three-dimensional topologically protected states of matter.