A 3: Collisions, Scattering and Correlation Phenomena I (joint session A/MO)

Time: Monday 11:45–13:00 Location: N 2

A 3.1 Mon 11:45 N 2

Floquet Resonances in Ultracold Gas Scattering — •Sebastian Eggert, Axel Pelster, and Christoph Dauer — University of Kaiserslautern-Landau (RPTU)

An alternative mechanism of tuning interactions between cold atoms is proposed, which is based on dynamically creating "Floquet bound states" using time-periodic fields. By developing a Floquet-scattering theory we show that sharp Floquet resonances occur at which the effective interaction can be tuned to very large attractive or repulsive values. The resulting predictions explain recent experimental data and provide additional tuning possibilities. Analytic predictions are given for adjusting amplitude, frequency and mean of the applied oscillating field in order to to accurately choose location and width of scattering resonances over a wide range. This paves the road to a versatile toolbox of tailored interactions in setups with multiple species.

A 3.2 Mon 12:00 N 2

Light scattering experiments in dense dipolar gases — •Ishan Varma, Marvin Proske, Rhutwik Sriranga, Dimitra Cristea, and Patrick Windpassinger — Staudingerweg 7, Institute of Physics, JGU Mainz

In ultracold atomic ensembles where interatomic spacing is smaller than the wavelength of scattered light, direct matter-matter coupling through electric and magnetic interactions significantly influence system dynamics, challenging the approximation of atoms as independent emitters. We study the role of magnetic dipole-dipole interactions (DDI) in the cooperative behavior of atomic ensembles using dysprosium, which has the highest ground-state magnetic moment (10 Bohr magnetons).

This talk focusses on the recently performed light scattering experiments in moderately-dense samples of ultracold dysprosium atoms. We study the scattering properties of the sample with respect to frequency detuning from resonance, optical depth, and external magnetic field. A detailed analysis of the fluorescence signal reveals first indications of super- and sub-radiance, which suggest cooperative behavior in the system. In addition, we also discuss the impact of optical dipole trap polarization on atomic lifetime and highlight the recent technical advancements made in vacuum technology and the design of microscope objectives. These developments enable a higher degree of control and accessibility of the atomic sample.

A 3.3 Mon 12:15 N 2

Transport resonances through periodically driven, weakly coupled impurity — •Jan Mathis Giesen, Daniel Weber, and Sebastian Eggert — Physics Department and Research Center OPTIMAS, RPTU University Kaiserslautern-Landau, D-67663 Kaiserslautern, Germany

We consider transport in an optical lattice through quantum well with time periodic driving and apply Floquet theory to calculate tunneling amplitudes. An analytic non-equilibrium solution of the problem is developed which allows the analytic prediction and analysis of the tunneling amplitudes as a function of frequency, driving amplitude, and energy level of the well. One main result is the discovery of a previously unknown resonant switching effect, where a very small driving field can induce perfect transmission. The results are relevant for corresponding setups using ultra-cold gases in optical lattices, photonic waveguides, quantum dots coupled to metallic leads or magnonic systems.

A 3.4 Mon 12:30 N 2

The interplay between single- and two-body interference of photoelectrons — •Fabian Rohrbach[1], Andreas Buchleitner[1,2], and Christoph Dittel[1,2] — [1]Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Straße 3, 79104 Freiburg, Germany — [2]EUCOR Centre for Quantum Science and Quantum Computing, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Straße 3, 79104 Freiburg, Germany

We clarify under which conditions fermionic exchange (anti-) symmetry manifests in the energy spectrum of photoelectrons generated by pulsed light interacting with matter, and how such signature can be discriminated against anticorrelations potentially arising from Coulomb repulsion. We demonstrate that photoelectrons emitted from two metal needle tips exhibit pronounced two-body interference fringes, and analyze how these features interplay with interference on the single-electron level, along different pathways in a pump–probe ionization scheme.

A 3.5 Mon 12:45 N 2

Protected quantum gates using qubit doublons in dynamical optical lattices — •Lars Fischer, Yann Kiefer, Zijie Zhu, Samuel Jele, Marius Gächter, Giacomo Bisson, Konrad Viebahn, and Tilman Esslinger — Institute for Quantum Electronics & Quantum Center, ETH Zürich, Otto-Stern-Weg 1, 8093 Zürich

Scalable quantum computation relies on configurable qubit connectivity through system-wide, error-free transport of quantum states. Neutral atoms in optical lattices represent a promising platform for quantum computing, where collisional gates provide a controlled mechanism for quantum logic. Here, we present a purely geometric two-qubit SWAP gate that transiently populates qubit doublon states of fermionic atoms in a dynamical optical lattice. Using atomic spin singlets of fermionic potassium-40, we demonstrate the experimental realisation of this quantum holonomy enabled by doublon states. The gate mechanism is based on a geometric evolution in which dynamical phases are entirely absent, making the mechanism intrinsically robust against fluctuations and inhomogeneities in the confining potentials.

We report a loss-corrected two-qubit SWAP gate fidelity of 99.91(7)%, measured across an ensemble of more than 17,000 atom pairs. Combined with tunable atomic collisions, we realise a universal set of two-qubit gates, paving the way toward large-scale, highly connected quantum processors. Our scheme, based on topological pumping of atoms, establishes the foundation for a fault-tolerant computational platform.