SAMOP-DP 1: S-AMOP Dissertation Prize Symposium

Time: Tuesday 10:30–12:30 Location: MENSA Dül

Invited Talk SAMOP-DP 1.1 Tue 10:30 MENSA Dül
Rovibronic ground state molecules near quantum degeneracy — •Johann Georg Danzl — Institut für Experimentalphysik, Universität Innsbruck, Innsbruck, Austria

Control over all internal and external degrees of freedom of molecules at the level of single quantum states will enable a series of fundamental studies in physics and chemistry. High phase-space density samples of molecules in a defined internal state, most notably in the lowest internal quantum state, will allow novel quantum gas experiments, cold controlled chemistry, quantum information, and quantum simulation experiments. We create ultracold and dense samples of molecules prepared in a single hyperfine sublevel of the rovibronic ground state while each molecule is trapped in the motional ground state of an optical lattice well. Starting from an atomic Mott-insulator state with optimized double-site occupancy, weakly bound Cs_2 molecules are efficiently formed on a Feshbach resonance and subsequently transferred to the rovibronic ground state by a coherent 4-photon process with the Stimulated Raman Adiabatic Passage technique. The molecules are trapped in the lattice with a lifetime of 8 s. We now aim to produce a Bose-Einstein condensate of ground state molecules by adiabatically removing the optical lattice potential. Our results can readily be generalized to heteronuclear polar molecules such as RbCs, opening up the possibility for creating dipolar quantum gas systems with long range and anisotropic interactions.

Invited Talk SAMOP-DP 1.2 Tue 11:00 MENSA Dül
Manipulation of Large Neutral Molecules with Electric Fields — •Frank Filsinger — Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin, Germany

For many experiments in chemistry and physics a high level of control over the external and internal degrees of freedom of the target molecules would be very beneficial. This includes, for instance, controlling the quantum state and the conformation of the molecules, as well as their spatial orientation in the laboratory frame.

Here, I will discuss how such control can be achieved using strong dc electric, ac electric, and laser fields. Conformers (structural isomers) of neutral molecules can be spatially separated with electric fields, based on their distinct dipole moment-to-mass ratios. In one setup, the conformers are separated employing ac electric fields in an alternating gradient m/μ-selector (the equivalent of the quadrupole mass filter for ions). In a second setup, conformer separation is accomplished in a Stern-Gerlach-type experiment. In this approach, a dc electric field disperses polar molecules in a supersonic jet according to their effective dipole moments μ_{eff}. Because molecules in the lowest rotational quantum states have the largest μ_{eff} and are deflected most, quantum-state selection is achieved as well. If such quantum-state-selected samples are used as targets, unprecedented degrees of laser-induced alignment and mixed-field orientation are obtained. This method is applicable to a wide range of polar molecules and should eventually enable experiments on pure samples of strongly aligned or oriented ground-state molecules offering new prospects in molecular sciences.

Invited Talk SAMOP-DP 1.3 Tue 11:30 MENSA Dül
Entanglement in spinor Bose-Einstein condensates — •Christian Gross, Tilman Zibold, Eike Nicklas, Helmut Strobel, Jiri Tomkovic, and Markus K Oberthaler — Kirchhoff Institute for Physics, University of Heidelberg

Entanglement is one of the fundamental and most puzzling concepts of quantum mechanics. Besides its fundamental importance for the understanding of many particle quantum mechanics some useful entangled states exist, which can serve as resources for emerging quantum technologies. Spinor condensates are ideal to study entanglement experimentally, since different interaction induced nonlinear terms in the hamiltonian can be used for the generation of different kinds of entangled states. We report on the realization of a quantum enhanced atom interferometer based on spin squeezed states with a sensitivity beyond the classical limit. By tomography we detect a quantum state containing 170 entangled atoms within the interferometer. In a recent experiment we use atomic pair creation due to spin changing collisions to engineer atomic squeezed vacuum states which fulfill Einstein-Podolsky-Rosen type entanglement criteria. Even for large atom numbers we observe a pair coherence above 90% by atomic homodyne detection.

Invited Talk SAMOP-DP 1.4 Tue 12:00 MENSA Dül
State-selective transport of single neutral atoms — •Michal Karski — Institut für Angewandte Physik, Universität Bonn, Germany

Tailoring the wave function of a single quantum particle and controlling its evolution by quantum interference phenomena opens up new perspectives in quantum engineering and information science. Individual neutral atoms in a one-dimensional optical lattice provide an ideal and transparent model system for this purpose. Their spin states and positions can be perfectly controlled and the state-selective transport enables the creation of spin-position entangled states. Such transport allowed us to implement a single-atom interferometer and a quantum walk which spreads much faster than its classical counter part — the random walk — by utilizing multi-path quantum interference of the atomic wave function. I present the experimental realization of the state-selective transport and its applications focussing on the discrete time quantum walk of an atom in position space, which provides all of the relevant features necessary to understand the fundamental differences between the quantum and classical regimes.