A 23: Trapped ions

Time: Wednesday 14:30–16:30 Location: N 3

Invited Talk A 23.1 Wed 14:30 N 3

Surface-electrode traps for scalable quantum information processing with atomic ions — •C. Ospelkaus[1,2], H. Hahn[1,2], M. Wahnschaffe[2,1], G. Zarantonello[1,2], T. Dubielzig[1], S. Grondkowski[1], J. Morgner[1,2], M. Kohnen[2,1], and A. Bautista-Salvador[2,1] — [1]Institut für Quantenoptik, Leibniz Universität Hannover — [2]Physikalisch-Technische Bundesanstalt, Braunschweig

Surface-electrode traps have emerged as a scalable platform for quantum information processing with trapped ions. We describe concepts and experiments aimed at implementing multi-qubit operations in such structures using near-fields from embedded microwave conductors rather than the commonly used focsed laser beams. We describe the design and operation of a trap structure allowing the implementation of entangling quantum logic gates and spin-spin interactions for quantum simulations with $^{9}Be^{+}$ ions. We demonstrate agreement between simulations of the near-field and measurements using a single ion as a quantum sensor at the sub-micron and few-degree level. We demonstrate motional sideband transitions as a prerequisite for entangling quantum logic operations and show microwave sideband cooling. We have set up a cryogenic ion trap system based on an ultra-low vibration (< 20 nm 0-pk) closed cycle cryostat. This will eliminate the main source of infidelities in recent experiments, which was anomalous motional heating. Furthermore, we have extended our fabrication capability to include multiple metal layers with interconnects and discuss how such multi-layer structures would allow the realization of quantum simulations in scalable surface-trap arrays.

A 23.2 Wed 15:00 N 3

Nuclear magnetic resonance signal detection for the Cosmic Axion Spin Precession Experiment (CASPEr-Wind) — •Gary Centers[1], John Blanchard[1], Nataniel Figueroa[1], Marina Gil Sendra[1], Arne Wickenbrock[1], Dmitry Budker[1], Antoine Garcon[1], and CASPEr Collaboration[2] — [1]Helmholtz Institute Mainz, Johannes Gutenberg University, 55128 Mainz, Germany — [2]Various locations

The Cosmic Axion Spin Precession Experiment (CASPEr), particularly the CASPEr-Wind, is a detection scheme searching for light particles that have a coupling to nuclear spin; some examples being dark matter candidates like the axion/axion-like particles, hidden photons, or any pseudo-Goldstone boson. The coupling induces precession of the nuclear spin about the axion momentum which will be detected using Nuclear Magnetic Resonance (NMR) techniques.

Using a sample of hyperpolarized liquid xenon to monitor the transverse magnetization is different from the application of short radiofrequency pulses typical in NMR. From this perspective, an analysis for detecting the wind-induced NMR signal is presented using transient, steady state, and closed form solutions of the Bloch equations in different limits. Considerations will include, but are not limited to, different schemes of varying the leading field, effects of radiation damping, different relaxation limits, and noise considerations.

A 23.3 Wed 15:15 N 3

First data analysis schemes for the Global Network of Optical Magnetometers for Exotic physics searches (GNOME) — •Hector Masia-Roig[1], Vincent Dumont[2], Arne Wickenbrock[1], Chris Pankow[3], Samer Afach[1], and Dmitry Budker[1] — [1]Helmholtz Institute, Johannes Gutenberg University, Mainz — [2]University of California, Berkeley, USA — [3]Northwestern University, Evanston, USA

This presentation is prepared on behalf of the GNOME collaboration. GNOME is a novel experimental scheme which enables the investigation of couplings between nuclear spins and exotic fields generated by astrophysical sources. It consists of a network of geographically separated, time synchronized, ultrasensitive ($\sim$ fT/$\sqrt{\text{Hz}}$) optical atomic magnetometers that measure atomic spin precession in multilayer magnetic shielding. Such a configuration enables the study of global transient effects due to non-magnetic interactions.

Currently, there are six magnetometers placed around the world which are able to measure synchronously. This presentation discusses the first techniques used for the analysis of time synchronized data and the results obtained. The algorithm is based on an excess power analysis. It surveys the data looking for regions in the time-frequency space where the power density exceeds the noise floor. This method enables one to find weak signals in a noisy environment without a specific wavelet shape. A 24 h coordinated run is analyzed and the excess power regions are identified. This information is then cross-correlated between the different magnetometers in the network.

A 23.4 Wed 15:30 N 3

On the magnetic interaction between two bound electrons of two separate ions — •Biplab Goswami[1], Andrey Volotka[1], and Stephan Fritzsche[1,2] — [1]Helmholtz-Institut Jena, D-07743 Jena, Germany — [2]Theoretisch-Physikalisches Institut, Friedrich-Schiller-Universität Jena, D-07743 Jena, Germany

The magnetic interaction between bound electrons of two separate ions is investigated with the help of Breit equation. A special attention is paid to the effects beyond the leading order spin-spin interaction. The magnetic dipole-dipole interaction between two ions have been recently studied experimentally [1,2]. In present work, it is found that the spin-orbit interaction, which is usually neglected in an experimental analysis, could play a key role at the distances between ions of about 0.2 μm or smaller.

[1] S. Kotler, N. Akerman, N. Navon, Y. Glickman, and R. Ozeri, Nature **510**, 376 (2014).
[2] F. Dolde, I. Jakobi, B. Naydenov, N. Zhao, S. Pezzagna, C. Trautmann, J. Meijer, P. Neumann, F. Jelezko, and J. Wrachtrup, Nature Phys. **9**, 139 (2013).

A 23.5 Wed 15:45 N 3

Photoexcitation of atoms by Laguerre-Gaussian beams — •Anton Peshkov[1], Daniel Seipt[2,3], Andrey Surzhykov[4,5], and Stephan Fritzsche[1,3] — [1]Helmholtz-Institut Jena, Germany — [2]Lancaster University, United Kingdom — [3]Friedrich-Schiller-Universität Jena, Germany — [4]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [5]Technische Universität Braunschweig, Germany

With the recent experimental advances in optics, it is possible to produce Laguerre-Gaussian (LG) light beams with a non-zero projection of the orbital angular momentum (OAM). During the last few years, it was shown that the OAM may affect the fundamental light-matter interaction processes. In a recent experiment, in particular, it was demonstrated for an atom placed on the axis of the incident LG light beam that the sublevel population of excited atomic states is determined by the beam's OAM [1]. Following this experiment, we investigate theoretically the sublevel population of atoms with an arbitrary position with regard to the axis of the beam. We show that the sublevel population may vary significantly when the atoms are moved away from the beam axis. The population of the excited atoms is also found sensitive to the polarization, radial index, as well as the OAM of the incident LG beam; these effects can be observed experimentally by measuring the angular distribution of the subsequent fluorescence radiation.

[1] C. T. Schmiegelow *et al.*, Nat. Commun. 7, 12998 (2016).
[2] A. A. Peshkov *et al.*, Phys. Scr. 91, 064001 (2016).

A 23.6 Wed 16:00 N 3

State flip at exceptional points in spectra of the hydrogen atom in parallel electric and magnetic fields — •Lukas Oberreiter, Jan Burkhardt, Jörg Main, and Günter Wunner — 1. Institut für Theoretische Physik, Universität Stuttgart, Germany

Resonances, which are unbound and decaying states, can be found in spectra of non-Hermitian Hamiltonians. If the system depends at least on two real parameters, exceptional points can be found at parameter values, where eigenvalues form a branch point singularity, and hence eigenvalues and eigenfunctions coalesce. If exceptional points are encircled on a closed loop in parameter space eigenvalues commute their positions.

A well-suited quantum system to study these effects is the hydrogen atom in parallel electric and magnetic fields due to its theoretical and experimental accessibility. A two-dimensional parameter space is set up by the field strengths. By continuous variation on a closed loop around an exceptional point two resonance states commute. Here it will be investigated whether this commutation behavior of eigenvalues is extendable to population interchange. Therefore the system gets initially prepared in one of the two resonances and the population dynamics for a time dependent parameter loop is calculated. Since these calculations are numerically expensive an approximation method based on a 2×2 matrix will be introduced which only considers the two commuting resonances. The population transfer can be maximized by variation of the loop trajectory's shape and the duration of the encircling.

A 23.7 Wed 16:15 N 3

Transmission Resonance Through a Periodically Driven Impurity — •Christoph Dauer, Axel Pelster, and Sebastian Eggert — State Research Center OPTIMAS and Fachbereich Physik, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany

Recently a one-dimensional tight-binding chain with a temporally oscillating on-site potential acting as an impurity was investigated [1]. Using the Floquet theory a steady-state solution was found, whose transmission shows a non-monotonic behavior with respect to potential strength, driving frequency, and particle energy. For special parameter values a complete vanishing of the one-particle transmission occurs. Such a transmission resonance can be related to the Fano-effect and the interaction with dynamically created bound states in the continuum [2]. Here we perform the continuum limit of a vanishing lattice constant, where we obtain a qualitative similar nontrivial dependence of the transmission coefficient on the respective parameters. Furthermore, we show that the transmission coefficient can not vanish below a critical frequency.

[1] D. Thuberg, S.A. Reyes, and S. Eggert, Phys. Rev. B **93**, 180301(R) (2016)

[2] A.E. Miroshnichenko and Y.S. Kivshar, Phys. Rev. E **72**, 056611 (2005)