FM 76: Entanglement: Spectroscopy

Time: Thursday 14:00–15:30 Location: 1015

Invited Talk FM 76.1 Thu 14:00 1015

Enhancing the precision of measurements with entanglement
— •Manuel Gessner — Département de Physique, École Normale Supérieure, PSL Université, CNRS, 24 Rue Lhomond, 75005 Paris, France — Laboratoire Kastler Brossel, ENS-PSL, CNRS, Sorbonne Université, Collège de France, 24 Rue Lhomond, 75005 Paris, France

Our fundamental understanding of Nature as well as technological developments depend crucially on our ability to implement measurements with better precision. Currently, spectroscopy of atomic frequencies yields some of the most precise measurements and allows us to define time standards with atomic clocks. These measurements are soon expected to reach a classical resolution limit, determined by quantum projection noise, that can only be overcome by making use of quantum strategies. In this talk, we will present an overview of quantum-enhanced methods to improve the sensitivity of intereferometric measurements, such as Ramsey spectroscopy. We will see how the sensitivity of general quantum states can be quantified and how suitable observables for precision measurements can be determined under realistic constraints. Furthermore, we show how entanglement witnesses can be constructed by deriving upper limits on the sensitivity of separable quantum states. We will discuss applications in atomic and photonic experiments.

FM 76.2 Thu 14:30 1015

Quantum discord in squeezed microwaves
— •Kirill G. Fedorov[1,2], Stefan Pogorzalek[1,2], Michael Renger[1,2], Qi-Ming Chen[1,2], Matti Partanen[1], Achim Marx[1], Frank Deppe[1,2,3], and Rudolf Gross[1,2,3] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany — [2]Physik-Department, TU München, 85748 Garching, Germany — [3]Munich Center for Quantum Science and Technology (MCQST), Schellingstr. 4, 80799 Munich, Germany

Quantum discord is known as a general measure for quantum correlations in bipartite systems. It encompasses all nonclassical correlations including entanglement. Quantum discord has many intriguing fundamental properties many of which require experimental verification such as the asymptotic robustness towards environmental noise. We experimentally investigate quantum discord in propagating two-mode squeezed (TMS) microwave states generated with the help of superconducting Josephson parametric amplifiers. We exploit asymmetric noise injection into these TMS states which allows us to demonstrate the robustness of quantum discord as opposed to the sudden death of entanglement. Finally, we discuss the relevance of quantum discord as a resource in quantum communication and sensing , in particular with respect to remote state preparation and quantum radar protocols.

We acknowledge support by the Excellence Cluster MCQST, the Elite Network of Bavaria through the program ExQM, and the European Union via the Quantum Flagship project QMiCS (Grant No. 820505).

FM 76.3 Thu 14:45 1015

Quantum Logic Spectroscopy of Highly Charged Ions
— •Lukas J. Spiess[1], Steven A. King[1], Peter Micke[1], Tobias Leopold[1], Erik Benkler[1], José R. Crespo López-Urrutia[2], and Piet O. Schmidt[1,3] — [1]Physikalisch-Technische Bundesanstalt, Braunschweig — [2]Max-Planck Institut für Kernphysik, Heidelberg — [3]Institut für Quantenoptik, Leibniz Universität Hannover

Highly charged ions (HCI) offer extreme properties, making them suitable candidates for the search for physics beyond the standard model or novel optical clocks [1]. Production and storage of HCI commonly occurs at MK temperatures, limiting the spectroscopic resolution to the hundreds of MHz scale. This has been overcome by sympathetically cooling HCI in a linear Paul trap using Be^+ ions [2].

Ar^{13+} ions are produced in an electron beam ion trap, from where they are extracted, transported to and injected into a Paul trap. A Be^+-Ar^{13+} two-ion crystal is prepared and cooled to its motional ground state. Spectroscopy on the $^2P_{1/2}$ to $^2P_{3/2}$ transition in the Ar^{13+} ion at 441 nm is performed using the quantum logic technique [3]. There, the internal state of the Ar^{13+} ion after laser excitation is transferred to the Be^+ ion through their shared motional mode for readout. The achieved sub Hz resolution gives insight into relativistic, interelectronic and QED contributions to the excited state g-factor. The first optical clock based on a HCI is also demonstrated.

[1] M. G. Kozlov *et al.*, Rev. Mod. Phys. 90, 045005 (2018)
[2] L. Schmöger *et al.*, Science 347 1233-1236 (2015)
[3] P. O. Schmidt *et al.*, Science 309 749 (2005)

FM 76.4 Thu 15:00 1015

Nonlinear spectroscopy with nonclassical light
— •Fabiano Lever and Markus Ghuer — Universitaet Potsdam

In this work, we explore the quantum-classical transition comparing a classical pump-probe experiment on a diatomic molecule to its quantum enhanced counterpart, where the pump and probe pulses are substitued by the signal and idler beams of a SPDC source.

Two photon absoption of biphotons generated with Spontaneous Parametric Down Conversion (SPDC) exploits quantum time-energy correlations to enhance the overall yeld and selectivity of the process, when compared with a classical pump-probe setup, while mantaining femtosecond time resolution. The results indicate that the quantum improvements in yeld are caused by a more efficient use of the total power available for the process.

FM 76.5 Thu 15:15 1015

Quantum-enhanced imaging for life science
— •Marta Gilaberta Basset, Josué R. León Torres, and Markus Gräfe — Fraunhofer Institute for Applied Optics and Precision Engineering IOF, Albert-Einstein-Straße 7, 07745 Jena

Nowadays, quantum physics turned from purely fundamental science to a research field with real-life applications. In particular, quantum photonics promises novel approaches for quantum enhanced-imaging. For instance quantum imaging with undetected photons was first implemented by the Zeilinger group in Vienna. Based on Mandels induced coherence, it becomes possible to image an object with light that never interacted at all with the object. It is worth to explicitly mentioned, thtat in stark contrast to Ghost imaging, here neither any coincidence detection is necessary nor any detection of the light that interacted with the object. By exploiting non-degenerated spontaneous parametric down conversion, photon pairs with large wavelength difference can be harnessed. The obvious advantage of this technique is that the wavelength of the idler photons can be tailored to match the interesting spectral range of the object (e.g. far IR, THz, deep UV). At the same time, the signal photons, which are actually detected, can stay in the VIS range where, e.g., Si-based detectors are optimized. We present a revised implementation of this imaging scheme. Our ansatz delivers a robust, miniaturized and mobile realization, by employing a single crystal scheme. Hence, it allows to record quantum images at video rate.