Q 60: Quanteneffekte: Dekohärenz

Zeit: Freitag 10:30–12:30 Raum: VMP 6 HS-D

Q 60.1 Fr 10:30 VMP 6 HS-D

Towards homodyne tomography of atomic states — •Jürgen Appel, Anne Louchet, Ulrich Busk Hoff, Daniel Oblak, Patrick Windpassinger, Niels Kjaergaard, and Eugene Polzik — Niels Bohr Institute, Copenhagen, Denmark

The collective enhancement of the coupling between light and atomic ensembles provides a mapping of the quadrature operators of the light field onto quasi-spin variables of atoms. This enables the demonstration of central building blocks of quantum technology such as entanglement, quantum memory, single-photon generation and teleportation. Recently [1] we presented a light shot noise limited method to perform quantum non-demolition measurements of the atomic state, and thus conditionally prepared an entangled and spin squeezed state of 10^5 atoms. I will report about our recent progress towards using this dispersive probing method for performing full tomography of the atomic quasi-spin state, in analogy to homodyne detection of light. We investigate the effect of our QND probing on the coherence between the atomic states and analyze the effect of phase noise of our microwave oscillator on these measurements.

[1] J. Appel et al. Arxiv 0810.3545 (2008)

Q 60.2 Fr 10:45 VMP 6 HS-D

Non-destructive quantum state measurements — •Patrick Windpassinger, Daniel Oblak, Ulrich Hoff, Jürgen Appel, Niels Kjaergaard, and Eugene S. Polzik — QUANTOP, Niels Bohr Institute, Copenhagen, Denmark

Quantum non-demolition probing of a collective atomic (pseudo)-spin is a powerful instrument in quantum information processing and control. We present a method for non-destructive probing on the clock transition of laser-cooled, dipole trapped Cs atoms. The phase shift imposed by the atomic sample on an off-resonant probe laser beam is determined with a Mach-Zehnder interferometer.

The non-destructive probing also allows to follow online the evolution of the population difference of the Cs-atom clock states when subjected to microwave fields. This allows us to observe Rabi oscillations on the clock transition non-destructively over an extended period of time, which should yield a significant improvement of the signal-to-noise ratio compared to the traditional fluorescence-based destructive probing. The talk focusses specifically on the the effect of the probe-induced inhomogeneous light-shift and of the destructive probe-induced spontaneous photon scattering.

[1] P. Windpassinger et. al, Phys. Rev. Lett. 100, 103601 (2008)
[2] P. Windpassinger et. al, New J. Phys. 10, 053032 (2008)
[3] D. Oblak et. al, EPJ D 50, 67 (2008)

Q 60.3 Fr 11:00 VMP 6 HS-D

Identifying and probing complex environments with optomechanical systems — •Konrad Kieling[1], Alexey Trubarov[2], Markus Aspelmeyer[2], and Jens Eisert[1] — [1]Institut für Physik and Astronomie, Universität Potsdam, Potsdam, Germany — [2]Institut für Quantenoptik und Quanteninformation, Vienna, Austria

Optomechanical systems offer the perspective of driving mechanical modes to close to the quantum ground state by a suitable radiation pressure coupling to the light field of a cavity. In this work, we study the influence of complex thermal baths to which the mechanical mode is coupled, and discuss effects of non-Ohmic damping. Complementary to efforts of cooling down the mirror to observe quantum mechanical behaviour, a new perspective of using such systems will be presented. We will discuss ideas of using the mechanical mirror at a finite temperature as an ultrasensitive device to probe properties of complex baths – which are unaccessible so far. This is done without making any possibly unjustified assumptions: Using the device as a black box in systems identification, one can think of certifiably and quantitatively probing properties of decohering environments.

Q 60.4 Fr 11:15 VMP 6 HS-D

Qubit protection in nuclear-spin quantum dot memory — •Zoltan Kurucz[1,2], Jakob M. Taylor[3], Mikhail D. Lukin[4], and Michael Fleischhauer[1] — [1]Fachbereich Physik, Univ. of Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Department of Physics and Astronomy, University of Aarhus, DK-8000 Aarhus — [3]Dept. of Physics, MIT, Cambridge, MA 02139, USA — [4]Dept. of Physics, Harvard Univ. Cambridge, MA 02138, USA

Nuclear spins in semiconductor nanostructures are excellent candidates for storing quantum information. While they are largely decoupled from their environment and have long intrinsic lifetimes, the hyperfine interaction with electron spins allows one to access ensembles of nuclear spins in a controlled way. In particular, the quantum state of an electron spin can be coherently mapped onto the nuclear spins constituting a quantum dot, thus giving rise to a collective quantum memory [1]. Nevertheless, memory lifetimes are limited, e.g., by dipole-dipole interactions among the nuclei. In the talk we demonstrate that the presence of the electron can substantially reduce the decoherence of this collective memory. The hyperfine-induced dynamic Stark shift energetically isolates the storage states from the rest of the Hilbert space and protects them against nuclear spin flips and spin diffusion. We show that our scheme is robust against the deleterious effects of inhomogeneous Knight shift and we also analyze the case when the nuclear spins are not perfectly polarized.

[1] J. M. Taylor, C. M. Marcus, M. D. Lukin, Phys. Rev. Lett. 90, 206803 (2003); J. M. Taylor, A. Imamoglu, M. D. Lukin, Phys. Rev. Lett. 91, 246802 (2003)

Q 60.5 Fr 11:30 VMP 6 HS-D

Decoherence of multiparticle entanglement — •Otfried Gühne[1], Fabian Bodoky[2], and Miriam Blaauboer[2] — [1]Inst. für Quantenoptik und Quanteninformation, ÖAW, A-6020 Innsbruck — [2]Kavli Institute of Nanoscience, Delft University of Technology, NL-2628 CJ Delft

Decoherence of quantum states is a fundamental obstacle for implementations of quantum information processing. Therefore, it is interesting to know how the entanglement of a multiparticle quantum state is affected by decoherence and how this depends on the state and the number of qubits. This is, however, difficult to investigate, since most entanglement measures are practically impossible to compute for mixed states.

In this contribution we present a method to determine the decay of quantum correlations as quantified by the geometric measure of entanglement under the influence of decoherence. With this, one can compare the robustness of entanglement in GHZ, cluster, W and Dicke states of four qubits and show that the Dicke state is most robust. Furthermore, the method allows to compare different decoherence models and to investigate the scaling of the entanglement decay for an increasing number of particles.

Q 60.6 Fr 11:45 VMP 6 HS-D

Emergence of pointer states in a non-perturbative environment — •Marc Busse and Klaus Hornberger — Arnold Sommerfeld Center for Theoretical Physics, Ludwigs-Maximilians-Universität München

The influence of environmental degrees of freedom on a quantum system typically leads to a superselection of a specific set of robust system states, called pointer states. Most characteristically, any superposition of these states gets rapidly mixed, while the only stable states are the pointer states themselves.

We study the emergence and dynamics of pointer states in the motion of a quantum test particle affected by collisional decoherence. We demonstrate that the complete set of pointer states is obtained by the solitonic solutions of the nonlinear equation suggested in [1]. They yield the expected probabilities, and move according to the corresponding classical equations of motion. In contrast to linear coupling models, the pointer basis turns out to be non-Gaussian, with a width determined by both the mean free path and the thermal de-Broglie wavelength of the gas environment. This result allows us to estimate the coherence length of atoms in interacting thermal gases.

[1] L. Diosi and C. Kiefer, Phys. Rev. Lett. 85, 3553 (2000).

Q 60.7 Fr 12:00 VMP 6 HS-D

Scalability of GHZ and random-state entanglement in the presence of decoherence — •de Melo Fernando[1], Leandro Aolita[2], Daniel Cavalcanti[2], Antonio Acin[2,3], Alejo Salles[4,1], Markus Tiersch[1], and Andreas Buchleitner[1] — [1]Physikalisches Institut, Albert-Ludwigs-Universität Freiburg — [2]ICFO - Institut de Ciències Fotòniques — [3]ICREA - Institució Catalana de Recerca i Estudis Avançats — [4]Instituto de Física, Universidade Federal do Rio de Janeiro

We derive analytical upper bounds for the entanglement of generalized Greenberger-Horne-Zeilinger (GHZ) states locally coupled to dephasing, depolarizing, and thermal reservoirs. The derivation is carried out under very weak constraints, and holds for any convex quantifier of entanglement.

The obtained bounds reveal an exponential entanglement decay with the number of qubits – the robustness of the generalized GHZ states decreases exponentially with the system size. This poses a severe limitation to many quantum communication protocols.

A comparison between the entanglement decay of randomly generated states with the GHZ family shows that the former decays slower, thus violating the previously obtained bounds. Furthermore, the random state's entanglement is *more robust* against noise for *larger* system size.

Q 60.8 Fr 12:15 VMP 6 HS-D

Decoherence of the electron spin of NV-centers in Diamond — •Florian Rempp[1], Norikazu Mizuochi[2], Phillipp Neumann[1], Johannes Beck[1], Vincent Jacques[1], Petr Siyushev[1], K. Nakamura[3], D. Twichen[4], H. Watanabe[5], S. Yamasaki[6], Fedor Jelezko[1], and Jörg Wrachtrup[1] — [1]Universität Stuttgart, germany — [2]University of Tsukuba, Japan — [3]Tokyo Gas Co., Tokyo, Japan — [4]Element Six Ltd., Ascot, UK — [5]AIST, Tsukuba, Japan — [6]AIST, Tsukuba, Japan

Nitrogen-vacancy color centers (NV-center) in diamond with proximal ^{13}C nuclear spins are one of the promising candidates for solid state quantum computers.

One of the main assets of the NV-center is the optical accessibility of single spins while showing exceptional long T_1 and T_2 times due to low residual spin density and the fact, that nearly no phonons are exited at room temperature.

We measured the T_2^* for various NV-centers at different concentrations of $^{1}3C$ and found good agreement with a pure dipole-dipole-interaction Model.