Q 66: Quantum effects: Entanglement and decoherence II

Time: Friday 14:00–15:45 Location: A 310

Group Report Q 66.1 Fri 14:00 A 310

Entanglement between two defects mediated by a surrounding chain — •Bruno G. Taketani[1], Thomás Fogarty[2], Endre Kajari[1], Pierre Wendenbaum[1,3], Alexander Wolf[1], Dragi Karevski[3], Thomas Busch[2], and Giovanna Morigi[1,4] — [1]Universität des Saarlandes, Saarbrücken, Germany — [2]University College Cork, Cork, Ireland — [3]Université de Lorraine, Nancy, France — [4]Universitat Autònoma de Barcelona, Bellaterra, Spain

Bath-mediated entanglement between two objects refers to the generation of entanglement between two physical systems which originates from the coupling with a common reservoir. Examples have been reported showing situations where the generated entanglement is stationary. An open question is how stationary entanglement, generated by the coupling with a bath scales with the distance between the objects. We consider this question by analysing two impurity defects embedded in a crystal structure, like an array of ions in a Paul trap. Entanglement is found for sufficiently cold chains and for a certain class of initial, separable states of the defects. It results from the interplay between localized modes which involve the defects and the interposed ions, it is independent of the chain size, and decays slowly with the distance between the defects. These dynamics can be observed in systems exhibiting spatial order: viable realizations are optical lattices, optomechanical systems, or cavity arrays in circuit QED.

These studies are then extended to the case in which instead of oscillators one considers a spin chain embedding two defect spins.

Q 66.2 Fri 14:30 A 310

Smooth Optimal Control of Nitrogen-Vacancy Centers — •Björn Bartels[1], Tobias Nöbauer[2], Johannes Majer[2], and Florian Mintert[1] — [1]Freiburg Institute for Advanced Studies, Albert-Ludwigs-Universität Freiburg, Albertstr. 19, 79104 Freiburg, Germany — [2]Vienna Center for Quantum Science and Technology, Atominstitut, Technische Universität (TU) Wien, Stadionallee 2, 1020 Vienna, Austria

We present pulse shaping techniques that allow us to control ensembles of NV centers with external time-dependent fields that contain only a few predefined frequency components. By doing this, we respond to experimental challenges in implementing the broad band pulses typically generated with existing optimal control algorithms. With our approach we target the design of control pulses for the manipulation of ensembles of NV centers and the interaction of such ensembles with microwave cavities. We construct high fidelity pulses that cope with inhomogeneous broadening in the ensemble as well as inhomogeneity in the control field itself.

Q 66.3 Fri 14:45 A 310

Dissipative preparation of steady-state multipartite entanglement — •Cecilia Cormick, Alejandro Bermudez, Susana F. Huelga, and Martin B. Plenio — Universität Ulm, Institut für Theoretische Physik, Ulm, Germany

We propose a method to create multipartite-entangled states of spin systems by means of engineered dissipative processes. The model we consider consists of a spin chain along which excitations are allowed to hop, while the on-site energy can be shifted by the coupling to a harmonic oscillator. We show that for small chains, by damping the harmonic oscillator the system can be driven towards an entangled asymptotic state which corresponds to the ground state of an XX spin chain with transverse field. We discuss the role of non-Markovianity of the environment and propose an implementation using ions in a linear trap.

Q 66.4 Fri 15:00 A 310

Quantum-Dense Read-Out for Interferometric Measurements — •Melanie Meinders, Sebastian Steinlechner, Jöran Bauchrowitz, Helge Müller-Ebhardt, Karsten Danzmann, and Roman Schnabel — Institut für Gravitationsphysik, Leibniz Universität Hannover and Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut), Callinstr. 38, 30167 Hannover, Germany

The sensitivity of interferometric measurements is affected by scattered, frequency shifted photons, so-called parasitic interferences [1]. In gravitational-wave detectors, parasitic interferences are possibly already a limiting factor in the lower audio-band. Future detectors that use higher laser powers will even be stronger disturbed by this kind of noise. In this talk we present a new read-out scheme which allows for the detection of two orthogonal quadratures with uncertainties below that of the meter's ground state. In contrast to science signals in the phase quadrature, parasitic signals due to scattered light have an arbitrary orientation in phase space. Therefore, our read-out scheme can be utilized to identify such signals. The scheme uses entangled, two-mode-squeezed states of light and was experimentally demonstrated on the basis of a table-top Michelson interferometer. In our setup a non-classical noise suppression of ~6dB was achieved in both quadratures.

[1] H. Vahlbruch, S. Chelkowski, K. Danzmann, R. Schnabel, Quantum engineering of squeezed states for quantum communication and metrology, New J. Phys. 9, 371 (2007).

Q 66.5 Fri 15:15 A 310

Dissipative Preparation of Spin Squeezed Atomic Ensembles in a Steady State — •Johannes Otterbach[1], Emanuele Dalla Torre[1], Eugene Demler[1], Vladan Vuletic[2], and Mikhail Lukin[1] — [1]Physics Department, Harvard University — [2]Physics Department, Massachussetts Institute of Technology

Spin squeezed states have attracted substantial interest over the last decades from fundamental and application points of view to study many-body entanglement and improve high-precision spectroscopy. One limiting factor for squeezing is the coupling to the environment which usually has detrimental effects on the generation and entanglement fidelity of these states. Here we present a scheme for the deterministic generation of spin squeezed states in coherently driven atomic ensemble of effective spin-1/2 particles collectively interacting with a strongly decaying cavity mode, thus turning dissipation into a resource for entanglement. We show that there exists a dark-state of the cavity dissipation exhibiting squeezing bounded only by the Heisenberg limit and calculate the timescale to reach this state. Upon taking spontaneous atomic scattering into account we find that the steady state is unique and independent of the initial state, and thus squeezing is generated by optical pumping. Finally we determine the general scaling of the squeezing as a function of the single-atom cooperativity and the number of atoms.

Q 66.6 Fri 15:30 A 310

Entanglement of two trapped ions via an optical resonator — •Bernardo Casabone[1], Konstantin Friebe[1], Andreas Stute[1], Birgit Brandstätter[1], Klemens Schueppert[1], Tracy Northup[1], and Rainer Blatt[1,2] — [1]Institut für Experimentalphysik, Universität Innsbruck, Technikerstrasse 25, 6020 Innsbruck, Austria — [2]Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften, Otto-Hittmair-Platz 1, 6020 Innsbruck, Austria

It is often proposed to use cavities at nodes of quantum networks as they provide a natural interface between matter and light. By working with just a few trapped ions, one can explore the cavity-mediated interactions between multiple particles while still enjoying the degree of control available in single-ion experiments. We present results of entanglement between two $^{40}Ca^{+}$ ions via coupling to the same mode of a resonator. The ions are stored in a linear ion trap and coupled to two degenerate polarization modes of a high-finesse optical resonator. A single photon is generated in one of the two polarization modes from each ion using a bichromatic Raman transition. By detecting one photon in each polarization mode the two ions are projected onto an entangled state. Entanglement is detected using parity oscillations. A fidelity up to $(92.7 \pm 2.7)\%$ with respect to the maximally entangled Bell state $\sqrt{1/2}(|10\rangle + |01\rangle)$ is reported. The results illustrate precise control of the ions' position in the standing wave and hence of the ion-cavity coupling.