Q 19: Quantum Optics II

Time: Tuesday 14:00–16:00 Location: f342

Invited Talk Q 19.1 Tue 14:00 f342

Interplay of dissipative and coherent processes in engineered quantum systems — •Anja Metelmann — Free University Berlin, Berlin, Germany

The concept of dissipation engineering has enriched the methods available for state preparation, dissipative quantum computing and quantum information processing. Combining such engineered dissipative processes with coherent dynamics allows for new effects to emerge. For example, we found that any factorisable (coherent) Hamiltonian interaction can be rendered nonreciprocal if balanced with the corresponding dissipative interaction. In this talk, we illustrate the basic recipe on how to realize nonreciprocity via reservoir engineering, and show that the dissipative process by itself can yield a purely unitary evolution on one subsystem.

Q 19.2 Tue 14:30 f342

Dynamical phase transitions in a chiral spin chain — •Giuseppe Buonaiuto[1,2], Ryan Jones[1,2], Beatriz Olmos[1,2], and Igor Lesanovsky[1,2] — [1]Institut für Theoretische Physik, Auf der Morgenstelle 14, Universität Tübingen, D-72076 Tübingen, Germany — [2]School of Physics School of Physics and Astronomy, University of Nottingham, Nottingham NG7 2RD, United Kingdom

Open quantum systems with chiral interactions can be realized by coupling atoms to guided radiation modes to waveguides. In their steady state these systems can feature intricate many-body phases such as entangled dark states, but their detection and characterization remains a challenge. We show that the counting statistics of the photons emitted into the waveguide provides a means to detect and characterize the many-body state of a chiral atom chain. Our approach [1] exploits that the guided photons do not only induce interactions between the emitters, but also carry information about their quantum state. This perspective allows to probe intricate dynamical phenomena such as transitions and the coexistence between dynamical phases. In the latter case, entangled states may occur as fluctuations in an intermittent dynamics and are heralded through characteristic features of the time-resolved photon count signal. Our approach also permits to systematically assess the effect of inevitable imperfections, such as the emission of photons into unguided modes

[1]G. Buonaiuto et al., *Dynamical creation and detection of entangled many-body states in a chiral atom chain*, *N. J. P.*, **21**, **11**, 2019

Q 19.3 Tue 14:45 f342

Chiral and correlated atoms driven by non-classical states of light — •Kevin Kleinbeck and Hans Peter Büchler — ITP 3, University of Stuttgart

Many quantum-optical systems consists of a bosonic field (e.g. photons) coupled to an atom-like subsystem, A full descriptions of the boson-atom system is in all but the most trivial cases a cumbersome endeavour, therefore typically just the atomic subsystem is considered, described by the quantum-optical master equation. The master equation enables to the calculations of atomic expectation values and, by the use of input-output relations, expectation values of the bosonic fields. For generic systems, however, correlation functions are inapproachable in this description.

We show, for systems with a chiral interaction (i.e., no backscattering of light) the quantum-optical master equation becomes an exact description, even for correlation functions. For the derivation of the master equation we use the Keldysh formulation, with which we also show how the scattering of non-classical states of light can be included in the master equation. As an example we consider the interaction of light with Rydberg superatoms.

Q 19.4 Tue 15:00 f342

Spinor self-ordering of thermal atoms in an optical cavity — •Luigi Giannelli, Simon Jäger, and Giovanna Morigi — Theoretische Physik, Universität des Saarlandes, 66123 Saarbrücken, Germany

We theoretically analyze the dynamics of cold atomic spins in a single-mode standing-wave cavity as a function of the intensity and relative phase of two transverse lasers, driving the atoms. We identify and discuss the conditions under which stable spatial patterns form, where atomic position and spin phase are correlated. We analyze spin-motion correlations and their dynamics. We finally analyze the properties of the light emitted by the cavity as a method to reveal the state of the system.

Q 19.5 Tue 15:15 f342

Observation of squeezed light from weakly coupled emitters — Jakob Hinney[1], Adarsh Prasad[1], Sahand Mahmoodian[2,3], Klemens Hammerer[2], Arno Rauschenbeutel[4], Samuel Rind[1], Philipp Schneeweiss[4], Anders Sørensen[3], Jürgen Volz[4], and •Max Schemmer[4] — [1]TU Wien, Atominstitut, Austria — [2]Leibniz University Hannover, Germany — [3]Niels Bohr Institute, University of Copenhagen, Denmark — [4]Humboldt-Universität zu Berlin, Germany

We show that the propagation of resonant light through an ensemble of weakly coupled emitters results in the generation of non-classical light. This manifest itself in a change in photon statistics [1]. Here, we present a study of the properties of the transmitted light through the ensemble via measuring the quadrature-squeezing of the transmitted light. The emitters consist of laser cooled Cesium atoms that evanescently couple to the light in the nanofiber. The dependence of the squeezing on input power and input detuning agrees well with theoretical predictions based on [2]. Furthermore, we are able to resolve the squeezing spectrum which reveals the spectral characteristics of the correlated photons that are generated in this process and which lie at the origin of the non-classical nature of the process.

[1] Prasad, A., et al. arXiv 1911.09701 2019

[2] Mahmoodian, S., et al. Phys. Rev. Lett. 2018

Q 19.6 Tue 15:30 f342

Collectively enhanced chiral photon emission from an atomic array near a nanofiber — Ryan Jones[1], Giuseppe Buonaiuto[1,2], Ben Lang[1], Igor Lesanovsky[1,2], and •Beatriz Olmos[1,2] — [1]School of Physics and Astronomy and Centre for the Mathematicsand Theoretical Physics of Quantum Non-Equilibrium Systems,The University of Nottingham, Nottingham, NG7 2RD, United Kingdom — [2]Institut für Theoretische Physik, Universität Tübingen, Auf der Morgenstelle 14, 72076 Tübingen, Germany

Emitter ensembles interact collectively with the radiation field. In the case of a one-dimensional array of atoms near a nanofiber, this collective light-matter interaction does not only lead to an increased photon coupling to the guided modes within the fiber, but also to a drastic enhancement of the chirality in the photon emission. We show that near-perfect chirality is already achieved for moderately-sized ensembles, containing 10 to 15 atoms. This is of importance for developing an efficient interface between atoms and waveguide structures with unidirectional coupling, with applications in quantum computing and communication such as the development of non-reciprocal photon devices or quantum information transfer channels.

Q 19.7 Tue 15:45 f342

Transferring entanglement from the spin domain to distinct momentum states — •Fabian Anders, Alexander Idel, Bernd Meyer, and Carsten Klempt — Institut für Quantenoptik, Leibniz Universität Hannover

Many-particle entangled states are commonly prepared in the spin degree of freedom of cold atoms. Within the spin domain entangled states such as the twin-Fock state allow for enhancement of Ramsey measurements beyond the standard quantum limit (SQL). For the application in atom interferometry, however, entanglement between distinct momentum states is needed. We adiabatically prepare twin-Fock states in two spin levels of a spinor Bose-Einstein condensate. By applying a Raman laser coupling we transfer one of the two spin levels to a finite momentum state. I will show first results on the verification of entanglement and present a scheme that allows for gravimetry beyond the SQL.