Q 34: Quantum Information (Quantum Communication)

Time: Tuesday 14:00–15:45 Location: K 1.020

Q 34.1 Tue 14:00 K 1.020

Coherent state coding approaches the capacity of non-Gaussian bosonic channels — •Stefan Huber and Robert König — Institute for Advanced Study & Zentrum Mathematik, Technische Universität München, 85748 Garching, Deutschland

The additivity problem asks if the use of entanglement can boost the information-carrying capacity of a given channel beyond what is achievable by coding with simple product states only. This has recently been shown not to be the case for phase-insensitive one-mode Gaussian channels, but remains unresolved in general. Here we consider two general classes of bosonic noise channels, which include phase-insensitive Gaussian channels as special cases: these are beamsplitters with general, potentially non-Gaussian environment states and classical noise channels with general probabilistic noise. We show that additivity violations, if existent, are rather minor for all these channels: the maximal gain in classical capacity is bounded by a constant independent of the input energy. Our proof shows that coding by simple classical modulation of coherent states is close to optimal.

Q 34.2 Tue 14:15 K 1.020

Optimal storage of a single photon in a single atom — •Luigi Giannelli[1], Tom Schmit[1], Stephan Ritter[2], Gerhard Rempe[2], and Giovanna Morigi[1] — [1]Theoretische Physik, Universität des Saarlandes, 66123 Saarbrücken, Germany — [2]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Strasse 1, 85748 Garching, Germany

We theoretically analyze the dynamics of a single photon propagating in free space and incident on the mirror of an optical cavity, in which an atom is trapped. Our purpose is to control the dynamics in order to store the photon in an atomic excitation. The cavity is modeled by a single mode and the relevant electronic states of the atom form a three-level Λ-system: one transition is coupled to the quantized field of the cavity via Jaynes-Cummings interaction, while the other transition is driven by a classical control field $\Omega(t)$. We optimize the temporal behavior of $\Omega(t)$ for the purpose of perfect photon storage. We consider several dissipative processes and compare the efficiency of adiabatic protocols, such as in [1-3]. We then develop a protocol in order to optimize the adiabatic transfer in presence of dissipative processes and determine its maximal fidelity. We then investigate the quantum speed limit of photon storage by means of optimal control theory (GRAPE algorithm).

[1] M. Fleischhauer, et al., Opt. Commun. 179, 395 (2000).
[2] A. V. Gorshkov, et al., Phys. Rev. A 76, 033804 (2007).
[3] J. Dilley, et al., Phys. Rev. A 85, 023834 (2012).

Q 34.3 Tue 14:30 K 1.020

Quantum state teleportation from a single ion to a single photon by heralded absorption — •Jan Arenskötter, Stephan Kucera, Matthias Kreis, Pascal Eich, Philipp Müller, and Jürgen Eschner — Universität des Saarlandes, Experimentalphysik, Campus E2.6, 66123 Saarbrücken

Quantum networks with trapped ions require interfaces between the nodes and channels and a resource of entanglement for long distance communication. Photon-pair sources based on spontaneous parametric down-conversion (SPDC) and tailored to match an atomic transition are such a resource [1]. Quantum state teleportation [2] provides a protocol for atom-photon interfaces, alternative to direct quantum state transfer [3].

We show the teleportation of a qubit encoded in the $D_{5/2}$ Zeeman sub-levels of the $^{40}Ca^+$ ion onto the polarization qubit of a single 854 nm photon. For this we use a cavity-enhanced SPDC source in Sagnac configuration, tunable and bandwidth-optimized for resonant interaction with the $^{40}Ca^+$ ion. The Bell state measurement of the teleportation protocol is implemented through heralded absorption of one photon of the pair [4]. The mean process fidelity of the teleportation after background correction is 86.3(23)%, and the mean overlap fidelity of the input states with the measured output states is 89.6(55)%.

[1] Haase et al., Opt. Let. **34**, 55 (2009).
[2] Bennett et al., Phys. Rev. Lett. **70**, 1895 (1993)
[3] Kurz et al., Phys. Rev. A **93**, 062348 (2016).
[4] Kurz et al., Nat. Commun. **5**, 5527 (2014).

Q 34.4 Tue 14:45 K 1.020

Propagation of high-dimensional twisted photons through atmospheric turbulence — •Timon Eichhorn, Giacomo Sorelli, Vyacheslav N. Shatokhin, and Andreas Buchleitner — Albert-Ludwigs-Universität, Freiburg i. Br.

Twisted photons are single excitations of electro-magnetic field modes characterized by helical phase fronts, and thus carry orbital angular momentum (OAM). The infinite dimension of the underlying Hilbert space makes these light modes potentially suitable for free space quantum communication. The main hurdle towards the latter application is the instability of twisted photons against turbulence-induced scattering into states lying outside the encoding subspace, leading, as a result, to the loss of information. We seek to identify high-dimensional OAM states which are most robust under such conditions, and present analytical as well as numerical results for the robustness of single photon superpositions of up to thirty OAM states.

Q 34.5 Tue 15:00 K 1.020

Protecting entanglement of twisted photons by adaptive optics — •Giacomo Sorelli[1], Nina Leonhard[2], Vyacheslav N. Shatokhin[1], Claudia Reinlein[2], and Andreas Buchleitner[1] — [1]Physikalisches Institut, Albert-Ludwigs-Unversität Freiburg i. Br. — [2]Fraunhofer Institute for Applied Optics and Precision Egineering, Jena

Spatial excitations of the electromagnetic field carrying orbital angular momentum (OAM), often called twisted photons, can be used to encode high dimensional quantum (entangled) states. These states are not only of fundamental interest, but also practically useful, since they can enhance channel capacity and security in quantum communication. However, transmission across a turbulent atmosphere introduces random phase-fluctuations of the photon's wavefront that destroy the information therein encoded. In this talk we consider the propagation of OAM entangled qutrit and ququart states. We show how phase front correction by methods of adaptive optics can significantly reduce crosstalk to OAM modes outside the encoding subspace, and thereby improve stability of high dimensional entanglement in atmospheric turbulence.

Q 34.6 Tue 15:15 K 1.020

Can the EPR paradox be resolved without recourse to non-locality? — •Keerthan Subramanian[1,3] and Nirmal Viswanathan[2] — [1]Centre for Interdisciplinary Sciences, Tata Institute of Fundamental Research, Hyderabad 500107, India — [2]School of Physics, University of Hyderabad, Hyderabad 500046, India — [3]Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, 69120 Heidelberg, Germany

Quantum mechanics is correct, but is it complete? This was the question raised by Einstein, Podolsky and Rosen(EPR) in 1935 through a gedanken experiment. Thanks to the work of Bohm and Bell states suggested by EPR were found to have mutually exclusive quantitative predictions from classical and quantum theories.

Most experiments that have been used to resolve the paradox have used non-locally correlated(aka entangled states) to demonstrate strong correlations in line with quantum mechanical predictions. Such experiments typically make use of the spin angular momentum(SAM) of photons. However, photons can also possess an orbital angular momentum(OAM) which is related to phase helicities. We demonstrate an interferometric scheme to perform OAM projections which when combined with SAM projections can measure correlations between the two. Subsequently by creating locally correlated SAM/OAM photon states that are non-separable and mathematically isomorphic with non-locally correlated states, we demonstrate strong correlations violating Bell's inequality thereby resolving the EPR paradox without recourse to non-locality.

Q 34.7 Tue 15:30 K 1.020

Distillation of Squeezing using an engineered downconversion source — •Thomas Dirmeier[1,2], Johannes Tiedau[3], Imran Khan[1,2], Vahid Ansari[3], Christian R. Müller[1,2], Christine Silberhorn[3], Christoph Marquardt[1,2], and Gerd Leuchs[1,2] — [1]Max Planck Institut für die Physik des Lichts, Staudtstr. 2, 91058 Erlangen — [2]Institut für Optik, Information und Photonik, FAU Erlangen-Nürnberg, Staudtstr. 7, 91058 Erlangen — [3]Integrierte

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Squeezed states are of interest in the quantum information processing or metrology context due to their distinguished non-classical feature - the noise reduction below shot noise in one of their phase quadratures. However, they are highly susceptible to losses during transmission.

This degradation can partially be countered by using suitable measurement protocols such as squeezing distillation. Our squeezing distillation protocol is based on subtracting photons from the squeezed modes and triggering a homodyne measurement on successful subtraction events. In our experiment, we optimize the operation parameters by employing an engineered PPKTP waveguide source to generate our squeezed states. With this, our source fulfills the demands of both, photon counting and homodyne measurements: a high brightness and a well-behaved spatial and spectral mode structure.