Q 69: Quanteninformation: Kommunikation

Time: Friday 14:00–16:00 Location: V38.04

Q 69.1 Fri 14:00 V38.04

High-fidelity polarisation storage in a broadband quantum memory — Duncan G. England[1], Patrick S. Michelberger[1], •Tessa F. M. Champion[1], Klaus F. Reim[1], Ka Chung Lee[1], Michael R. Sprague[1], Xian-Min Jin[1,2], Nathan K. Langford[1], William S. Kolthammer[1], Joshua Nunn[1], and Ian A. Walmsley[1] — [1]Department of Physics, University of Oxford — [2]Centre for Quantum Technologies, National University of Singapore

Quantum memories are an essential requirement for the efficient distribution of quantum information across large-scale quantum networks. Coherent storage and on-demand retrieval of polarisation-encoded information is demonstrated for the first time in a broadband quantum memory. Based on the far-off-resonant Raman interaction, our memory protocol allows storage of sub-nanosecond light pulses in a room-temperature caesium vapour. The polarisation of weak coherent states is stored in a dual-rail Raman memory inside a polarisation interferometer. Full process tomography of the system reveals process fidelities of up to 97±1% for the storage and retrieval processes. For longer storage times, the process fidelities remain high despite decreased memory efficiencies. The memory's ability to preserve polarisation information is therefore largely insensitive to loss. In particular, a process fidelity of 86±4% is found for a storage time of 1.5μs, which is 5000 times longer than the pulse duration itself. Hence, high-fidelity storage is combined with a large time-bandwidth product in a technically simple room-temperature device. This demonstrates the Raman memory's suitability for integration into large-scale quantum networks.

Q 69.2 Fri 14:15 V38.04

Quantum repeaters and QKD: analysis of se- cret key rates — •Silvestre Abruzzo[1], Sylvia Bratzik[1], Hermann Kampermann[1], Dagmar Bruss[1], Nadja K. Bernardes[2], and Peter van Loock[2] — [1]Heinrich-Heine-Universität Düsseldorf, Institut für Theoretische Physik III, Düsseldorf, Germany — [2]Optical Quantum Information Theory Group, Max Planck Institute for the Science of Light, Erlangen, Germany

Quantum repeaters[1] were proposed as a solution for increasing the distance between two parties who wish to extract a secret key using quantum key distribution. We study memory-based quantum repeaters which use entanglement distillation at most in the first nesting level. We consider three different repeater architectures: optical schemes based on the original repeater proposal [1], more advanced heralded schemes employing atomic ensembles and linear optics [2], and so-called hybrid quantum repeaters using single spins and bright light sources [3]. For each of these three models we calculate the asymptotic secret key rate and we estimate the minimal amount of resources and the minimal quality of the devices of the experimental set-up permitting to extract a secret key.

[1] H. J. Briegel et al., Phys. Rev. Lett. 81, 5932-5935 (1998).
[2] J. Minář et al., arXiv:1111.5185v1 [quant-ph]
[3] P. van Loock et al., Phys. Rev. Lett. 96, 240501 (2006).

Q 69.3 Fri 14:30 V38.04

Quantum repeaters and quantum key distribution: the influence of distillation on the secret key rate — •Sylvia Bratzik, Hermann Kampermann, and Dagmar Bruss — Heinrich-Heine-Universität, Institut für theoretische Physik III, Universitätsstr. 1, 40225 Düsseldorf

The resource for entanglement-based quantum key distribution (QKD) are photon pairs which are distributed over the desired distance. As the probability that a photon is absorbed by the fiber degrades exponentially, recent QKD setups are limited to around two hundred kilometers. This distance can be overcome using a quantum repeater [1]. The quantum repeater stations which are situated at the intermediate positions perform entanglement swapping and entanglement distillation. Without entanglement distillation, the fidelity of the final quantum state may drop to a level such that it cannot be used for quantum key distribution. We investigate under which circumstances entanglement distillation is necessary for long-distance quantum key distribution. For this purpose we study distillation protocols with dual-rail entanglement [2] and recent ones that make use of hyper-entanglement [3].

[1] H.J. Briegel, W. Dür, J. I. Cirac, and P. Zoller, Phys. Rev. Lett. **81**, 5932 (1998).
[2] C.H. Bennett et al., Phys. Rev. Lett. 76, 722 (1996); D. Deutsch et al., Phys. Rev. Lett. **77**, 2818 (1996).
[3] C. Wang, H. Q. Ma, R. Z. Jiao, and Y. Zhang, Eur. Phys. J. D **64**, 573 (2011); Y.-B. Sheng and F.-G. Deng, Phys. Rev. A **81**, 032307 (2010).

Q 69.4 Fri 14:45 V38.04

Security of Continuous Variable Quantum Key Distribution using the Entropic Uncertainty Relation — •Torsten Franz[1], Fabian Furrer[1], Mario Berta[2], Volkher B. Scholz[1], Marco Tomamichel[2], and Reinhard F. Werner[1] — [1]Institut für Theoretische Physik, Leibniz Universität Hannover — [2]Institut für Theoretische Physik, ETH Zürich

We report on a security proof for continuous variable QKD using the entropic uncertainty relation. Our analysis is valid under general coherent attacks, gives bounds for finite key length and is composable secure. We give extractable key rates for a protocol using two mode squeezed vacuum states that is implementable with current technology. (see arXiv: 1112.2179)

Q 69.5 Fri 15:00 V38.04

QKD with finite resources: Taking advantage of quantum noise — •Markus Mertz, Hermann Kampermann, Zahra Shadman, and Dagmar Bruss — Institute for Theoretical Physics III, Heinrich-Heine-Universität Düsseldorf, 40225 Düsseldorf

We compare the effect of different types of noise models on the achievable rate of an epsilon-secure key for the BB84 and the six-state protocol. We study the situation where quantum noise is added deliberately, and investigate the remarkable benefit for the finite key rate. We compare the results to the case of added classical noise and the asymptotic key rate, i.e. in the limit of infinitely many signals. As a complementary interpretation we show that under the realistic assumption, that the noise unavoidably introduced by a real channel is not fully dedicated to the eavesdropper, the secret key rate will increase significantly.

Q 69.6 Fri 15:15 V38.04

Gaussian super-activation of the quantum channel capacity requires nonlinear interaction — •Daniel Lercher[1], Géza Giedke[1,2], and Michael Marc Wolf[1] — [1]Department of Mathematics, Technische Universität München, 85748 Garching, Germany — [2]Max-Planck-Institut für Quantenoptik, 85748 Garching, Germany

The quantum capacity of bosonic Gaussian quantum channels was recently shown to be non-additive in a particularly striking way: a pair of such optical-fibre type channels can individually have zero quantum capacity but super-activate each other such that the combined channel has strictly positive capacity. This has been shown in [Nature Photon. 5, 6(2011)] where it was conjectured that non-linear squeezing is necessary for this phenomenon. We prove a stronger version of this conjecture by showing that super-activation in this scheme is not possible if the system-environment interaction can be obtained by means of linear optics, even if the environment is in an arbitrary, possibly squeezed, state.

Technically, we prove that a Gaussian channel whose interaction matrix admits a diagonal symplectic singular value decomposition is entanglement breaking if its Choi matrix is PPT. Consequences on the preparation of bound entangled Gaussian states are outlined.

Q 69.7 Fri 15:30 V38.04

Superluminal Twin Beams, Superluminal Images and the Arrival Time of Spatial Information in Optical Pulses with Negative Group Velocity — •Ulrich Vogl, Ryan T. Glasser, and Paul D. Lett — Joint Quantum Institute, NIST and the University of Maryland, Gaithersburg, MD 20899 USA

We report the demonstration of superluminal pulse generation via non-collinear four-wave mixing in hot rubidium vapor with a double-Λ scheme. Two steep gain features result in a large dispersion near the gain lines, resulting in both slow and fast light effects. We identify large negative group indices in the wings of the gain line and observe group velocities of up to -1/2000 c for the injected beam. A novel feature of this system is that the generated conjugate can also be superluminal, and that the group velocity of both the probe and the conjugate can be tuned over a wide range via the probe's two-photon detuning and also via the probe power. In another experiment we imprint spatial patterns on the probe pulse. We show that anomalous dispersion can be used as an additional degree of freedom for image processing, complementary to existing schemes to slow down and store images. This scheme allows us also to investigate the propagation of spatial information through a medium of anomalous dispersion. By doing this we can address the velocity of information without introducing temporal waveforms with a frequency bandwidth outside the region of anomalous dispersion. Prospects include the investigation of correlations between the generated twin beams when passed through an anomalous dispersion medium.

Q 69.8 Fri 15:45 V38.04

Parametric frequency down-conversion of single photons — •Susanne Blum[1], Georgina Olivares-Rentería[2,3], Carlo Ottaviani[3], Sebastian Zaske[1], Andreas Lenhard[1], Christoph Becher[1], and Giovanna Morigi[1] — [1]Universität des Saarlandes, Germany — [2]Universidad de Concepción, Chile — [3]Universitat Autònoma de Barcelona, Spain

Efficient single photon transmission in future quantum networks requires wavelengthes in the low loss band of optical fibres. Currently most single photon sources do not emit in this spectral region, but rather in the red or near-infrared. We analyse theoretically the conversion efficiency of single photons into the low-loss band at 1550 nm, using difference frequency generation in a $\chi^{(2)}$ material. For this purpose we use Heisenberg-Langevin equations for the signal, idler, and pump fields, in the limit of a strong classical signal field. We consider the effects of quantum noise sources, e.g. photon loss in pump and ilder modes, and noise photon generation at 1550 nm due to optical parametric fluorescence as well as stokes and antistokes scattering from the signal to idler wavelength. Using this model we study the single photon down-conversion process by calculating the intensity-intensity correlationfunction , the influence of quantum noise sources and signal to noise ratios at gated detectors. Our analysis shows that values of $g^{(2)}(0)$ far below 0.5 can be achieved in present experiments [1]. We discuss in gereral the bounds on the level of noise for realising efficient single-photon down-conversion for quantum communication purposes.

[1] S. Zaske *et al.*, Optics Express, 19, 12825 (2011)