Q 4: Quantum information: Quantum communication I

Time: Monday 11:00–12:30 Location: F 342

Q 4.1 Mon 11:00 F 342

Quantum repeaters and secret key rates: the role of distillation and classical communication — •Sylvia Bratzik, Silvestre Abruzzo, Hermann Kampermann, and Dagmar Bruss — Institut für theor. Physik III, Heinrich-Heine-Universität, Universitätsstr.1, 40225 Düsseldorf

Using the original repeater protocol [1] we calculate secret key rates and compare them for different distillation protocols (the *Deutsch et al.* protocol [2] and entanglement pumping [3]) and different distillation strategies (varying the number of distillation rounds in the nesting levels). The secret key rate is composed of the secret fraction and the repeater rate. In our analysis we derive formulas for the repeater rate which account for the classical communication time due to entanglement swapping and entanglement distillation. Depending on the type and value of the experimental imperfections, we show which distillation configuration leads to the optimal secret key rate.

[1] H.J. Briegel, W. Dür, J.I. Cirac, and P. Zoller, Phys. Rev. Lett. **81**, 5932 (1998).
[2] D. Deutsch et al., Phys. Rev. Lett. **77**, 2818 (1996).
[3] W. Dür, H.J. Briegel, J.I. Cirac, and P. Zoller, Phys. Rev. A **59**, 169 (1999).

Q 4.2 Mon 11:15 F 342

Light storage in the presence of four-wave mixing — •Nikolai Lauk, Christopher O'Brien, and Michael Fleischhauer — Fachbereich Physik, TU Kaiserslautern

We investigate the effects of four-wave mixing (FWM) in a quantum memory which exploits electromagnetically induced transparency (EIT) to map a signal field, ideally a single photon, onto a long-lived collective atomic excitation by adiabatically switching off and on a strong control field. At high optical depths a four-wave mixing process can occur in this scheme, since the control field starts to act on both possible transitions producing a new idler field, which in turn affects the propagation of the signal field. FWM amplifies the signal field but also introduces noise to the signal channel. We use a full quantum mechanical approach to solve the coupled Maxwell-Bloch equations in order to determine when FWM is beneficial and when it is detrimental to light storage.

Q 4.3 Mon 11:30 F 342

A wavelength tunable quantum light-emitting diode — •Jiaxiang Zhang[1], Fei Ding[1], Eugenio Zallo[1], Santosh Kumar[1], Bianca Höfer[1], Armando Rastelli[2], Rinaldo Trotta[2], and Oliver G. Schmidt[1] — [1]Institute for Integrative Nanosciences, IFW-Dresden, Helmholtzstrasse 20, D-01069 Dresden, Germany — [2]Institute of Semiconductor and Solid State Physics, Johannes Kepler University Linz, Altenbergerstrasse 69, A-4040 Linz, Austria

In an optical quantum network it is desirable to have trigged quantum light sources that emit single photons with exactly the same wavelength. Previous work has realized two photon interference of the emission from two self-assembled quantum dots (QDs). The key is to use giant Stark shift to tune the emissions [Nat. Photon. 4, 632 (2010)]. However the design is cumbersome for the purpose of electrical injection. Here we demonstrate an electrically driven, wavelength tunable singlephoton source utilizing self-assembled InAs/GaAs QDs embedded in a p-i-n light-emitting diode (LED). Triggered singlephoton emission is realized by applying ultra-short electrical pulses to the LED, while the wavelength of the emitted single photons is precisely controlled ($>$ 10meV) by external biaxial stresses applied to the LED. We also characterize the decay dynamics of the excitonic states and the pulsed single-photon emission [g2(t)] in this device. Our technique therefore presents strong promise for the realization of two photon interference from separated electrically injected single-photon sources.

Q 4.4 Mon 11:45 F 342

Strain Tuning of Quantum Dot Emissions: Towards Indistinguishable Photons from Separate Sources — •Bianca Höfer[1], Fei Ding[1], Eugenio Zallo[1], Jaixiang Zhang[1], Armando Rastelli[2], Rinaldo Trotta[2], and Oliver G. Schmidt[1] — [1]Institute for Integrative Nanosciences, IFW-Dresden, Helmholtzstrasse 20, D-01069 Dresden,Germany — [2]Institute of Semiconductor and Solid State Physics,Johannes Kepler University Linz, Altenbergerstrasse 69, A-4040 Linz, Austria

For optical quantum networks it is necessary to create entangling states from separated single photon sources. Epitaxially grown semiconductor quantum dots QDs are promising candidates for this purpose, mainly due to the possibility to be integrated into solid state devices. In order to create entangled single photon states, the emission characteristics (such as energies, exciton lifetimes) of two QDs have to be identical. However, as-grown quantum dots have spectral inhomogeneity, which make post-growth tuning techniques indispensable. Among the others, strain has very recently emerged as a powerful tool to tune the excitonic emissions in QDs [R.Trotta et al., Advanced Materials 23, 2706 (2011)]. Here we present independent control over the exciton lifetime and the emission energy in a single InAs/GaAs QD, by using the combination of external strain and electrical fields. Our approach promises a higher degree of indistinguishability of photons emitted by separated QDs.

Q 4.5 Mon 12:00 F 342

State selective resonant excitation of single silicon-vacancy centres in diamond — •Tina Müller[1], Christian Hepp[2], Benjamin Pingault[1], Elke Neu[2], Christoph Becher[2], and Mete Atatüre[1] — [1]University of Cambridge, Cavendish Laboratory, Cambridge, United Kingdom — [2]Universität des Saarlandes, Saarbrücken, Germany

Colour centres in diamond have attracted wide interest in recent years for applications in quantum enabled technologies. The negatively charged silicon-vacancy (SiV) centre is a particularly promising candidate due to its exceptional brightness and high concentration of the emission into the zero-phonon line, which shows four individual transitions at liquid helium temperature. Also, electron-spin resonance measurements and calculations based on density-functional theory indicate a paramagnetic ground state with S=1/2 for this centre. However, no optical signature of this electronic spin has been observed yet.

Using resonance fluorescence to resonantly drive the SiV centre at finite magnetic fields, we show that the emission intensity into the individual Zeeman-split zero phonon line transitions depends strongly on the resonantly driven transition. Two subsets of transitions can be observed, which indicates that population transfer in the optical excited state e. g. via phonon-mediated thermalisation processes can be strongly suppressed. We propose that the reason for this selectivity are two different electron spin projections for these excited states. This is in good agreement with a recently developed model based on a S=1/2 electron associated with this centre.

Q 4.6 Mon 12:15 F 342

Towards indistinguishability of photons from dissimilar sources — •Christoph Berkemeier, Andreas Ahlrichs, Andreas W. Schell, Otto Dietz, Tim Kroh, Benjamin Sprenger, and Oliver Benson — AG Nano Optics, Institut für Physik, HU Berlin

Long-distance quantum key distribution will require quantum repeater nodes, which are necessary for entanglement swapping between entangled photon pairs. A first step towards this goal is tailoring photons from dissimilar sources, in this case quantum dots and a photon pair source, to be indistinguishable in all degrees of freedom [1]. To increase the distance between nodes, single photon conversion into the telecommunications bands as shown in [2] could interconnect the different units with a low damped wavelength for long distance transmission in fiber.

The sources we use are single photons from quantum dots, and those from a parametric downconversion source in a cavity. We present a cascaded Fabry-Pérot filtering system, based on [3], which is simultaneously applied on photons from both sources. The quantum dot photons are filtered to 100 MHz width, and the system is optimized for long-term stability.

[1] Solomon et al., J. Opt. Soc. Am. B, 29, 319 (2012)
[2] Zaske et al., Opt. Express, 19, 12825 (2011)
[3] Palittapongarnpim et al., Rev. Sci. Instrum. 83, 066101 (2012)