Q 11: Quantum Optics II

Time: Monday 17:00–18:45 Location: P 5

Q 11.1 Mon 17:00 P 5

Electro-optic polarization modulators for on-chip integration in $LiNbO_3$ based advanced quantum circuits — •Sebastian Brauner[1], Polina Sharapova[2], Harald Herrmann[1], Raimund Ricken[1], Torsten Meier[2], and Christine Silberhorn[1] — [1]Universität Paderborn, Integrierte Quantenoptik, Warburger Str. 100, D-33098 Paderborn — [2]Universität Paderborn, Computational Optoelectronics and Photonics, Warburger Str. 100, D-33098 Paderborn

Polarization modulation is of key importance for various kinds of quantum processing with single photons. Advanced integrated quantum circuits require compact and reliable modulators which can be directly implemented on-chip.

We demonstrate a wavelength selective integrated electro-optically driven polarization modulator in periodically poled z-cut lithium niobate (PPLN). The operation principle relies on an electrical field driven TE-TM conversion in a Ti-indiffused waveguide exploiting the r_{51} coefficient of the electro-optic tensor. Poling periods in the range of 20 μm enable the required phase-matching for wavelengths in the range of 1.5 μm. Complete conversion, i.e. TE to TM or vice versa, is obtained in our 7.5 mm long waveguide with 21.5 V drive voltage in a spectral bandwidth of 3.2 nm.

Besides experimental investigations using classical light for device characterization, we present detailed theoretical and experimental studies in the quantum regime in particular for biphoton wave packets generated e.g. via parametric down-conversion in the same chip.

Q 11.2 Mon 17:15 P 5

Towards optimized single mode Rubidium exchanged waveguides in KTP for quantum optical applications — •Laura Padberg, Christof Eigner, Matteo Santandrea, Raimund Ricken, Helge Rütz, and Christine Silberhorn — Universität Paderborn, Integrierte Quantenoptik, Warburger Str. 100, D-33098 Paderborn

Single mode and periodically poled potassium titanyl phosphate (KTP) waveguides are very attractive for non-linear processes in integrated quantum optics. They have been used for many different processes such as photon pair generation in telecommunication bands or coupling of photons between atomic quantum memories in the UV range to communication applications in the infrared. Moreover, a PDC source in the visible is attractive for quantum cryptography, as it allows the use of low-cost Si-APDs detectors as well as it could be coupled to ionic traps. However this technological platform is still in an exploratory stage and therefore the production of each device needs to be optimized depending on the required performances.

Rubidium-potassium-ion exchange is a practical approach for waveguide fabrication in KTP. In-house fabrication of single mode waveguides allows us to control the Rb-exchange parameters to achieve the desired results in terms of guided mode profile and waveguide losses. We show our approach in manufacturing single mode, low loss waveguides in Rb:KTP at 800nm and 1550nm. Moreover we present our progress in manufacturing PDC sources for generation of photon pairs at 800nm.

Q 11.3 Mon 17:30 P 5

Highly efficient frequency conversion with bandwidth compression of quantum light — •Markus Allgaier[1], Vahid Ansari[1], Linda Sansoni[1], Christof Eigner[1], Viktor Quiring[1], Raimung Ricken[1], Georg Harder[1], Benjamin Brecht[1,2], and Christine Silberhorn[1] — [1]Integrated Quantum Optics, Applied Physics, University of Paderborn, 33098 Paderborn, Germany — [2]Clarendon Laboratory, Department of Physics, University of Oxford, Oxford OX1 3PU, United Kingdom

Hybrid quantum networks rely on efficient interfacing of dissimilar quantum systems such as parametric down-conversion sources, quantum dots or atoms. However, these are are fundamentally different in frequency and bandwidth of their spectra. While optical pulse manipulation has been demonstrated in many different systems, there is none that combines efficient bandwidth compression and substantial frequency translation. Here, we present a device that achieves both goals using an engineered sum-frequency conversion process in Lithium Niobate. We show the conversion of pure photons at telecom wavelengths from a parametric down-conversion source to the visible range while compressing the spectral bandwidth by a factor of 7.47 under preservation of non-classical photon-number statistics. We achieve internal conversion efficiencies of 61.5 %. With external efficiencies of 16.5 % our experiment significantly outperforms spectral filtering; at the achieved bandwidths this represents a gain in efficiency of 26 %.

Q 11.4 Mon 17:45 P 5

Bridging the UV-IR gap: Fabrication and characterization of an integrated frequency converter — •Matteo Santandrea, Helge Rütz, Christof Eigner, Laura Padberg, Raimund Ricken, and Christine Silberhorn — Universität Paderborn, Integrierte Quantenoptik, Warburger Str. 100, D-33098 Paderborn

One of the basic building blocks of quantum networks will be interfaces between different physical systems, e.g. between atoms and low loss fibers. The transition wavelengths of atoms and ions often lie in the ultraviolet spectral range; therefore, it is necessary to develop devices able to bridge the gap between these two wavelength ranges. Periodically-poled, rubidium-exchanged potassium titanyl phosphate (PP Rb:KTP) waveguides are ideally suited interfaces, thanks to their high photorefractive damage resistance and the possibility to achieve poling periods in the μm range.

We designed and fabricated a PP Rb:KTP waveguide to perform sum frequency generation (SFG) between 397 nm and 1564 nm in order to interface a $^{40}Ca^{+}$ quantum memory with a standard telecom fiber network in the C-band.

Here, we want to present the measured properties, both linear and nonlinear, of our first working prototype and discuss how to further improve the performance of the device.

Q 11.5 Mon 18:00 P 5

Demonstration of a low-noise quantum memory in Cs vapour — Krzysztof T. Kaczmarek, Patrick M. Ledingham, •Benjamin Brecht, Sarah Thomas, Joseph H. D. Munns, Amir Feizpour, Dylan J. Saunders, Joshua Nunn, and Ian A. Walmsley — Clarendon Laboratory, University of Oxford, Parks Road, Oxford OX1 3PU, United Kingdom

Quantum memories will play a pivotal role in the realization of large-scale quantum networks. In such architectures, they will serve as both active and passive network nodes.

Here, we realise a quantum memory in warm atomic Caesium vapour. Our memory is based on a so-called ladder protocol, which combines low-noise operation with outstanding experimental simplicity. We demonstrate the storage and retrieval of heralded single photons from a parametric down-conversion source. Both the stored and retrieved photons feature a heralded $g^{(2)}(0)$ correlation of less than 0.5, which verifies the successful memory operation.

Q 11.6 Mon 18:15 P 5

Spin-orbit coupling of photons emitted by a single ion — •Gabriel Araneda[1], Daniel Higginbottom[2], Jürgen Volz[3], Arno Rauschenbeutel[3], Yves Colombe[1], and Rainer Blatt[1,4] — [1]Institut für Experimentalphysik, Universität Innsbruck, Technikerstr. 25, A-6020 Innsbruck, Austria — [2]Australian National University, Canberra ACT 0200, Australia — [3]Vienna Center for Quantum Science and Technology, TU Wien - Atominstitut, Stadionallee 2, 1020 Vienna, Austria — [4]Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften, Technikerstraße 21a, A-6020 Innsbruck, Austria

The photon emission process in an atom conserves the total angular momentum of the atom-photon system. The angular momentum carried by the photon can be present as spin angular momentum, corresponding to the polarization of the light, and orbital angular momentum, which is related to the phase fronts of the radiated field. We present an experiment where the photons detected in a given direction carry solely orbital angular momentum. In this configuration, the apparent position of the emitter is shifted depending on the σ^+ or σ^- polarization of the emitted photons. The expected displacement is λ/π, where λ is the wavelength of the emitted photons. We detect σ^+ and σ^- photons in a direction perpendicular to the quantization axis, and observe a displacement of the apparent location of the ion that is compatible with the expected λ/π value.

Q 11.7 Mon 18:30 P 5

High temperature superconducting surface ion traps. —

•Kirill Lakhmanskiy[1], Philip Holz[1], Dominic Schärtl[1], Muir Kumph[2], Yves Colombe[1], and Rainer Blatt[1,3] — [1]Institute for Experimental Physics, University of Innsbruck, Austria — [2]IBM Thomas J. Watson Research Center, USA — [3]Institute for Quantum Optics and Quantum Information, Innsbruck, Austria

Ion traps are used as a tool to perform quantum simulations [1] and quantum computation [2]. One approach to achieve large scale quantum systems is to utilize surface ion traps. However, the closeness of the ions to the trap's surface leads to an increase of the heating rate of the motional state, which degrades the fidelity of quantum operations. The origin of this heating is not well understood [3]. To investigate different sources of motional heating, we operate a surface ion trap made of YBCO, a high-temperature superconducting material. The trap is designed in such a way that Johnson noise should be the dominant source of motional heating above the critical temperature Tc∼85 K, whereas below Tc it should be negligible compared to other noise sources. By measuring the motional heating rate of a trapped ion, we observe large changes in the magnitude of the electric field noise in a small temperature range around Tc, which is consistent with our calculations of the Johnson noise.

[1] R. Blatt and C.F. Roos, Nature Phys. 8, 277 (2012)
[2] R. Blatt and D. Wineland, Nature 453, 1008 (2008)
[3] M. Brownnutt, M. Kumph, P. Rabl, and R. Blatt, Rev. Mod. Phys. 87, 1419 (2015)