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## *Experiments on Quantum Frequency Conversion of Photons*

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ABSTRACT

Coherently converting photons between different states offers intriguing new possibilities and applications in quantum optical experiments. In this thesis three experiments on this theme are presented.The first experiment demonstrates the creation and verification of discrete color entanglement. High-quality, discretely color-entangled states are produced by converting polarization entanglement of non-degenerate photons onto the color degree-of-freedom. This technique can be generalized to transfer polarization entanglement for example onto orbital angular momentum of photons.The second experiment realizes conversion of polarization entangled photons between different frequencies. This offers an elegant solution for the often difficult trade-off of choosing the optimal photon wavelength, e.g. regarding optimal transmission and storage of photons in quantum memory based quantum networks. The implementation is robust and flexible, making it a practical building block for future quantum technologies.The third part of the work introduces a novel deterministic scheme for photonic quantum information processing. While single photons offer many advantages, key unresolved challenges are: scalable on-demand single photon sources, deterministic two-photon interactions, and near 100%-efficient detection. All these can be solved with a single versatile process – a novel four-wave mixing process that we introduce here as a special case of the more general scheme of coherent photon conversion (CPC). Notably, this would enable scalable photonic quantum computing. Using photonic crystal fibers, we experimentally demonstrate a nonlinear process suited for coherent photon conversion. The results of the experiment show how current technology can provide a feasible path towards deterministic operation.