

Stephan Welte

Group of Prof. Gerhard Rempe,  
Max-Planck-Institute of Quantum Optics (MPQ), Garching



## 1. Short CV

1988: born in Freiburg, Germany

2007-2013: studied Physics at Albert-Ludwigs-Universität Freiburg

2013: Master of physics at Albert-Ludwigs-Universität Freiburg (“Experimental and theoretical studies of Berry phases in an EIT medium” under Prof. H. Helm)

Since June 2014: ExQM PhD student in the group of Prof. Gerhard Rempe, Max Planck Institute of Quantum Optics in Garching (“Resonator based interactions between atoms and photons”)

### External collaborations:

H. Helm - Albert-Ludwigs-Universität Freiburg

H.P. Breuer - Albert-Ludwigs-Universität Freiburg

A. Reiserer - TU Delft

## 2. PhD Project: “Deterministic Photon-Photon interactions ”

In my PhD thesis, I work with single atoms trapped at the center of a high-finesse optical cavity. The atoms interact strongly with single photons reflected from the cavity. As was shown in previous experiments in the group of Prof. Rempe, a quantum gate between a single atom and a single photon can be implemented employing this experimental platform [4]. Based on this result, the implementation of a quantum gate between two photons mediated by an atom was realized experimentally during my PhD thesis [3]. This result was a long standing goal in optical quantum information processing since it paves the way towards scalable optical quantum computing due to its deterministic nature. The implementation of such a gate is achieved by reflecting two photons (control and target) from the atom-cavity system successively. The gate requires a deterministic interaction of an atom and a photon which is so strong that a single control photon can influence a target photon by changing the state of the atom as an intermediate step. Afterwards, the target photon interacts with the atom and is influenced by its state. The nonlinear atom-cavity system provides the necessary platform to achieve this strong interaction.

**Publications and preprints:**

- [1] F. Meinert, C. Basler, A. Lambrecht, S. Welte, and H. Helm, “Quantitative analysis of the transient response of the refractive index to conditions of electromagnetically induced transparency”, *Phys. Rev. A* **85**, 013820 (2012)
- [2] S. Welte, C. Basler, and H. Helm, “Studies of Berry's phase and its sign in quantum superposition states of thermal  $87\text{Rb}$  atoms”, *Phys. Rev. A* **89**, 023412 (2014)
- [3] B. Hacker, S. Welte, G. Rempe, S. Ritter, “A photon-photon quantum gate based on a single atom in an optical resonator”, *Nature* **536**, 193-196 (2016)

**References:**

- [4] A. Reiserer, N. Kalb, G. Rempe, & S. Ritter A quantum gate between a flying optical photon and a single trapped atom. *Nature*, **508** 237-240 (2014)
- [5] M. Uphoff, M. Brekenfeld, G. Rempe, & S. Ritter An integrated quantum repeater at telecom wavelength with single atoms in optical fiber cavities. *Applied Physics B* **122**, 46 (2016).

**Presentations at conferences:**

- 2014: NIM workshop at Glocknerhaus (Austria), “Nondestructive detection of an optical photon” (talk)
- 2015: ExQM seminar (Munich), “Nondestructive detection of an optical photon” (talk)
- 2015: Young Atom Opticians conference (Zurich), “Optimisation of an atom-photon quantum gate” (poster)
- 2015: Resonator QED conference (Munich), “Optimisation of an atom-photon quantum gate” (poster)
- 2016: DPG spring meeting (Hannover), “A cavity-mediated photon-photon gate” (poster)
- 2016: ExQM seminar (Munich), “A photon-photon quantum gate” (talk)
- 2016: Gordon Conference on Quantum science (Stonehill College, USA), “A cavity-mediated photon-photon gate” (poster)