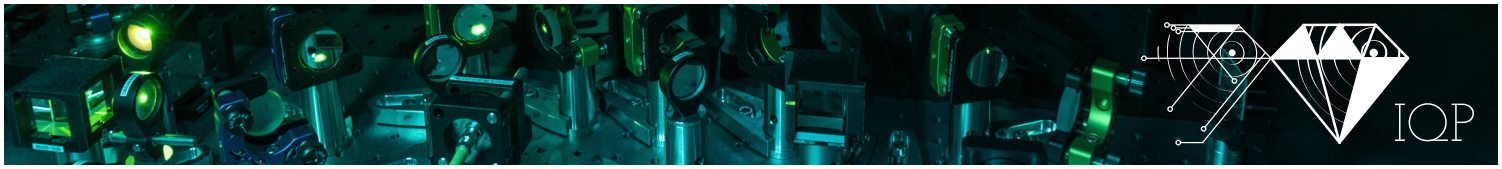

PhD-Project: Quantum Nonlinear Photonics with Single Photons and Atoms (experimental quantum optics)

Project A goal of current research is the implementation of a large-distance quantum network, where individual quantum nodes are connected with each other through photon-mediated entanglement. The Integrated Quantum Photonics Group (Prof. Dr. Tim Schröder) at the Department of Physics at Humboldt-Universität zu Berlin focuses on fundamental and applied research using quantum control and photonic integration based on atom-like color centres in diamond. These “artificial” atoms form spin quantum bits (qubit) and can be addressed optically. Using optical control protocols based on single pulses, the spin qubit can be initialized, manipulated, and moreover, the spin state can be entangled with a single photon. To enhance light-matter interaction and maximizing emission and collection efficiencies of single photons in particular optical modes, the spin defect is coupled to a nanophotonic cavity.

When the interaction strength between such an atom-like system and a single photon becomes large, we enter the regime of quantum nonlinear optics. In this PhD project, you will develop a photonic integrated platform to explore quantum nonlinear interactions of an individual quantum system with single photons. For example, the implementation of a quantum phase control gate will be demonstrated. Furthermore, based on the nonlinear interaction, entanglement generation will be investigated.

In the project, mainly the interaction between photons and single color centres in diamond nanostructures are explored. In addition, the concepts of nonlinear photon–atom interaction will be extended to warm atom vapours in collaboration with the research group Physical Foundations of IT Security (Prof. Dr. Janik Wolters) at the German Aerospace Center (DLR).

Literature

- D. E. Chang et al., "Quantum nonlinear optics — photon by photon," Nature Photon 8, 685–694 (2014)
- H. Le Jeannic et al., "Dynamical photon–photon interaction mediated by a quantum emitter," Nat. Phys. 18, 1191–1195 (2022)
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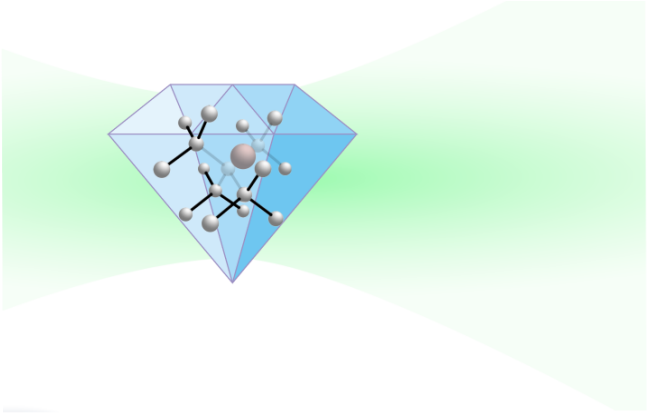

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