ABSTRACT

The emerging world of quantum technologies aims at the creation and development of practical applications basing on the consequences of quantum physics. Among these one can find quantum communication, quantum computing, quantum metrology, or quantum imaging. The main goal is to propose and implement solutions by taking advantage of quantum phenomena like quantum superposition or quantum entanglement. These, however, can lead to very surprising and even counterintuitive implications, research on which is interesting both from fundamental and practical perspectives. A fundamentally interesting problem to address is the interaction of light in a Fock state, $|n\rangle$, with a given number of absorbers, N. It offers insights into the very nature of quantum mechanics, helping us to better understand the behavior of light and matter at their most fundamental level. A number of applications were developed in this context including secure quantum communication, quantum information processing, quantum microscopy, or virtual-state spectroscopy, to name a few. This thesis is devoted to the problem of light-matter interaction on a single-photon level. First of all, theoretical research on the performance of a quantum ghost imaging setup is conducted. The spatial mode profile of the illuminating photon is studied and interesting results regarding the optical setup's resolution and photon losses are obtained. Secondly, experimental work demonstrating the interaction of a single photon with an ensemble of nitrogen-vacancy (NV) centers in ambient conditions is performed. Quantitative results, regarding the dynamics of NV centers under single-photon excitation are obtained. Finally, experiments aiming at the investigation of the interaction of a single photon with a given number of NV centers, N, are run. The possibility of single-photon superradiance demonstration in NV centers in diamond is verified and the signal-to-noise ratio limits for small values of N are discussed.

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