Please use this identifier to cite or link to this item: http://hdl.handle.net/123456789/5268

Title:	Light-Matter interactions: Quantum memories and atom-photon gates
Authors:	Teja, G.P.
Keywords:	Light Quantum Atom Photon
Issue Date:	3-Aug-2022
Publisher:	IISER Mohali
Abstract:	Abstract Light-matter interactions play a central role in realizing practical quantum computers and long distance quantum communication. Some of the essential tools in realizing quantum communication are quantum memory (QM) and quantum gates. Photonic quantum memory is a device capable of storing and retrieving the quantum states of photons on demand. They are typically realized in atoms or artificial-atoms such as quantum dots. Most of the present day QM's are proposed using light-matter interactions and have been demonstrated on various platforms such as solid-state systems, atom traps and vapour cells. Quantum gates are the operations performed on quantum systems in order to implement quantum algorithms. In the first part of the thesis, we have devised a novel photonic quantum memory using an intra-atomic frequency comb (I-AFC). The frequency comb is constructed between two degenerate energy levels of an atom. Since the frequency comb is constructed from individual atoms, these atoms can be used individually or in ensembles to realize the quantum memory. The I-AFC based quantum memory is efficient and robust against environmental fluctuations. Also it provides the possibility for realizing on-chip quantum memory for photons. Second part of the thesis deals with atom-photon quantum gates. In this part we study light-matter interactions in atom-cavity setups to realize certain operations on atom- photon combined systems. Using these gates, we demonstrate an efficient scheme to prepare arbitrary atomic states using a chain of single photons interacting sequentially with the atom. We also use the atom-photon gates to implement the quantum channel transparency protocol on an atomic system.
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