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Microwave Single Photon Source Using Landau-Zener Transitions

Authors : Siddhi Khaire, Samarth Hawaldar, Baladitya Suri

Abstract : As efforts towards quantum communication advance, the need for single photon sources becomes imminent. Due to the extremely low energy of a single microwave photon, efforts to build single photon sources and detectors in the microwave range are relatively recent. We plan to use a Cooper Pair Box (CPB) that has a ‘sweet-spot’ where the two energy levels have minimal separation. Moreover, these qubits have fairly large anharmonicity making them close to ideal two-level systems. If the external gate voltage of these qubits is varied rapidly while passing through the sweet-spot, due to Landau-Zener effect, the qubit can be excited almost deterministically. The rapid change of the gate control voltage through the sweet spot induces a non-adiabatic population transfer from the ground to the excited state. The qubit eventually decays into the emission line emitting a single photon. The advantage of this setup is that the qubit can be excited without any coherent microwave excitation, thereby effectively increasing the usable source efficiency due to the absence of control pulse microwave photons. Since the probability of a Landau-Zener transition can be made almost close to unity by the appropriate design of parameters, this source behaves as an on-demand source of single microwave photons. The large anharmonicity of the CPB also ensures that only one excited state is involved in the transition and multiple photon output is highly improbable. Such a system has so far not been implemented and would find many applications in the areas of quantum optics, quantum computation as well as quantum communication.

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