Design of Lambda systems in superconducting architectures

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The implementation of a Lambda scheme in superconducting artificial atoms could allow detection of STimulated Raman Adiabatic Passage (STIRAP) and other quantum manipulations in the microwave regime. Despite many proposals this problem is still experimentally unsettled. We have shown [1] that implementing an efficient Lambda system in a qutrit depends on the tradeoff between efficient coupling and non-Markovian (low-frequency 1/f [2]) components of noise. Indeed protection from noise and suppression of pump coupling depend on the same symmetry and are conflicting issues. Substantial efficiency can be achieved within present fabrication technology by exploiting tuning of symmetry breaking. We find results [2] uniquely due to non-Markovianity of noise, namely: (a) the efficiency for STIRAP depends essentially on noise channels in the qubit trapped subspace; (b) a physically motivated figure of merit for evaluation of design and operating prescriptions is derived; (c) a scheme of dynamical decoupling related to symmetries of the three-level band-structure of the device is found [3].

We next study two ingredients towards the implementation of population transfer and quantum state engineering in solid-state Circuit-QED or nanomechanichal architectures. The first is a 2+1-photon scheme allowing for a Lambda configuration at the symmetry point [3]. Pump coupling and noise protection now both increase for increasing Josephson energy, this advantage being however limited by leakage from the three-level subspace in a more and more harmonic spectrum. The second issue is a protocol where usual STIRAP is triggered by a suitable modulation of detunings, allowing to operate with an always on field. The absence of an exact dark state makes non trivial achieving destructive interference. This operation mode may allow to switch couplings to quantized modes in solid-state architectures.

We finally comment about possible applications to Quantum Technologies, as single-photon generation and light harvesting.

[1] G. Falci et al., arXiv:1305.0204, Phys. Rev. B, June 2013.

[2] E. Paladino, Y. Galperin, G. Falci, B. Altshuler, "1/f noise: implications for quantum information", arXiv:1304.7925, subm. to Rev. Mod. Phys.

[3] G. Falci et al., Physica Scripta T151, 014020 (2012).