**DYNAMICS OF THE QUBIT INITIALIZATION PROCEDURE WITH A TUNABLE ENVIRONMENT**

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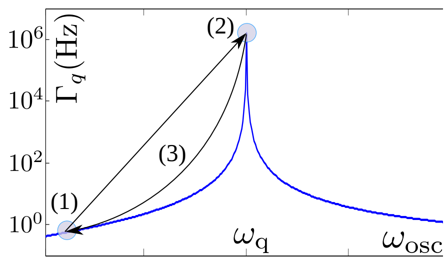
Preparation of a qubit to a well-defined initial state is one of the key-requirements in any quantum computational algorithm. The conventional approach relies on the ground state relaxation of the qubit, caused by the unavoidable coupling to the environment. On the other hand, one wishes to maximize the relaxation times to guarantee the quantum coherence during the computations. Initialization by successive projective measurements and by cooling have been proposed to improve this apparent conflict of interests.

We study theoretically the quantum dynamics of a superconducting qubit whose coupling to a thermal bath can be controlled by using a sequence of tunable $LC$ oscillators. Previous proof-of-principle calculations with realistic circuit parameters have shown that, in this way, the relaxation rate $\Gamma_q$ of the qubit can be adjusted by several orders of magnitude [1, 2]. Thus, such engineered environment could be used both for efficient protection of the qubit coherence from experimental noise and for rapid initialization of the qubit state when needed. We study a realization of the above model where Jaynes-Cummings system, formed by an $LC$ oscillator and a charge qubit, is coupled capacitively to a resistive environment via another oscillator with a tunable resonance frequency.

In the figure, we show a schematic of the initialization protocol: (1) The qubit is protected from the external perturbations when it is detuned from both oscillators. (2) By tuning the environmental oscillator into resonance with the qubit ($\omega_{\rm osc} = \omega_{\rm q}$), one can increase qubit's relaxation rate by several orders of magnitude. (3) After initialization, the oscillator is again detuned so that the qubit state is maximally protected.




We generalize the previous Fermi's golden rule calculations by deriving the Born-Markov master equation for the reduced time-dependent qubit-bath Hamiltonian in the adiabatic basis. This allows us to optimize the initialization protocol for the qubit, and also to study the quantum dynamics of open systems on a more general level. We are especially interested in optimizing the speed and the path of the detuning step (3) with minimal qubit excitation during the process.

[1] P. J. Jones, J. A. M. Huhtamäki, J. Salmilehto, K. Y. Tan, and M. Möttönen, Sci. Rep. **3**, 1987 (2013).

[2] P. J. Jones, J. Salmilehto, and M. Möttönen, J. Low. Temp. Phys. **173**, 152 (2013).