QUBIT INITIALIZATION PROTOCOL WITH A TUNABLE ENVIRONMENT

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Preparation of a qubit close to a known pure state is one of the key requirements for any quantum computational algorithm. We propose [1] a rapid initialization protocol that uses an engineered dissipative environment [2] and does not essentially increase the qubit dissipation during computations. The protocol can be realized for a superconducting qubit by coupling it to a thermal bath through two LC resonators [3, 4]. One of the resonators is directly coupled to the cold bath and its natural resonance frequency $\omega_{\rm L}(t)$ can be dynamically adjusted. On-demand ground state initialization is achieved (see Figure) by starting from the far-detuned limit ($\omega_{\rm L}(0) \gg \omega_{\rm R}, \omega_{\rm q}$) and by visiting in succession the resonances $\omega_{\rm L} = \omega_{\rm q}$ and $\omega_{\rm L} = \omega_{\rm R}$, where the relaxation rates of the qubit and the other resonator are increased by several orders of magnitude, respectively [4]. As a consequence, possible excitations in the resonant constituents decay fast to the desired fidelity. In the end, the adjustable resonator is rapidly detuned, resulting in an effective decoupling of the qubit and the engineered environment. We solve the quantum dynamics corresponding our protocol with a Markovian master equation and show that with optimized and realistic superconducting circuit parameters the initialization time $\tau \approx 300$ ns, which is almost an order-of-magnitude improvement to the current experimental benchmark [5]. Importantly, an intrinsic qubit temperature of 100 mK can be reduced to one third, corresponding to a qubit excited-state occupation $P^{\rm q}_{\rm ex} \sim 10^{-6}$ at the end of the protocol.

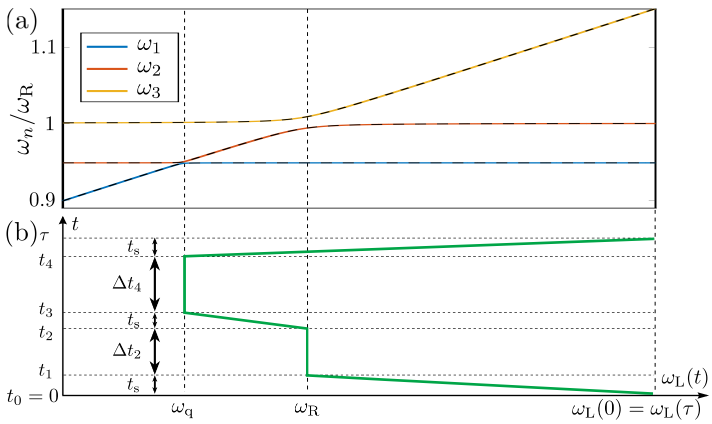

Figure: Qubit initialization protocol. (a) Three lowest excited-state eigenfrequencies ω_n of the system formed by the qubit and the two resonators as a function of the control parameter $\omega_{\rm L}$. (b) Initialization protocol in terms of the control parameter $\omega_{\rm L}(t)$.

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