Unifying Floquet theory of longitudinal and dispersive coupling

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In circuit quantum electrodynamics (cQED), fast qubit measurements rely on dispersive readout: a transverse interaction between the two lowest levels of a superconducting artificial atom and a resonator shifts the frequency of the resonator, enabling quantum non-demolition (QND) measurements. Recently, a longitudinal interaction had been proposed to perform faster-than-dispersive measurements in superconducting qubits. However, mechanisms to achieve such interaction are nowadays hard to connect, as they stem from distinct theoretical frames, adopting different approximations. Such a situation calls for a unified description, embracing different devices and regimes.

We devise a Floquet theory to establish a connection between AC Stark shift, longitudinal coupling and dispersive readout in cQED. We find that when a qubit transversally coupled to a resonator is driven at the resonator frequency, the resonator probes the Floquet spectrum of the qubit at the drive amplitude. An effective longitudinal interaction then arises from the slope of the Floquet spectrum while a dispersive shift arises from the curvature. We derive semi-analytical results supported by exact numerical calculations, which we apply to superconducting and spin cQED settings, providing a unifying, seamless and simple description of longitudinal and dispersive readout in generic cQED systems.

Our approach unifies the adiabatic limit, where the cavity dynamics is so slow that the longitudinal coupling results from the static spectrum curvature, with the diabatic one, where the static spectrum plays no role.

References

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