Appendix 5

Exploring collective states of superconducting qubits

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Abstract:

Presently developed platforms for building quantum computers offer a variety of techniques to experiment with open driven quantum systems. Superconducting qubits are presently the most advanced technology for quantum computing. These qubits are electronic circuits which can be easily scaled up in number. Putting many qubits together in the form of an array makes it possible to experimentally study the quantum dynamics of an open quantum system with many degrees of freedom. In this talk, I will present an overview of our recent experiments with arrays of superconducting qubits coupled to a cavity or a waveguide. We dub these arrays quantum metamaterials as they are artificial engineered media of meta-atoms that enable tailored interactions with electromagnetic waves. While modern technology does not allow making the transition frequencies of superconducting qubits exactly the same, their frequency spread can be traded against their coupling strength to propagating electromagnetic fields. We have observed quantum synchronization in arrays of different types of superconducting qubits, achieving strong coupling between electromagnetic field and mesoscopic ensembles of qubits. Our recent experiments involve qubit arrays with local frequency control. By consecutively tuning the qubits to a common resonance frequency we observe the formation of super- and subradiant states, as well as the emergence of a bandgap. These experiments open the way towards single-photon detecting by using collective states in qubit arrays, as well as large-scale applications in superconducting waveguide quantum electrodynamics.