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Experiments on superconducting flux quantum circuits

Circuits consisting of nano-, micro-, and millimeter scale superconducting structures on dielectric substrates have been considered as promising candidates for scalable quantum information processing since the late nineties. So far, two- and three-level systems (qubits/qutrits), harmonic oscillators (microwave LC resonators), and quasi-1D continua (open transmission lines) have been and are still being extensively studied in theory and experiment in many groups all over the world. In this respect, a fruitful exchange of ideas and concepts with the quantum optics community has been possible due to the similarity in theoretical treatment: qubit circuits can be considered as two-level atoms with exceptionally large dipole moment and LC resonators represent cavities with very small mode volumes. Despite the fact that in superconducting circuits quantum coherence continues to be an issue, the design flexibility and the possibility of obtaining large coupling strengths between them have enabled exciting "quantum optics on a chip" experiments. In this talk, I will present the recent progress at the WMI on superconducting flux qubits (ultrastrong coupling, tunable tunnel matrix element), linear circuits (transmission line resonators, microwave beam splitters), and single-mode squeezing in a Josephson parametric amplifier.

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