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Coherent Response of Superconducting Qubit Arrays

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A large array of qubits can be viewed as a quantum metamaterial, e.g., an artificially fabricated medium composed of two-level systems acting as artificial atoms. The electromagnetic wave propagation through such a medium is accompanied by excitation of intrinsic quantum transitions within individual meta-atoms and modes corresponding to the interactions between them. We have studied the microwave propagation through arrays of superconducting qubits. I will present experimental results on arrays of flux and transmon qubits coupled to resonators. The studied systems constitute different implementations of quantum metamaterials in the sense that many artificial atoms are coupled collectively to the quantized mode of a photon field. More recent experiments involve qubit arrays embedded into transmission lines. Here we employed two-cell superconducting flux qubits featuring tunneling between mirror-symmetric fluxoidal states. By varying an external magnetic field, we detected strong variations of the metamaterial transparency that are explained by magnetic flux localization and tunneling between metastable states in the two-cell flux qubits forming the quantum metamaterial.