Flux in Superconductor Quantum Devices

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**Abstract**. This talk elucidates the pivotal role of magnetic flux in superconducting quantum devices, spanning noise dynamics, quasiparticle interactions, and topological state engineering. First, we demonstrate how telegraph flux noise in transmon qubits generates anomalous Ramsey fringe beating patterns, with experimental observations validated by a random telegraph noise model. Second, we reveal an unexpected negative magnetoresistance in zero-bias conductance peaks of Kondo-correlated Josephson junctions under weak magnetic fields. This phenomenon arises from vortices in superconducting leads acting as quasiparticle traps, suppressing dissipation and enhancing coherent Cooper pair transport—a mechanism corroborated by geometry-dependent threshold fields (6–60 mT) and temperature-dependent smearing. Finally, we show that flux quantization in full-shell InAs nanowires produces synthetic analogs of Caroli-de Gennes-Matricon (CdGM) states as 1D van Hove singularities. These states exhibit magnetic field-skewed energy dispersions within Little-Parks lobes, consistent with theoretical predictions of radial confinement and angular momentum effects. Collectively, these studies establish flux as both a challenge (noise source) and a resource (state engineering tool), offering insights for optimizing quantum coherence, mitigating quasiparticle losses, and harnessing topological phenomena in superconducting architectures.