Landau-Zener-Stückelberg-Majorana interferometry without two-level systems

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Résumé

The non-adiabatic transition of a quantum system across an avoided level crossing is known as a Landau-Zener-Stückelberg-Majorana (LZSM) transition. Under periodic driving, the accumulation of phase during repeated passages gives rise to LZSM interferences (1). The precise understanding of LZSM transitions in quantum systems enabled the implementation of fast quantum protocols and the characterization of the system's decoherence properties (2,3).

In this work, we explore the emergence of LZSM interferences in nonlinear superconducting resonators made of flux-tunable Josephson junction arrays. By tailoring the nonlinearity over several order of magnitudes, we study the physics of the model as a function of the ratio between the Kerr nonlinearity and the photon loss rate.

We demonstrate that at low readout power, the same interference pattern can be observed independently of the nonlinearity. Increasing the readout power, we then investigate the simultaneous competition between nonlinearity and interference pattern. In weakly nonlinear resonators, we observe the deformation and merging of classical Duffing oscillator instabilities. Within a different circuit where the nonlinearity exceeds the photon loss rate, we demonstrate a regime in which the quantized nature of the photonic field competes with the non-adiabatic nature of the modulation to form a novel interference pattern.

(1) O. Ivakhnenko et al., *Nonadiabatic Landau–Zener–Stückelberg–Majorana transitions, dynamics, and interference*, Physics Reports 995, 1-89, 2023

(2) F. Forster et al., *Characterization of Qubit Dephasing by Landau-Zener-Stückelberg-Majorana Interferometry*, PRL 112, 116803, 2014

(3) C. M. Quintana et al., *Cavity-Mediated Entanglement Generation Via Landau-Zener Interferometry*, PRL 110, 173603, 2013

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