False Vacuum Decay and Defect Formation in Nonequilibrium ultracold Bose-Bose mixtures

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We investigate nonequilibrium dynamics in two-dimensional coherently coupled Bose–Bose mixtures, focusing on false vacuum decay and condensation from vacuum. Using the stochastic Gross–Pitaevskii equation, we prepare thermal states in a metastable phase and extract decay rates from magnetization dynamics, finding an exponential temperature dependence consistent with thermal instanton theory, with coupled phase–magnetization dynamics [**?**]. We further study condensation driven by a ramp of the chemical potential, leading to miscible or immiscible states. In the immiscible regime, domain statistics and, in the miscible regime, vortex densities obey universal Kibble–Zurek scaling, with spatial distributions consistent with Poisson statistics, revealing robust universal features of far-from-equilibrium superfluid dynamics [**?**].

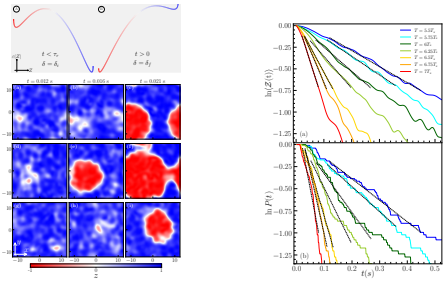

FIG. 1. Snapshots of bubble nucleation during false vacuum decay induced by detuning ramps in a Z_2-broken ferromagnetic condensate. The right panel shows the corresponding survival probability as a function of time.

[1] Sivasankar *et al.*, arXiv: 2602.03834 (2026).
[2] Patra *et al.*, arXiv: 2510.12770 (2025).

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