Quantum quench in p+ip superfluids: Non-equilibrium topological gapless state(s)

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Ground state "topological protection" has emerged as a main theme in quantum condensed matter physics. A key question is the robustness of physical properties including topological quantum numbers to perturbations such as disorder or non-equilibrium driving. In this work we investigate the dynamics of a p+ip superfluid following a zero temperature quantum quench. The model describes a 2D topological superconductor with a non-trivial (trivial) BCS (BEC) phase. Proposed experimental realizations include ultracold atomic and molecular gases. We work with the full interacting BCS Hamiltonian, which we solve exactly in the thermodynamic limit using Liouville integrability. The non-equilibrium phase diagram is obtained for generic quenches. A large region of the phase diagram describes strong to weak-pairing quenches wherein the order parameter vanishes in the long-time limit, due to pair fluctuations. Despite this, we find that the pseudospin winding number survives for quenches in this regime, leading to the prediction of a "gapless topological" state.