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Probing Quantum Fields in the lab

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Ultra cold quantum gases are an ideal model system to quantum simulate field theories in the lab. Matter wave interferometry gives direct access to the quantum field and thereby offers an unprecedented view on its equilibrium properties and non-equilibrium evolution. We experimentally illustrate the particle creation when cutting a quantum field in two halfs, and demonstrate the establishment of a new (pre) thermal equilibrium within a light cone horizon. In our system the quantum sine-Gordon model is realized with high accuracy through two tunnel-coupled 1d superfluids as verified by an analysis of the connected correlations in the quantum field up to 10th order. Finite time quenches in the tunnelling coupling can be used to simulate inflationary physics within the sine-Gordon model, seeded by quantum fluctuations.

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