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## *Non-equilibrium dynamics beyond dephasing: Recurrences and loss induced cooling in one-dimensional Bose gases*

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Abstract:

Out-of-equilibrium dynamics in complex quantum many-body systems is a vast topic of research touching many different areas of physics. One of the most versatile experimental platforms to investigate these effects are ultracold atoms, due to their flexibility and easy isolation from the environment. In this thesis, we investigate non-equilibrium dynamics of one-dimensional (1d) Bose gases realized with ultracold 87Rb atoms on an atom chip. Focusing on phenomena emerging on timescales beyond the typical dephasing times of excitations, we report on the observation of recurrences and the finding of a novel cooling mechanisms. A recurrence, the dynamic return of a system to its initial state, can generally not be observed in large systems as the complexity of their excitation spectra shifts its appearance to prohibitively long times. Yet, by realizing a commensurate spectrum in a pair of near-homogeneous 1d Bose gases, recurrences in their low energy dynamics can be observed on experimentally accessible timescales. We demonstrate this by initializing two gases in a phase coherent state by coupling them through a tunneling barrier before suddenly ramping the coupling to zero. The subsequent dynamics is monitored by matter-wave interferometry, providing access to the relative phase field between the gases. After an initial dephasing dynamics we observe multiple recurrences of the coherent initial state due to a rephasing of the underlying excitations. Additionally, analyzing the damping of these recurrences we detect otherwise elusive scattering effects between excitations. Furthermore, we investigate the dynamics of a 1d Bose gas under a continuous loss of particles. With thermalization strongly inhibited in these systems standard evaporative cooling is rendered ineffective; yet, we still observe a substantial cooling effect. This cooling is driven by a novel mechanism that neither relies on an energy selective extraction of particles nor on efficient thermalization channels. Instead, it proceeds through a loss-induced reduction of density fluctuations and a continuous dephasing of the involved excitations. %If the loss is uniform and the gas is initially in a thermal state, it stays close to this thermal form, agreeing well with our observations. For experiments with 1d Bose gases, this mechanism fills an important gap in the understanding of the state preparation and the limits of cooling.