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Dynamics of One-Dimensional Bose Gases in Time-Dependent Traps

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ABSTRACT

In the scope of this thesis, an experiment is prepared to reliably produce Bose-Einstein condensates in an atom chip trap. In this setup, the dynamics and relaxation processes in an ultracold cloud of ^{87}Rb in a time-dependent trapping potential are investigated. The system under scrutiny is a gas of interacting Bosons in a highly elongated magnetic trap created by wire structures on the atom chip. Such a trap allows confining the gas to the motional ground state of the radial trapping potential, while still accommodating axial excitations at temperatures between 10 to 200 nanokelvins, constituting the one-dimensional realization of a Bose – Einstein condensate, called ‘quasicondensate’. This scenario is described by the Lieb – Liniger model of weakly interacting Bosons in a one-dimensional geometry. Both the Lieb – Liniger model as well as its effective low-energy limit in the quasicondensate regime, the Luttinger liquid model, can be mapped to models describing the dynamics of 1d spin chains in solid state physics, which is why an understanding of their non-equilibrium dynamics is of interest beyond the field of cold atom physics.

The trapping potential is manipulated according to various different protocols and investigate the time evolution of excitations in the cloud. Specifically, a dynamical scale invariance present in the system allowing the exact calculation of time-dependent correlation functions, the feasibility of optimal control to engineer the cloud’s state after a quench, as well as the 1d expansion of a quasicondensate are investigated. Experimental data is compared to numerical simulations based on a stochastic nonlinear Schrödinger equation as well as to exact results from analytical models.

The final part of the thesis describes the preparation of a new experiment combining an atom chip with optical nanofibers to create a novel atom – photon interface.