Higher-order correlations and what we can learn about the solution for many body problems from experiments

Thomas Schweigler and Jörg Schmiedmayer

Vienna Center for Quantum Science and Technology (VCQ), Atominstitut, TU-Wien

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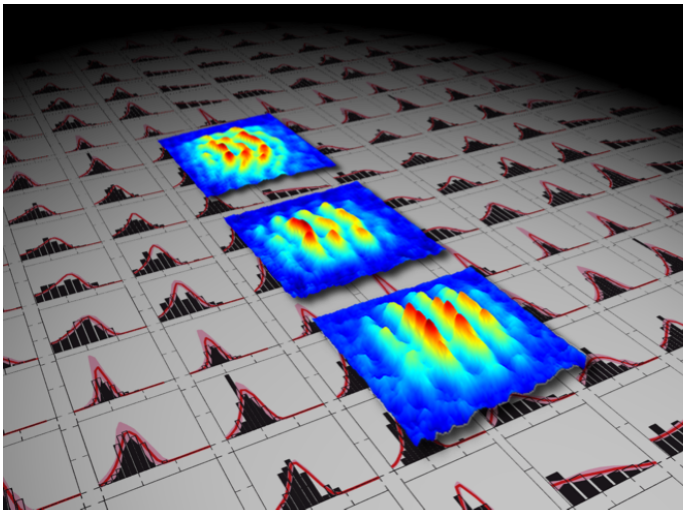
The knowledge of all correlation functions of a system is equivalent to solving the corresponding quantum many-body problem. If one can identify the relevant degrees of freedom, the knowledge of a finite set of correlation functions is in many cases enough to determine a sufficiently accurate solution of the corresponding field theory. Complete factorization of the correlation functions is equivalent to identifying the relevant degrees of freedom where the Hamiltonian becomes diagonal. We will give examples on how one can apply this powerful theoretical concept in experiments.



After a splitting quench, the system of two 1-dimensional quantum gases relaxes to a pre-thermalized state [1]. A detailed study of non-translation invariant correlation functions reveals that this state is described by a generalized Gibbs ensemble [2]. This is verified through phase correlations up to 10th-order. Interference in a pair of tunnel-coupled one-dimensional atomic superfluids, which realize the quantum Sine-Gordon / massive Thirring models, allows us to study if, and under which conditions, the higher correlation functions factorize [3]. This allows us to characterize the essential features of the model solely from our experimental measurements: We detect the relevant quasi-particles, their interactions and the different topologically distinct vacuum-states. The experiment thus provides a comprehensive insight into the components needed to solve a non-trivial quantum field theory. Our examples establish a general method to analyse quantum systems through experiments. It thus represents a crucial ingredient towards the implementation and verification of quantum simulators.

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References

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[2] T. Langen et al., Science **348**, 207-211 (2015).

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