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Non-equilibrium dynamics of large bosonic quantum many-body systems under the microscope

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Quantum gas microscopy (QGM) provides unique access to the properties of quantum many-body system in- and out-of-equilibrium. In this talk, I will report recent work on thermalizationdynamics of hard-core bosons in quasi-1D systems. We make use of site-resolved densitysnapshots in order to monitor the full counting statistics of particle-number fluctuations inoptical ladders, contrasting systems with ballistic and chaotic dynamics.

We find excellentagreement between our results and predictions using macroscopic fluctuation theory (MFT),which allows us to accurately extract diffusion constants from fluctuation growth. Our resultssuggest that large-scale fluctuations of isolated quantum systems display emergenthydrodynamic behavior, expanding the applicability of MFT to the quantum regime. In thesecond part of my talk, I will focus on new experimental results, where we have developed atechnique to measure kinetic operators, such as kinetic energy or current operators, in QGMsby projecting the many-body wave function onto isolated double wells.

These operators canbe measured and manipulated with single-bond resolution, hence, significantly expanding thetoolbox of QGMs. Beyond simple expectation values of these observables, the single-shotmeasurements allow to access full counting statistics and complex correlation functions. Thispaves the way for the implementation of efficient quantum state tomography and hybridquantum computing protocols for itinerant particles on a lattice.

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