Q 9: Quantum Gases

Time: Wednesday 10:45–12:15 Location: H2

Invited Talk Q 9.1 Wed 10:45 H2

Critical dynamics and prethermalization in lattice gauge theories — •Jad Halimeh[1,2,3] and Philipp Hauke[1,2,3] — [1]Kirchhoff Institute for Physics, Ruprecht-Karls-Universität Heidelberg, Im Neuenheimer Feld 227, 69120 Heidelberg, Germany — [2]Institute for Theoretical Physics, Ruprecht-Karls-Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg, Germany — [3]Department of Physics, University of Trento, Via Sommarive 14, 38123 Povo (TN), Italy

Local gauge invariance is always violated to some extent in quantum simulation experiments. A rigorous understanding of gauge-invariance violation and how to protect against it are thus of paramount importance. We present analytic and numerical results showing that gauge-invariance violation in a quantum simulator resulting from inherent gauge-noninvariant processes grow only perturbatively at short times, before entering long-lived prethermal plateaus, and eventually settling at long times into an equal admixture of all gauge-invariant sectors of the system. An energy constraint penalizing terms driving the system away from the initial gauge-invariant sector suppresses the violation up to infinite times. In congruence with our numerical results that show that this suppression is independent of system size, we argue analytically why this suppression will hold even in the thermodynamic limit. Finally, we present experimental results for the quantum simulation of a U(1) quantum link model mapping on a single-species bosonic lattice, where we sweep through a quantum phase transition and certify the emergent gauge-invariant dynamics.

Invited Talk Q 9.2 Wed 11:15 H2

Zooming in on Fermi Gases in Two Dimensions — •Philipp Preiss, Luca Bayha, Jan Hendrik Becher, Marvin Holten, Ralf Klemt, Philipp Lunt, Keerthan Subramanian, and Selim Jochim — Physics Institute, Heidelberg University

Interacting Fermi systems in two dimensions display intriguing phenomena such as pseudogap physics and high temperature superfluidity. Their central features, such as fermion pairing and collective excitations, can approximately be understood in the many-particle limit. It is an open question how large a system has to be for such a many-body picture to apply.

I will report on experiments that realize microscopic two-dimensional systems with ultracold fermionic lithium. With the ability to deterministically prepare few-body ground states and to observe individual atoms in momentum space, they enable a microscopic view of strongly interacting two-dimensional Fermi systems.

Surprisingly, we find that characteristic features of many-body Fermi gases can already be found in systems of no more than a dozen particles: In spectroscopy, we observe collective excitations that are the few-body precursor of the Higgs amplitude mode of a superfluid. Moreover, in spin-resolved momentum space probes, we can directly image individual ‘Cooper pairs’ and show the presence of fermionic pairing even in a microscopic setting. These findings confirm our qualitative picture of fermionic pairing in two dimensions and may be compared to other finite-size Fermi systems, such as atomic nuclei and superconducting grains.

Invited Talk Q 9.3 Wed 11:45 H2

New physical concepts: Fermionic Exchange Force and Bose-Einstein Force — •Christian Schilling — Arnold Sommerfeld Center for Theoretical Physics, LMU München

The particle-exchange symmetry has a strong influence on the behavior and the properties of systems of N identical particles. While fermionic occupation numbers are restricted according to Pauli’s exclusion principle, $0 \leq n_k \leq 1$, bosonic occupation numbers can take arbitrary values $0 \leq n_k \leq N$. It is also a matter of fact, however, that occupation numbers in realistic systems of interacting fermions and bosons can never attain the maximal possible value, i.e., 1 and N, respectively. By resorting to one-particle reduced density matrix functional theory we provide an explanation for this: The gradient of the exact functional diverges repulsively whenever an occupation number n_k tends to attain the maximal value. In that sense we provide in particular a fundamental and quantitative explanation for the absence of complete Bose-Einstein condensation (as characterized by $n_k = N$) in nature. These new concepts are universal in the sense that the fermionic exchange force and the Bose-Einstein force are present in all systems regardless of the particle number N, the spatial dimensionality and the interaction potentials.