ESI Erwin Schrödinger International Institute for Mathematics and Physics

universität wien

DVR 0065528

Seminar

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Practical quantum advantage of dynamical structure factors in analog quantum simulations

Thursday, October 3, 2019

at 14:00 h

ESI, Boltzman Lecture Hall

Abstract: The dynamical structure factor is one of the experimental quantities crucial in scrutinising the validity of the microscopic description of strongly correlated systems. However, despite its long-standing importance, it is exceedingly difficult in generic cases to numerically calculate it, ensuring that the necessary approximations involved yield a correct result. Acknowledging this practical difficulty we consider how analogue quantum simulators can offer a computational speed-up over classical algorithms. We improve on a novel, readily available, measurement setup allowing for the determination of the dynamical structure factor on different architectures, including arrays of ultra-cold atoms, trapped ions, Rydberg atoms, and superconducting qubit chips. We go on to study the dynamical structure factor in the presence of typical experimental imperfections, and show an inherent robustness for the particular cases of the short and long range transverse field Ising models. Our numerical results suggest that quantum simulations employing these near-term noisy intermediate scale quantum devices should allow for the observation of the characteristic features of the dynamical structure factor of correlated quantum matter, even in the presence of current experimental imperfections, and for larger system sizes than what is currently achievable by classical simulation techniques. We then turn to identifying the computational complexity of this task in general, linking it to other standard problems in quantum simulation such as simulating out-of-equilibrium time evolution and quantum annealing, related to the complexity class BQP. With this work, we show that analogue quantum simulators can measure dynamical structure factors, and that the computational complexity of calculating this quantity belongs to the BQP-hard class, hinting at an excellent prospect for demonstrating practical quantum advantages in the near term.

T. Calarco

October 2, 2019