TT 36: Transport: Quantum Coherence and Quantum Information Systems - Theory 2 (Joint session of HL, MA and TT organized by TT)

Time: Tuesday 14:00–15:00 Location: H22

TT 36.1 Tue 14:00 H22

Emulating the 1-Dimensional Fermi-Hubbard Model with Superconducting Qubits — •Jan-Michael Reiner, Michael Marthaler, and Gerd Schön — Institut für Theoretische Festkörperphysik, Karlsruhe Institute of Technology (KIT), 76131 Karlsruhe, Germany

A chain of qubits with both ZZ and XX couplings is described by a Hamiltonian which coincides with the Fermi-Hubbard model in one dimension. The qubit system can thus be used to study the quantum properties of this model. We investigate the specific implementation of such an analog quantum simulator by a chain of tunable Transmon qubits, where the ZZ interaction arises due to an inductive coupling and the XX interaction due to a capacitive coupling.

TT 36.2 Tue 14:15 H22

A method to efficiently simulate the thermodynamic properties of the Fermi-Hubbard model on a quantum computer — •Pierre-Luc Dallaire-Demers and Frank K. Wilhelm — Saarland University, Saarbrücken, Germany

Many phenomena of strongly correlated materials are encapsulated in the Fermi-Hubbard model whose thermodynamic properties can be computed from its grand canonical potential. In general, there is no closed form expression of the grand canonical potential for lattices of more than one spatial dimension, but solutions can be numerically approximated using cluster methods. To model long-range effects such as order parameters, a powerful method to compute the cluster's Green's function consists in finding its self-energy through a variational principle. This allows the possibility of studying various phase transitions at finite temperature in the Fermi-Hubbard model. However, a classical cluster solver quickly hits an exponential wall in the memory (or computation time) required to store the computation variables. Here it is shown theoretically that the cluster solver can be mapped to a subroutine on a quantum computer whose quantum memory usage scales linearly with the number of orbitals in the simulated cluster and the number of measurements scales quadratically. A quantum computer with a few tens of qubits could therefore simulate the thermodynamic properties of complex fermionic lattices inaccessible to classical supercomputers.

TT 36.3 Tue 14:30 H22

Scattering of photons on Bose-Hubbard lattices — •Kim Georg Lind Pedersen and Mikhail Pletyukhov — Institute for Theory of Statistical Physics, RWTH Aachen, 52056 Aachen

We study the photonic transport of weakly coherent light in various Bose-Hubbard lattice geometries implemented as QED cavity arrays. We use a diagrammatic scattering approach to study the relation between lattice geometry and the second order intensity correlation of the transmitted light. The motivation is twofold: First, a large induced correlation can be used to design circuit elements useful for "photonics applications". Second, the scattering of photons on complex lattices offers a promising way to characterize quantum correlation in a range of different, exotic states of matter theorized to be present in higher-dimensional cavity arrays.

TT 36.4 Tue 14:45 H22

Quantum Simulation of Hawking Radiation With Surface Acoustic Waves — •Raphael Schmit, Bruno G. Taketani, and Frank K. Wilhelm — Saarland University, Theoretical Physics Departement

In 1975, Hawking predicted particles and light to leave the surface of a black hole. This so called Hawking radiation follows the thermal spectrum of a black body with a certain temperature, called Hawking temperature. Its investigation is extremely desired since scientists believe it to provide clues for unanswered questions like the trans-Planckian problem or the information paradox, but a direct observation is challenging since the Hawking temperature is too small or the distance to the black hole is too large. For this purpose, we propose an experimental setup for emulating a black hole and measuring its analogue Hawking radiation. The setup consists of two adjacent piezoelectric semiconducting layers, one of them carrying a flying qubit serving as detector for Hawking radiation, and the other one with an attached MOS diode structure, imposing an effective curved metric on the surface acoustic wave (SAW) propagation. In the moving reference frame of the flying qubit, this metric matches the Painlevé-Gullstrand-metric describing an uncharged, non-rotating black hole with an event horizon for SAWs. We show that for GaAs as used layer material, the system can possess Hawking radiation in the μK regime. The flying qubit interacts with the Hawking phonons via piezoelectrically induced photons, and thus can be used to measure the temperature of the Hawking phonons.