Speaker: Annabelle Bohrdt (TU Munich)

Title: New probes of the Fermi-Hubbard model

Abstract: The phase diagram of the Fermi-Hubbard model and its connection to high-temperature superconductivity have been the subject of a vast amount of theoretical and experimental studies in the past decades. Here, we present recent results motivated by the new perspective quantum gas microscopes provide. Our theoretical approach, the geometric string theory, describes doped holes moving in an AFM environment as meson-like bound states of spinons and chargons [1]. Matrix product state based simulations of the ground state show convincing evidence for this scenario. We numerically study the dynamics of a single hole created in the ground state for a dimensional crossover from one to two dimensions and are able to explain our findings in the framework of geometric string theory.
We furthermore compare geometric string theory predictions for spin correlation functions as well as string patterns at finite temperature and finite doping to experimental data of a cold atom experiment and find remarkable agreement [2]. For an unbiased comparison of theories and experiment, we apply machine learning to classify experimental data at finite doping into different theoretical categories in order to determine which theory describes the system best on the microscopic level [3].

[1] F. Grusdt et al., Microscopic spinon-chargon theory of magnetic polarons in the t-J model. arXiv:1901.01113
[2] C.S. Chiu et al., String patterns in the doped Hubbard model. arXiv:1810.03584
[3] A. Bohrdt et al., Classifying Snapshots of the Doped Hubbard Model with Machine Learning. arXiv:1811.12425

Speaker: Christoph Kastl (Walter Schottky Institute)

Title: Quantum (opto)electronics in novel low-dimensional solid-state materials: From single defects to topological electronics.

Abstract: In the past decade, interest has been renewed in 2D layered materials, which were initially explored in their 3D bulk form more than 50 years ago. In these layered materials, extreme quantum confinement, reduced symmetries and strong spin-orbit interactions give rise to a complex zoo of emergent quantum phenomena. Recent efforts have been devoted to exploring and ultimately controlling such quantum properties by engineering these materials with atomistic precision.
I will present recent examples from our group, where we explore (opto)electronic quantum phenomena in novel low-dimensional materials: On the one hand, we locally introduce atomistic quantum emitters in 2D materials in a controlled manner by focused ion beam bombardment, and we elucidate the electronic structure of such point defect by high resolution scanning probe microscopy. On the other hand, we exploretopological phenomena, which are robust against defects, towards optical control of spin and charge dynamics in topological quantum materials.

Speaker: Kai Redeker[1], Robert Garthoff[1], Tim van Leent[1], Derya Taray[1], Matthias Seubert[1],Wei Zhang[1], Wenjamin Rosenfeld[1], and Harald Weinfurter[1,2]
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Title: Basic quantum network link formed by two entangled 87Rb-atoms separated by a distance of 398 m

Abstract: Entanglement is the essential feature of quantum mechanics and a key resource for different quantum technologies, e.g. quantum computing and secure quantum communication. One of the current challenges is the distribution of entanglement over long distances. Here we present an experiment achieving heralded entanglement between two quantum memories, in our case two trapped 87Rb- atoms, separated by a distance of 398 m line of sight.

In the experiment two remote atoms are independently optically excited to emit a photon each, whose polarization is entangled with the respective atomic spin states. The photons are sent to a station where a Bell state measurement is implemented with a fiber beamsplitter followed by a polarizing beamsplitter at each output port and four single photon detectors. The detection of two-photon coincidences swaps the entanglement to the atoms and heralds its creation. After receiving the heralding signal the atomic state is determined with high efficiency using state selective ionization and subsequent detection of ionization fragments.

This setup demonstrates remote entanglement between quantum memories forming the basic quantum network link. Additionally, it allows us to violate Bell's inequality without the major experimental loopholes [1]. Furthermore, this Bell test fullfils all requirements for device-independent protocols, e.g. the certification of the quantum network link [2] without auxiliary assumptions.

[1] W. Rosenfeld et al. Event-Ready Bell Test Using Entangled Atoms Simultaneously Closing Detection and Locality Loopholes, Phys. Rev. Lett. 119, 010402 (2017)
[2] J.-D. Bancal et al. Device-independent certification of an elementary quantum network link, arXiv:1812.09117 (2018).

Speaker: Pablo Sala de Torres-Solanot (TU Munich)

Title: Ergodicity-breaking arising from Hilbert space fragmentation in dipole-conserving Hamiltonians

Abstract: I will explain how the combination of charge and dipole conservation---characteristic of fracton systems---leads to an extensive fragmentation of the Hilbert space, which in turn can lead to a breakdown of thermalization. As a concrete example, we investigate the out-of-equilibrium dynamics of one-dimensional spin-1 models that conserve charge (total Sz) and its associated dipole moment. First, we will consider a minimal model including only three-site terms and find that the infinite temperature auto-correlation saturates to a finite value---showcasing non-thermal behavior. The absence of thermalization is identified as a consequence of the strong fragmentation of the Hilbert space into exponentially many invariant subspaces in the local Sz basis, arising from the interplay of dipole conservation and local interactions. Second, we extend the model by including four-site terms and find that this perturbation leads to a weak fragmentation: the system still has exponentially many invariant subspaces, but they are no longer sufficient to avoid thermalization for typical initial states. More generally, for any finite range of interactions, the system still exhibits non-thermal eigenstates appearing throughout the entire spectrum.