THU 9: Correlated Quantum Matter: Contributed Session to Symposium II

Time: Thursday 14:15–15:45 Location: ZHG101

THU 9.1 Thu 14:15 ZHG101

Intertwined superconductivity and orbital selectivity in a three-orbital Hubbard model for the iron pnictides — Vito Marino[1,2], Alberto Scazzola[3], Federico Becca[4], Massimo Capone[1], and •Luca F. Tocchio[2] — [1]International School for Advanced Studies (SISSA) and CNR-IOM, Trieste, Italy — [2]Institute for Condensed Matter Physics and Complex Systems, DISAT, Politecnico di Torino, Italy — [3]Department of Electronics and Telecommunications, Politecnico di Torino, Italy — [4]Dipartimento di Fisica, University of Trieste, Italy

We study a three-orbital Hubbard-Kanamori model relevant for iron-based superconductors using variational wave functions explicitly including spatial correlations and electron pairing. We span the non-magnetic sector from filling $n = 4$, which is representative of undoped iron-based superconductors, to $n = 3$, where a Mott insulating state with each orbital at half filling is found. In the strong-coupling regime, when the electron density is increased, we find a spontaneous differentiation between the occupation of d_{xz} and d_{yz} orbitals, leading to an orbital-selective state with a nematic character that becomes stronger at increasing density. One of these orbitals stays half filled for all densities while the other one hosts (together with the d_{xy} orbital) the excess of electron density. Most importantly, in this regime long-range pairing correlations appear in the orbital with the largest occupation. Our results highlight a strong link between orbital-selective correlations, nematicity, and superconductivity, which requires the presence of a significant Hund's coupling.

THU 9.2 Thu 14:30 ZHG101

Collective advantages in finite-time thermodynamics — •Alberto Rolandi[1,2], Paolo Abiuso[3], and Martí Perarnau-Llobet[2,4] — [1]Atominstitut, TU Wien, Vienna, Austria — [2]Département de Physique Appliquée, Université de Genève, Genève, Switzerland — [3]Institute for Quantum Optics and Quantum Information - IQOQI, Vienna, Austria — [4]Física Teòrica: Informació i Fenòmens Quàntics, Universitat Autònoma de Barcelona, Bellaterra (Barcelona), Spain

A central task in finite-time thermodynamics is to minimize the excess or dissipated work W_{diss} when manipulating the state of a system in contact with a thermal bath. We consider this task for an N-body system whose constituents are identical and uncorrelated at the beginning and end of the process. In the regime of slow but finite-time processes, we show that W_{diss} can be dramatically reduced by considering collective protocols in which interactions are suitably created along the protocol. This can even lead to a sub-linear growth of W_{diss} with N: $W_{\mathrm{diss}} \propto N^x$ with $x < 1$; to be contrasted to the expected $W_{\mathrm{diss}} \propto N$ satisfied in any non-interacting protocol. We derive the fundamental limits to such collective advantages and show that $x = 0$ is in principle possible, however it requires long-range interactions. We further explore collective processes with spin models featuring two-body interactions and achieve noticeable gains (sub-linear scaling of the dissipation) under realistic levels of control in simple interaction architectures. As an application of these results, we focus on the erasure of information in finite time and prove a faster convergence to Landauer's bound.

THU 9.3 Thu 14:45 ZHG101

Phase diagram of the extended anyon Hubbard model in one dimension — •Imke Schneider[1], Martin Bonkhoff[2], Shijie Hu[3], Kevin Jägering[1], Axel Pelster[1], and Sebastian Eggert[1] — [1]University of Kaiserslautern-Landau, Landesforschungszentrum OPTIMAS — [2]Universität Hamburg — [3]Beijing Computational Science Research Center

We study one-dimensional lattice anyons with extended Hubbard interactions. At unit filling a repulsive next-nearest neighbor interaction generally leads to gapped phases, but it is far from trivial which correlations are the dominant ones as a function of topological exchange angle and on-site interaction U. We find that a careful derivation of all terms in the Luttinger liquid theory predicts an intermediate phase between a Mott insulator for large repulsive U and a charge density wave at negative U. As a function of exchange angle the intermediate phase changes from Haldane insulator for pseudo bosons to a dimerized phase for pseudo fermions at an interesting multicritical point. Our results are confirmed by extensive numerical simulations.

THU 9.4 Thu 15:00 ZHG101

The Impact of Tree Tensor Networks for Open Quantum System Simulations — Richard Maximilian Milbradt[1], •Pouriya Haji Ghadimi[2], and Christian Mendl[1,3] — [1]Technische Universität München, School of Computation, Information and Technology, Munich, Germany — [2]University of Bologna, Department of Physics and Astronomy, Bologna, Italy — [3]Technische Universität München, Institute of Advanced Studies, Munich, Germany

In recent years tensor network methods have seen increasing use in the classical simulation of quantum systems that interact with an environment. We explore the use of more general tree tensor networks compared to the more common matrix product/tensor train structure for these kinds of simulations. We explore the impact of the tree structure for a direct solution of the Lindblad master equation by time evolving a density matrix represented as a tree structure in the Liouville space. Additionally, we consider tree tensor network representations of pure states in the quantum jump method. We compare this impact for spin chain models, such as the Ising and Heisenberg models, as well as for the Bose-Hubbard model for dozens of sites.

THU 9.5 Thu 15:15 ZHG101

Parafermions Ex Machina — •Steffen Bollmann[1], Andreas Haller[2], Jukka I. Väyrynen[3], Thomas Schmidt[2] und Elio J. König[4] — [1]Max Planck Institut for Solid State Research, Stuttgart, Germany — [2]University of Luxembourg, Limpertsberg Luxembourg, Luxembourg — [3]Purdue University, West Lafayette, Indiana, USA — [4]University of Wisconsin-Madison, Madison, Wisconsin, USA

Fractional quantum anomalous Hall states in materials such as transition metal dichalcogenides and penta-layer graphene suggest that heterostructures of fractional Hall edge states and superconductors will be experimentally much more realistic. It has been theorized that such heterostructures could host parafermions of interest for topological quantum computing.

Building on these developments, we explore a Z_3 parafermion chain that can be realized using FQH states, subject to fluctuations in the superconducting order parameter. By employing a combination of analytical techniques and numerical methods, including density matrix renormalization group (DMRG), we construct the phase diagram and examine critical behaviour as a function of system parameters. We find various Mott insulating phases and two gapless phases - one with excitations of charge 2e/3 and one with excitations of minimal charge 2e. We compare our results for the transition between these states with the conjecture that the $U(1) \times Z_3$ model flows to an emergent $SU(2)_3$ theory and discuss the appearance of parafermionic domain wall states beyond mean field superconductivity.

THU 9.6 Thu 15:30 ZHG101

Few-electron states in molecular networks bonded to metals — •Max Best and Carsten Henkel — Universität Potsdam, Institut für Physik und Astronomie, Germany

A simple tight-binding model for electrons in an organic molecule ("network") is studied to provide some understanding on electron transport beyond the single-particle picture. Many-fermion states are properly anti-symmetrised without using Slater determinants explicitly. The geometric symmetry group of the network (e.g., hexagonal ring) is implemented carefully on the N-electron subspaces. We discuss the influence of the Coulomb interaction on the electron-hole symmetry, the assignment of degeneracies to irreducible representations of the symmetry group, and the splitting of these under a magnetic field. Hydrodynamic models for a metallic surface including exchange and von-Weizsäcker kinetic energy are developed as a tribute to 100 years of quantum physics and applied to current problems in plasmonic catalysis.