# TT 65: Correlated Electrons: Other Theoretical Topics

Time: Friday 9:30–12:15 Location: HSZ 204

TT 65.1 Fri 9:30 HSZ 204

**Quantum oscillations beyond the Onsager relation in a doped Mott insulator** — •Valentin Leeb[1,2] and Johannes Knolle[1,2,3] — [1]Technical University of Munich, Germany; TUM School of Natural Sciences, Department of Physics, TQM — [2]Munich Center for Quantum Science and Technology (MCQST), 80799 Munich, Germany — [3]Blackett Laboratory, Imperial College London, London SW7 2AZ, United Kingdom

The kinetic energy of electrons in a magnetic field is quenched resulting in a discrete set of highly degenerate Landau levels (LL). This gives rise to fascinating phenomena like quantum oscillations or the integer and fractional quantum Hall effect. The latter is a result of interactions partially lifting the degeneracy within a given LL while inter-LL interactions are usually assumed to be unimportant. Here, we study the LL spectrum of the Hatsugai–Kohmoto model, a Hubbard-like model which is exactly soluble on account of infinite range interactions. For the doped Mott insulator phase in a magnetic field we find that the degeneracy of LLs is preserved but inter-LL interactions are important leading to a non-monotonous reconstruction of the spectrum. As a result, strong interactions lead to aperiodic quantum oscillations of the metallic phase in contrast to Onsager's famous relation connecting oscillation frequencies with the Fermi surface areas at zero field. In addition, we find unconventional temperature dependencies of quantum oscillations and effective mass renormalizations. We discuss the general importance of inter-LL interactions for understanding doped Mott insulators in magnetic fields.

TT 65.2 Fri 9:45 HSZ 204

**Non-Fermi-liquid behavior from critical electromagnetic vacuum fluctuations** — •Peng Rao and Francesco Piazza — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

We study two-dimensional materials where electrons are coupled to the vacuum electromagnetic field of a cavity. We show that, at the onset of the superradiant phase transition towards a macroscopic photon occupation of the cavity, the critical electromagnetic fluctuations, consisting of photons strongly overdamped by their interaction with electrons, can in turn lead to the absence of electronic quasiparticles. Since transverse photons couple to the electronic current, the appearance of non-Fermi-Liquid behavior strongly depends on the lattice. In particular, we find that in a square lattice the phase space for electron-photon scattering is reduced in such a way to preserve the quasiparticles, while in a honeycomb lattice the latter are removed due to a non-analytical frequency dependence of the damping $\propto |\omega|^{2/3}$. Standard cavity probes could allow to measure the characteristic frequency spectrum of the overdamped critical electromagnetic modes responsible for the non-Fermi-liquid behavior.

TT 65.3 Fri 10:00 HSZ 204

**Collapse of fermionic quasiparticles upon coupling to local bosons** — Adam Kłosiński, Piotr Wrzosek, Krzysztof Wohlfeld, and •Cliò Efthimia Agrapidis — Insitute of Theoretical Physics, Faculty of Physics, University of Warsaw, Poland

We study the stability of the fermionic quasiparticle in a fermion-boson model on a Bethe lattice, with fermions interacting with local bosons thorough a Peierls coupling. We solve the model by mapping it onto a non-interacting chain with a site-dependent potential. We show that the model does not support a quasiparticle solution – provided that a finite number of local bosonic excitations cost zero energy. The quasiparticle disappearance becomes easier with an increase in: (i) the total number of bosons with zero energy, and (ii) the relative strength of the coupling between bosons and fermions. The postulated model can be applied to study systems in which fermions are coupled to condensed bosons or magnons in spin stripes embedded in hole-doped 2D antiferromagnets or Ising-like magnetic interfaces (ferromagnetic-antiferromagnetic). Finally, we show how this model leads to an in-depth understanding of the onset of quasiparticles in the 1D and 2D $t$-$J^z$ model.

TT 65.4 Fri 10:15 HSZ 204

**Breakdown of the many-electron perturbation expansion beyond particle-hole symmetry** — •Herbert Essl, Matthias Reitner, and Alessandro Toschi — Institute of Solid State Physics, TU Wien

The breakdown of the self-consistent perturbation theory for many-electron systems has several physical and formal manifestations. Among the latter, one of the most studied is the divergence of two-particle irreducible vertex functions. Hitherto most investigations of the divergences appearing in the irreducible vertex functions of many-electron systems have been restricted to the particle hole symmetric cases and the calculations were performed at finite temperatures. This work is a first step beyond such restrictions. To this aim we investigate the two particle properties of the Hubbard Atom, both for positive (repulsive) and negative (attractive) on-site interaction. As a main result a *universal phase-diagram* of vertex divergences, valid for arbitrary (finite) temperatures, has been determined. Using this result as a "compass", the T=0 limit has been investigated, in order to unveil possible connections between the vertex divergences and the validity or the violation of the Luttinger Theorem. We also study the convergence of the self-consistent perturbation series beyond the particle-hole symmetry condition, determining specific constraints for the convergence of the series to the physical solution at arbitrary electronic densities.

TT 65.5 Fri 10:30 HSZ 204

**Cooling and heating in the Bose-Hubbard model by parameter tuning** — •Sebastian Eggert, Sven Stawinski, and Axel Pelster — University of Kaiserslautern

We investigate short-range interacting Bosons in an optical lattice at finite temperature. It is well known that the system shows a Mott-Superfluid transition when changing the repulsion $U$, the hopping $t$ and/or the filling. However, it is much less clear how the temperature is affected by those changes, assuming the parameters $U$ and/or $t$ are tuned adiabatically. We now present higher order calculations for the full Free energy and derive the temperature and entropy in a large parameter space. We discuss where significant heating or cooling effects can be expected in the superfluid phase, in the Mott region and near the phase transition lines.

**15 min. break**

TT 65.6 Fri 11:00 HSZ 204

**Fixed-point annihilation and duality in the SU(2)-symmetric spin-boson model** — •Manuel Weber[1,2] and Matthias Vojta[2] — [1]Max-Planck-Institut für Physik komplexer Systeme, Dresden, Germany — [2]Institut für Theoretische Physik and Würzburg-Dresden Cluster of Excellence ct.qmat, Technische Universität Dresden, Germany

The annihilation of two intermediate-coupling renormalization-group (RG) fixed points is of interest in diverse fields from statistical mechanics to high-energy physics, but has so far only been studied using perturbative techniques. Using the recently developed wormhole quantum Monte Carlo method, we present high-accuracy results for the SU(2)-symmetric $S = 1/2$ spin-boson (or Bose-Kondo) model. We study the model with a power-law bath spectrum $\propto \omega^s$ where, in addition to a critical phase predicted by perturbative RG, a stable strong-coupling phase is present. Using a detailed scaling analysis, we provide direct numerical evidence for the collision and annihilation of two RG fixed points at $s^* = 0.6540(2)$, causing the critical phase to disappear for $s < s^*$. In particular, we uncover a surprising duality between the two fixed points, corresponding to a reflection symmetry of the RG beta function, which we utilize to make analytical predictions at strong coupling which are in excellent agreement with numerics. Our work makes phenomena of fixed-point annihilation accessible to large-scale simulations, and we comment on the consequences for impurity moments in critical magnets.

TT 65.7 Fri 11:15 HSZ 204

**Thermodynamics properties of interacting Dirac fermion with SO(3) symmetry** — •Zihong Liu[1], Matthias Vojta[2], Fakher F. Assaad[1], and Lukas Janssen[2] — [1]Institut für Theoretische Physik und Astrophysik and Würzburg-Dresden Cluster of Excellence ct.qmat, Universität Würzburg, 97074 Würzburg, Germany — [2]Institut für Theoretische Physik and Würzburg-Dresden Cluster of Excellence ct.qmat, Technische Universität Dresden, 01062 Dresden, Germany

In the previous work[Physical Review Letters, 128(8):087201, 2022], we figure out the zero temperature phasediagram of a interacting Dirac fermion model processed explicit SO(3) symmetry with unbias quantum Monte Carlo(QMC) method. By threading size dependent magnetic flux ($B \sim 1/L^2$) across two dimensional honeycomb lattice, we reduce the finite size effect in the QMC simulation and suppress the superconductivity in the strong coupling region. In this scenario, the ground state phase diagram of the model is splitted by two phase transitions. In this talk, we implement the QMC simulation by turning off the magnetic flux. Without the externel magnetic field, the model recover to a higher symmetry and the superconductivity emergence in the strong coupling region on the ground state. In addition, we investigate the thermodynamics properties near the second transition point, where the finite temperature phase boundary are determined by the Ising type particle-hole order parameter and the Kosterlitz-Thouless transition govered by the U(1) symmetry breaking.

TT 65.8 Fri 11:30 HSZ 204

**Long-term memory magnetic morrelations driven by local electronic repulsion** — •Emin Moghadas[1], Matthias Reitner[1], Clemens Watzenböck[1], Giorgio Sangiovanni[2], and Alessandro Toschi[1] — [1]TU Wien — [2]University of Würzburg

We investigate the onset of non-decaying temporal magnetic correlations in simple electronic models with on-site (Hubbard) electrostatic repulsion U. This effect[1] corresponds to the existence of a finite difference between the static/isothermal and the zero-frequency limit of the dynamical Kubo (magnetic) susceptibility. The long-term behavior is studied, on the one hand, analytically for the non-interacting Bethe lattice case in infinite dimensions and, on the other hand, for finite-size Hubbard ring-molecules by means of exact diagonalization. This way, we can directly observe and investigate the link between the emergence of infinitely long-lived temporal correlations and the degeneracies of the exact many-body eigenspectrum, possibly inferring underlying relations with the entropic properties of the system. Our findings also pave the way to study the enhancement of the static/isothermal density response in the proximity of metal-insulator transitions [2] and, in particular, of its possible impact on the renormalization of electron-phonon coupling.

[1] C. Watzenböck et al., Sci. Post Phys. (2022)
[2] M. Reitner et al., PRL (2020) and references therein.

TT 65.9 Fri 11:45 HSZ 204

**Simulation of anyonic tight-binding Hamiltonians** — •Nico Kirchner[1], Adam Smith[2,3], Babatunde Ayeni[5], Frank Pollmann[1,4], and Joost Slingerland[5,6] — [1]Department of Physics, TFK, Technische Universität München, James-Franck-Straße 1, D-85748 Garching, Germany — [2]School of Physics and Astronomy, University of Nottingham, Nottingham, NG7 2RD, UK — [3]Centre for the Mathematics and Theoretical Physics of Quantum Non-Equilibrium Systems, University of Nottingham, Nottingham, NG7 2RD, UK — [4]Munich Center for Quantum Science and Technology (MCQST), Schellingstr. 4, 80799 München, Germany — [5]Department of Mathematical Physics, National University of Ireland, Maynooth, Ireland — [6]Dublin Institute for Advanced Studies, School of Theoretical Physics, 10 Burlington Rd, Dublin, Ireland

Anyons are quasiparticles with exotic exchange statistics that can be supported in two-dimensional systems such as quantum spin liquids and fractional quantum Hall systems. In general, even effective models for such systems are not exactly solvable, which leads to numerical approaches to study the properties of anyons. In this talk, I will discuss how to numerically simulate anyonic tight-binding Hamiltonians for general abelian and non-abelian anyon models using the formalism of fusion diagrams. The presented results for such tight-binding Hamiltonians include energy level spacing statistics, which reveal level repulsion for all considered anyons. Further, it is observed that the density distribution following a quench becomes homogeneous at large times for these systems, which indicates thermalization.

TT 65.10 Fri 12:00 HSZ 204

**Absence of fractal quantum criticality in the quantum Newman-Moore model** — •Raymond Wiedmann[1,2], Lea Lenke[1], Matthias Mühlhauser[1], and Kai Phillip Schmidt[1] — [1]Friedrich-Alexander-Universität, Erlangen-Nürnberg, Germany — [2]MPI-FKF, Stuttgart, Germany

The quantum phase transition between the high-field polarized phase and the low-field fracton phase with type-II fracton excitations is investigated in the two-dimensional self-dual quantum Newman-Moore model. We apply perturbative and numerical linked cluster expansions to calculate the ground-state energy per site in the thermodynamic limit revealing a level crossing at the self-dual point. In addition, high-order series expansions of the relevant low-energy gaps are determined using perturbative continuous unitary transformations indicating no gap-closing. Our results therefore predict a first-order phase transition between the low-field fracton and the high-field polarized phase at the self-dual point.