TT 88: Quantum-Critical Phenomena III

Time: Thursday 11:30–13:00 Location: H 3010

TT 88.1 Thu 11:30 H 3010

Holography and criticality in matchgate tensor networks — •Alexander Jahn, Marek Gluza, Fernando Pastawski, and Jens Eisert — Dahlem Center for Complex Quantum Systems, Freie Universität Berlin, 14195 Berlin, Germany

The AdS/CFT correspondence conjectures a holographic duality between gravity in a bulk space and a critical quantum field theory on its boundary. Tensor networks have come to provide toy models to understand such bulk-boundary correspondences, shedding light on connections between geometry and entanglement. We introduce a versatile and efficient framework for studying tensor networks, extending previous tools for Gaussian matchgate tensors in 1+1 dimensions. Using regular bulk tilings, we show that the critical Ising theory can be realized on the boundary of both flat and hyperbolic bulk lattices. Within our framework, we also produce translation-invariant critical states by an efficiently contractible network dual to the multi-scale entanglement renormalization ansatz. Furthermore, we explore the correlation structure of states emerging in holographic quantum error correction. We hope that our work will stimulate a comprehensive study of tensor network models capturing bulk-boundary correspondences.

TT 88.2 Thu 11:45 H 3010

Fermion-induced quantum critical points with two length scales — •Emilio Torres[1], Laura Classen[2], and Michael Scherer[1] — [1]Institute of theoretical Physics, University of Cologne, Germany — [2]Physics Department, Brookhaven National Laboratory, NY, USA

The quantum phase transition to a Z3-ordered Kekule phase in two-dimensional Dirac semimetals is governed by a fermion-induced quantum critical point, which renders the putative discontinuous transition continuous. We study the resulting universal, critical behavior in terms of a functional RG approach, which permits to access scaling behavior also on the symmetry-broken side of the phase transition. We show that the fermion-induced criticality leads to a scaling form with two divergent length scales, due to the breaking of the discrete Z3 symmetry. This provides a second source for scaling corrections besides the proximity to the first order transition.

TT 88.3 Thu 12:00 H 3010

Quantum critical behavior of Dirac systems at higher-loop order — •Bernhard Ihrig[1], Michael Scherer[1], Luminita Mihaila[2], and Nikolai Zerf[2] — [1]Universität Köln — [2]Universität Heidelberg

Dirac fermions appear as quasi-particle excitations in many different condensed-matter systems. They display various quantum transitions which represent unconventional universality classes related to variants of Gross-Neveu-Yukawa models. For the first time, we study these models – at three- and four-loop order, and compute critical exponents in $4-\epsilon$ dimensions for general number of fermion flavors.We apply the computed series for the exponents and their Padé approximants to several phase transitions of current interest: metal-insulator transitions of spin-1/2 and spinless fermions on the honeycomb lattice, emergent supersymmetric surface field theory in topological phases, as well as dualities in a deconfined quantum criticality scenario. Comparison with the results of other analytical and numerical methods is discussed.

TT 88.4 Thu 12:15 H 3010

Avalanche of entanglement and correlations at quantum phase transitions — •Andreas Osterloh, Konstantin V. Krutitsky, and Ralf Schützhold — Universität Duisburg-Essen, Duisburg, Deutschland

We study the two, three, and four-point correlations in the ground-state of the quantum Ising model in a transverse field with nearest neighbor ferromagnetic coupling J and find a partial inversion of their hierarchy. Namely, the four-point correlation exceeds the three- and two-point correlations, well before the critical point is reached. Qualitatively similar behavior is also found for the Bose-Hubbard model, suggesting this change in hierarchy to be a general feature of a quantum phase transition. It should be taken into account in approximations starting from a mean-field limit.

In addition, we find a sequential increase of entanglement depth d with growing J, hence an avalanche that starts with two-point entanglement, as measured by the concurrence, and continues via the three-tangle and four-tangle, until finally, deep in the ferromagnetic phase for $J=\infty$, the exact model would arrive at a pure L-partite (GHZ type) entanglement of all L spins.

TT 88.5 Thu 12:30 H 3010

Quantum phase transition with dissipative frustration — •Dominik Maile[1,2], Sabine Andergassen[2], Wolfgang Belzig[1], and Gianluca Rastelli[1,3] — [1]Fachbereich Physik, Universität Konstanz, D-78457, Germany — [2]Institut für Theoretische Physik and Center of Quantum Science, Auf der Morgenstelle 14, Universität Tübingen, D-72076 Tübingen, Germany — [3]Zukunftskolleg, Universität Konstanz, D-78457, Konstanz, Germany

We study the quantum phase transition of the one dimensional phase model in presence of dissipative frustration, provided by an interaction of the system with the environment through two non-commuting operators [1]. Such a model can be realized in Josephson junction chains with shunt resistances and resistances between the chain and the ground. Using a self-consistent harmonic approximation, we determine the phase diagram at zero temperature which exhibits a quantum phase transition between a long-range ordered phase, corresponding to the superconducting state, and a disordered phase, corresponding to the insulating state with localized superconducting charge. Interestingly, we find that the critical line separating the two phases has a non monotonic behavior as a function of the dissipative coupling strength. The non monotonic behavior is reflected also in the purity of the system that quantifies the degree of correlation between the system and the environment, and the logarithmic negativity as entanglement measure that encodes the internal quantum correlations in the chain.
[1] D. Maile, S. Andergassen, W. Belzig, G. Rastelli, arXiv:1711.11346

TT 88.6 Thu 12:45 H 3010

Emergent symmetry in quantum critical Dirac systems — •Lukas Janssen[1], Igor F. Herbut[2], and Michael M. Scherer[3] — [1]Institut für Theoretische Physik, Technische Universität Dresden, Germany — [2]Department of Physics, Simon Fraser University, Burnaby, Canada — [3]Institut für Theoretische Physik, Universität Köln, Germany

Within the standard Landau-Ginzburg paradigm, $O(N)$ symmetry, when not present explicitly on the microscopic level, can emerge dynamically at some critical point only for small $N<3$. We show that this classical conclusion becomes severely overturned in the presence of gapless fermion degrees of freedom. We study the quantum multicritical point in 2+1D Dirac systems between the semimetallic phase and two ordered phases that are characterized by anticommuting mass terms with $O(N_1)$ and $O(N_2)$ symmetry, respectively. Using ϵ expansion around the upper critical space-time dimension of four, we demonstrate that the multicritical point is characterized by an emergent $O(N_1+N_2)$ symmetry for arbitrary values of N_1 and N_2 and fermion flavor numbers N_f, as long as the corresponding representation of the Clifford algebra exists. Put differently, small $O(N)$-breaking perturbations near the chiral $O(N)$ fixed point are irrelevant for all $N>1$.