TT 20: Correlated Electrons: (General) Theory 1

Time: Tuesday 15:30–16:30 Location: HSZ 301

TT 20.1 Tue 15:30 HSZ 301

Anyons as Landau Quasi-Particles - Kitaev's Toric Code in a magnetic Field — •Kai Phillip Schmidt[1], Sébastien Dusuel[2], Ronny Thomale[3], and Julien Vidal[4] — [1]Lehrstuhl für theoretische Physik I, TU Dortmund, 44221 Dortmund, Germany — [2]Lycée Saint-Louis, 44 Boulevard Saint-Michel, 75006 Paris, France — [3]Institut für Theorie der Kondensierten Materie, Universität Karlsruhe, 76128 Karlsruhe, Germany — [4]LPTMC, Jussieu, 75252 Paris Cedex 05, France

Kitaev's Toric Code is an exactly solvable two-dimensional spin model which is relevant for topological quantum computation. Elementary excitations are abelian anyons which are strictly local due to conservation laws. In the presence of a finite external magnetic field, the anyonic excitations gain a kinetic energy and they start to interact. Using perturbative continuous unitary transformations, we set up a true quasi-particle description of the abelian anyons inside the topological phase. We study one-particle properties like the anyon dispersion but also the formation of bound states including two or more anyon excitations. These collective modes turn out to be fermions or bosons. Finally, we study the full phase diagram of the model which turns out to be very rich including multi-criticality and self-duality on different lines in parameter space. The critical properties of the model therefore strongly depend on the direction of the magnetic field. Apart from perturbative continuous unitary transformations we use exact diagonalization as a complentary tool.

TT 20.2 Tue 15:45 HSZ 301

Entanglement and relative local entropies: Introducing a quantitative measure of correlations in correlated electron systems — •Krzysztof Byczuk[1], Walter Hofstetter[2], and Dieter Vollhardt[3] — [1]Institute of Theoretical Physics, University of Warsaw, ul. Hoza 69, PL-00-681 Warszawa, Poland — [2]Institut fur Theoretische Physik, Johann Wolfgang Goethe-Universitaet, D-60438 Frankfurt/Main, Germany — [3]Theoretical Physics III, Center for Electronic Correlations and Magnetism, Institute for Physics, University of Augsburg, D-86135 Augsburg, Germany

We employ the concept of entanglement and relative local entropies to provide a quantitative measure of the strength of correlations in interacting electronic systems. As an application we solve the Hubbard model within the dynamical mean-field theory and extract the entanglement local entropy as well as the relative local entropy, using different Hartree-Fock-like ground states as reference states. The strength of the correlations in the paramagnetic and antiferromagnetic phase, expressed by the relative entropies with respect to the Hartree-Fock solutions, is discussed.

TT 20.3 Tue 16:00 HSZ 301

Upper bound of truncation errors in continuous unitary transformations — •Nils A. Drescher[1], Tim Fischer[1], and Götz S. Uhrig[1,2] — [1]Technische Universität Dortmund, Lehrstuhl für Theoretische Physik I, 44221 Dortmund, Germany — [2]School of Physics, University of New South Wales, Kensington 2052, Sydney NSW, Australia

Self-similar continuous unitary transformations (CUTs) are a method to systematically derive effective models for many-particle-systems of finite or infinite size. They allow us to separate Hilbert spaces of different numbers of quasiparticle. Technically this is done by solving the flow equations for the coefficients of the various terms in the Hamiltonian. In order to keep the number of equations finite truncations are inevitable. The choice of an efficient truncation scheme which preserves the relevant physics is a highly non-trivial task. Here we present the mathematical derivation of a method to quantify the truncation error so that different truncation schemes can be compared without bias. Thereby we can establish rigorous bounds on the accuracy of the ground state energy calculated by CUT. Exemplary results a shown for zero and one dimensional systems[1,2].

[1] S. Dusuel and G.S. Uhrig, Journal of Physics A: Mathematics and General 37, 9275- (2004).

[2] C. Knetter, K.P. Schmidt, and G.S. Uhrig, Journal of Physics A: Mathematics and General 36(29), 7889 (2003).

TT 20.4 Tue 16:15 HSZ 301

Simulating strongly correlated fermions with unitary networks — •Carlos Pineda and Jens Eisert — University of Potsdam, 14476 Potsdam, Germany

One of the central challenges in the numerical study of quantum many-body systems is to efficiently identify ground state properties of strongly correlated two- and higher-dimensional quantum systems. Recently, it has become clear that efficiently contractable tensor networks offer new perspectives for such simulations: In one dimension, the density-matrix renormalization group method and entanglement renormalization can both be grasped as such networks, with natural higher-dimensional analogues [1,2,3,4]. In this work, we introduce a framework of unitary tensor networks for fermions, which is not overburdened by encountering non-local string operators in the spin representation. In fact, there is only a constant overhead in the effort to compute local expectation values. We present a formalism of dynamical relabeling of fermions and dicuss first results on this framework.

[1] G. Vidal, Phys. Rev. Lett. 99, 220405 (2007).

[2] C.M. Dawson, J. Eisert, T.J. Osborne, Phys. Rev. Lett. 100, 130501 (2008).

[3] M.-C. Banuls, D.P.-García, M.M. Wolf, F. Verstraete, J.I. Cirac, Phys. Rev. A 77, 052306 (2008).

[4] U. Schollwoeck, Rev. Mod. Phys. 77, 259 (2005).