TT 2: Tutorial: Advanced Algorithms for Correlated Quantum Matter

This Tutorial provides an introduction into a most important sub-field of computational physics, namely the investigation of strongly correlated quantum systems by modern numerical methods. Further details and recent scientific advancements will be presented in the corresponding TT Focus Session (Tuesday, starting at 9:30 in HSZ 03).

Organizers: Fakher Assaad (Uni Würzburg), Ulrich Eckern (Uni Augsburg)

Time: Sunday 16:00–18:25 Location: HSZ 04

Tutorial TT 2.1 Sun 16:00 HSZ 04

DMRG and Entanglement Scaling — •Fabian Heidrich-Meisner — Ludwig-Maximilians-University Munich, Germany

This talk will provide an introduction to the density matrix renormalization group method which provides numerical access to many-body wave functions of quantum lattice models such as the Hubbard, Heisenberg, or the t-J model. The main idea is to approximate wave-functions through finite-dimensional matrix product states (MPS). The performance of the technique is intimately related to the entanglement encoded in the target wave-function. For gapped Hamiltonians with short range interactions, the so-called area law states that their ground states are only mildly entangled, permitting an efficient representation of many-body states using MPS in one dimension. The more difficult case of two-dimensional systems, critical systems in one dimension, and time-evolution will also be discussed.

5 min. break

Tutorial TT 2.2 Sun 16:50 HSZ 04

Introduction to Tensor Networks — •Roman Orus — Institut für Physik, Johannes Gutenberg Universität, Staudingerweg 7, 55099 Mainz, Deutschland

In this tutorial I will give an introduction to Tensor Network methods for strongly correlated systems. Motivated by DMRG and the entanglement properties of 1d systems (see the related previous tutorial), I will extend the ideas to deal with other types of situations, such as 2d and scale-invariant systems. The PEPS and MERA tensor networks will be presented and discussed. After providing practical examples, I will explain some of the related numerical methods at an introductory level.

5 min. break

Tutorial TT 2.3 Sun 17:40 HSZ 04

Quantum Monte Carlo Methods — •Stefan Wessel — Institute for Theoretical Solid State Physics, RWTH Aachen University, Aachen, Germany

This tutorial will introduce the basic ideas behind modern quantum Monte Carlo simulation methods, focusing on world-line approaches for quantum spin systems. In particular, the cluster-based loop algorithm in the continuous-time formulation as well as the stochastic series expansion and the directed loop update approach will be presented. The advantages and limitations of these simulations methods will be discussed.