DVR 0065528

"Tensor networks & entanglement"

within the programme "Quantum Paths"

May 14 – May 18, 2018

organized by
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- **Monday, May 14, 2018**
  11:00 Mari-Carmen Banuls (MPI für Quantenoptik, Garching)
  Using Matrix Product Operators to explore MBL

  The extension of matrix product states to operators (MPO) offer several ways of numerically exploring out-of-equilibrium problems. One example application includes approximating the steady state of a dissipative quantum system. Another one is simulating the evolution of mixed states, and identifying the operators that show the slowest evolution and thus will give rise to large time scales in the system. Such techniques can be successfully applied to different scenarios, such as many body localization. Combining tensor network techniques and quantum information concepts also provides new perspectives to explore the characteristics of this kind of systems.

- **Tuesday, May 15, 2018**
  11:00 Anatoli Polkovnikov (Boston University)
  Cluster Truncated Wigner Approximation for strongly correlated quantum systems

  In this talk I will discuss how one can consistently improve accuracy of the semiclassical truncated Wigner approximation (TWA) by increasing classical phase space dimensionality. This is done by treating local correlations as independent classical variables. Such mapping allows one to correctly account for short distance entanglement as well as approximate long distance entanglement through classical mutual information. I will also introduce related ideas for fermionic systems, where the mapping to classical phase space is done through identifying bilenears with phase space variables. I will discuss general ideas, some important subtleties and show applications of these methods to various non-trivial problems.

- **Wednesday, May 16, 2018**
  11:00 Olalla Castro Alvaredo (City University London)
  Entanglement Content of Particle Excitations in Quantum Field Theory

  In this talk I will present recent work on the entanglement entropy of excited states of free massive theories. The kind of excited states we will be considering are characterised by a finite number of one-particle excitations of equal or distinct rapidities.
  The results are surprising due to their universality and simplicity.We findthat for infinitevolumethe difference between the Rnyientropies of the ground state and an excited state, is independent of the volume, the particle momenta and the mass scale. Instead itis asimple function (e.g. the logarithm of a polynomial) of the ratio of interval length to system length. This simple function admits a very intuitive "qubit" inter-

pretation and is identical for free fermions and bosons. Additional computations in (interacting)quantum spin chains and numerical results for a harmonic chain suggestthe behaviour we have found isuniversal beyond free theories and even the QFT regime. The techniques employed in our work involve the branch point twist field approach to measures of entanglement, the finite volume form factor approach that will allow us to compute correlators of these fields in excited states at finite volume, and a particular technique useful in free theories which is known as the doubling trick and which allows for realisations of the branch point twist field in terms of simpler U(1) symmetry fields.
This work has been carried out in collaboration with Benjamin Doyon, Cecilia de Fazio and Istvan Szécsényi.

- **Thursday, May 17, 2018**
  11:00 Belén Paredes (Ludwig Maximilian University Munich)
  Boson-Lattice construction for anyon models

- **Friday, May 18, 2018**
  11:00 Frank Pollmann (TU Munich)
  Quantum Thermalization Dynamics

  The past decade has seen a great interest in the question about whether and how quantum many-body system locally thermalize. It has been driven by theoretical findings involving the long sought demonstration that many-body localization (MBL) exists as well as the derivation of exact bounds on chaos. In my talk, I will introduce matrix-product state (MPS) based methods that allow for an efficient numerical simulation of the quantum thermalization dynamics. Firstly, I will show that, contrary to the common belief that the rapid growth of entanglement restricts simulations to short times, the long time limit of local observables can be well captured using the MPS based time-dependent variational principle. Secondly, I will consider 1D spin-chains evolving under random local unitary circuits and prove a number of exact results. These results follow from the observation that the spreading of operators in random circuits is described by a "hydrodynamical" equation of motion.