



FOCUS WEEK 1: TENSOR NETWORKS

TITLES AND ABSTRACTS

MINICOURSE (3 hours)

Speaker: Maricarmen Bañuls

Title: An introduction to tensor networks

Abstract: In this series of talks I will give an introduction to the rapidly developing subject of tensor network states (TNS). Starting from the graphical representation of TNS, I will present the main characteristics of (some of) the most significant families of TNS (MPS, MPO, PEPS, trees, MERA). In the last part, I will review some of the most important numerical algorithms with TNS.

The talks will start at the most basic level, and are intended for an audience without TNS expertise, to provide some background that helps following more advanced talks during the rest of the focus week.

TALKS

Speaker: Gemma de las Cuevas

Title: Local descriptions of mixed states

Abstract: Local descriptions of mixed states face a fundamental challenge: the description that is locally positive is arbitrarily more costly than the most efficient one. This is due to the separation between the rank and positive semidefinite rank. More generally, several decompositions of mixed states correspond, in a particular case, to decompositions of nonnegative matrices such as the nonnegative factorisation, the positive semidefinite factorisation, the completely positive factorisation and the completely positive semidefinite decomposition. I will give several examples of what can be learnt by exploiting this correspondence. Based on joint work with Tim Netzer.

Speaker: Paul Fendley

Title: SPT, AKLT, CFT, and Onsager

Abstract: I explain how everything in the title arises in a nearest-neighbour parafermion Hamiltonian, using self-duality as an essential tool.

Speaker: Angelo Lucia

Title: Boundary Hamiltonians and spectral gaps for 2D PEPS

Abstract: Proving that the parent Hamiltonian of a Projected Entangled Pair State (PEPS) is gapped remains an important open problem. I will present two recent results which advance our understanding of this problem. First, I will give a condition on the boundary state of rectangular subregions which is sufficient to prove that the parent Hamiltonian of the bulk 2D PEPS has a constant gap in the thermodynamic limit. Secondarily I will show that boundary states which are Gibbs states of a local Hamiltonian on the virtual indices satisfy such condition. The proof employs the martingale method of nearly commuting projectors, and exploits a result of Araki on the robustness of one dimensional Gibbs states.

Based on joint work with M. J. Kastoryano and D. Perez-Garcia.

Speaker: Bruno Nachtergaele

Title: A Dynamical Toric Code model and Stability of the superselection sectors of two-dimensional quantum lattice models

Abstract: Kitaev's quantum double models provide a rich class of examples of twodimensional lattice systems with topological order in the ground states and a spectrum described by anyonic elementary excitations. The infinite volume ground states of the abelian quantum double models come in a number of equivalence classes called superselection sectors. We prove that the superselection structure remains unchanged under uniformly small perturbations of the Hamiltonians. We introduce a Dynamical Toric Code Model and discuss some of its features.

(Joint work with Matthew Cha, Pieter Naaijkens, and Nicholas Sherman)

Speaker: Yoshiko Ogata

Title: Classification of symmetry protected topological phases in quantum spin chains

Abstract: For the classification of SPT phases, defining an index is a central problem. In the famous paper, Pollmann, Tuner, Berg, and Oshikawa introduced \${\mathbb Z}_2\$-indices for injective matrix products states (MPS) which have either \${\mathbb Z}_2\times {\mathbb Z}_2\$ dihedral group (of \$\pi\$-rotations about \$x\$, \$y\$, and \$z\$-axes) symmetry, time-reversal symmetry, or reflection symmetry. We introduce an index which generalizes the index by Pollmann et.al. The index is an invariant of the \$C^1\$-classification of SPT phases.

Speaker: Norbert Schuch

Title: Title: Construction and analysis of SU(3) spin liquids and resonating trimer models using Projected Entangled Pair States

Abstract: Topological spin liquids are novel phases of matter where spins order topologically rather than magnetically, making them challenging to construct and analyze. In my talk, I will explain how Projected Entangled Pair States (PEPS) can be used to construct and characterize topological spin liquid wavefunctions with SU(N) symmetry. In particular, I will introduce two ways to generalize the kagome SU(2) Resonating Valence Bond spin liquid to SU(3) - the first of which can be linked to RG fixed points, and the other to resonating trimer models. I will show how the PEPS description allows us to analyze these models, and in particular gives us direct access to order parameters for anyons which enable us to explicitly characterize the topological features of the system.

Amanda Young

Title: A gapped family of two-dimensional AKLT models

Abstract: The one-dimensional AKLT spin chain is the prototypical example of a frustration-free quantum spin system with a spectral gap above its ground state. Affleck, Kennedy, Lieb, and Tasaki conjectured that the two-dimensional version of their model on the hexagonal lattice also exhibits a spectral gap. We introduce a family of variants of the hexagonal AKLT model, defined by decorating each edge of the lattice with an AKLT chain of length n, and prove that these decorated models are gapped for all $n \ge 3$.