



Deutsches Elektronen-Synchrotron DESY
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Quantum computing and Tensor Networks

Karl Jansen and Andreas Athenodorou



ECT*
EUROPEAN CENTRE
FOR THEORETICAL STUDIES
IN NUCLEAR PHYSICS AND RELATED AREAS



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Proposal for Syllabus on Tensor Network

- ❖ 1 Linear Algebra, Tensor Products
- ❖ 2 Introduction into Matrix Product States and DMRG
- ❖ 3 Algorithms and Techniques for Matrix Product States
- ❖ 4 Tips and tricks for matrix product states simulations
- ❖ 5 Simple Applications
- ❖ 6 Entropy, conformal charge and all that
- ❖ 7 Algorithms for tensor networks in larger than 1 dimension

Pre-existing material and gaps on Tensor Networks

- ❖ 7 Advanced Applications of tensor networks in condensed matter physics (sign problems, chemical potential, topological terms)
- ❖ 8 Real and imaginary time evolution
- ❖ 9 Advanced Applications of tensor networks in lattice gauge theory
- ❖ 10 Advanced Applications of tensor networks in conformal field theory
- ❖ 11 Alternative Techniques (tensor trains etc.)

People involved involved so far in Tensor Networks

- ❖ Karl Jansen
- ❖ Stefan Kuehn
- ❖ Mari Carmen Banuls
- ❖ Simone Montangero
- ❖ Michal Heller

Syllabus on Quantum Computing – 1

- ❖ 1 Vector Spaces, Tensor Products and Qubits
- ❖ 2 Introduction to Quantum Circuits
- ❖ 3 Simple Quantum Algorithms I (also hands on tutorials)
- ❖ 4 Simple Quantum Algorithms II (also hands on tutorials)
- ❖ 5 Noise in Quantum Computers - part 1
- ❖ 6 Noise in Quantum Computers - part 2
- ❖ 7 Introduction to advanced Quantum Algorithms
- ❖ 8 Variational Quantum Algorithms

Syllabus on Quantum Computing – 2

- ❖ 9 Quantum Machine Learning Algorithms
- ❖ 10 Introduction to Quantum Classifier Algorithms
- ❖ 11 Barren Plateaus, Problems in Trainability and methods to mitigate them
- ❖ 12 Error mitigation in quantum computations
- ❖ 13 Dimensional Expressivity Analysis
- ❖ 14 Selected Applications I
- ❖ 15 Selected Applications II
- ❖ Comments:
 - ❖ (i) from here one could also move to Quantum hardware or advanced applications
 - ❖ (ii) there are also good video tutorials on youtube

People involved so far on Quantum Computing



- ❖ Karl Jansen
- ❖ Stefan Kuehn
- ❖ We can also ask people from IBM