New trends in tensor networks: from machine learning to Quantum computing

Xavier Waintal

CEA Grenoble, France

xavier.waintal@cea.fr

Tensor network techniques are well-established numerical tools for solving seemingly exponentially hard problems in quantum many-body physics with important successes in the simulation of model correlated electronic systems, quantum magnetisms and quantum computers. In this tensor network historical use, the quantum many-body wave function is compressed, using tensor networks, allowing for a considerable speed-up of an otherwize impossible calculation.

In the last few years, a crucial piece of learning algorithm (e.g. the Tensor Cross Interpolation algorithm) has emerged. These techniques can learn a tensor network representation of a mathematical object a priori unrelated to tensors. These new algorithms provide a path to transfer all the technology that have been developped for the quantum many-body wave function to an entirely new set of mathematical problems: Integrals in high dimensions, Partial differential equations, function optimization. New applications for e.g. computational fluid dynamics, basis set in chemistry, Feynman diagram calculations, plasma physics…are quickly emerging.

In this tutorial, I will discuss these new developments focussing on a few practical examples.