Categorical Tensor Networks

Biamonte (Oxford), SR Clark (CQT, Oxford) and Jaksch (Oxford, CQT)

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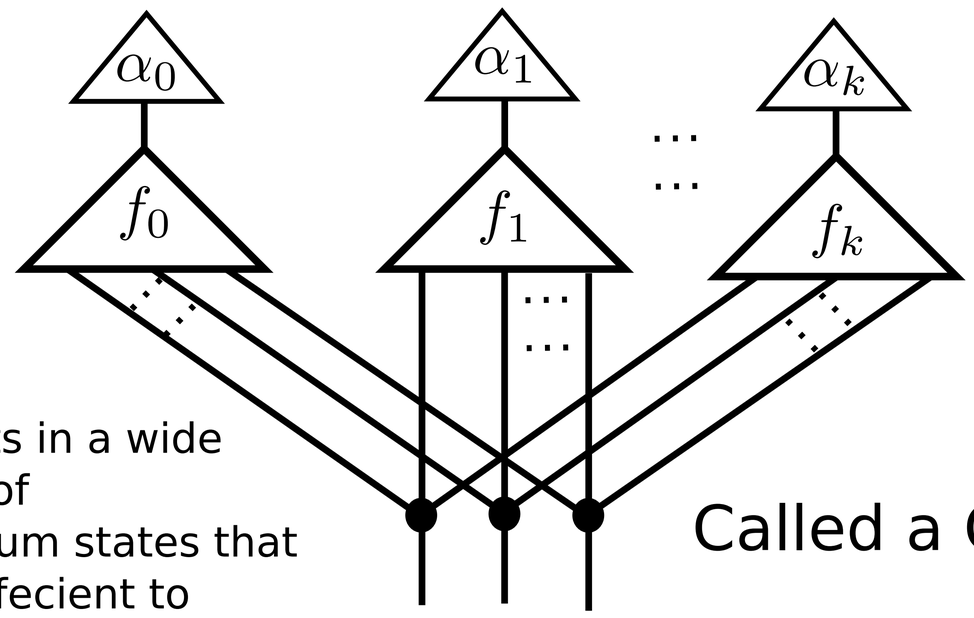
Jacob.Biamonte@qubit.org

Abstract

We examine the use of the mathematics of category theory in the description of quantum states by tensor networks. This approach enables the development of a categorical framework allowing a solution to the quantum decomposition problem. Specifically, given an n-body quantum state ψ, we present a general method to factor ψ into a tensor network. Moreover, this decomposition of ψ uses building blocks defined mathematically interms of purely diagrammatic laws. We use the solution to expose a previously unknown and large class of quantum states which we prove can be sampled efficiently and exactly. This general framework of categorical tensor networkstates, where a combination of generic and algebraically defined tensors appear, enhances the theory of tensor network states.

A normal form on states

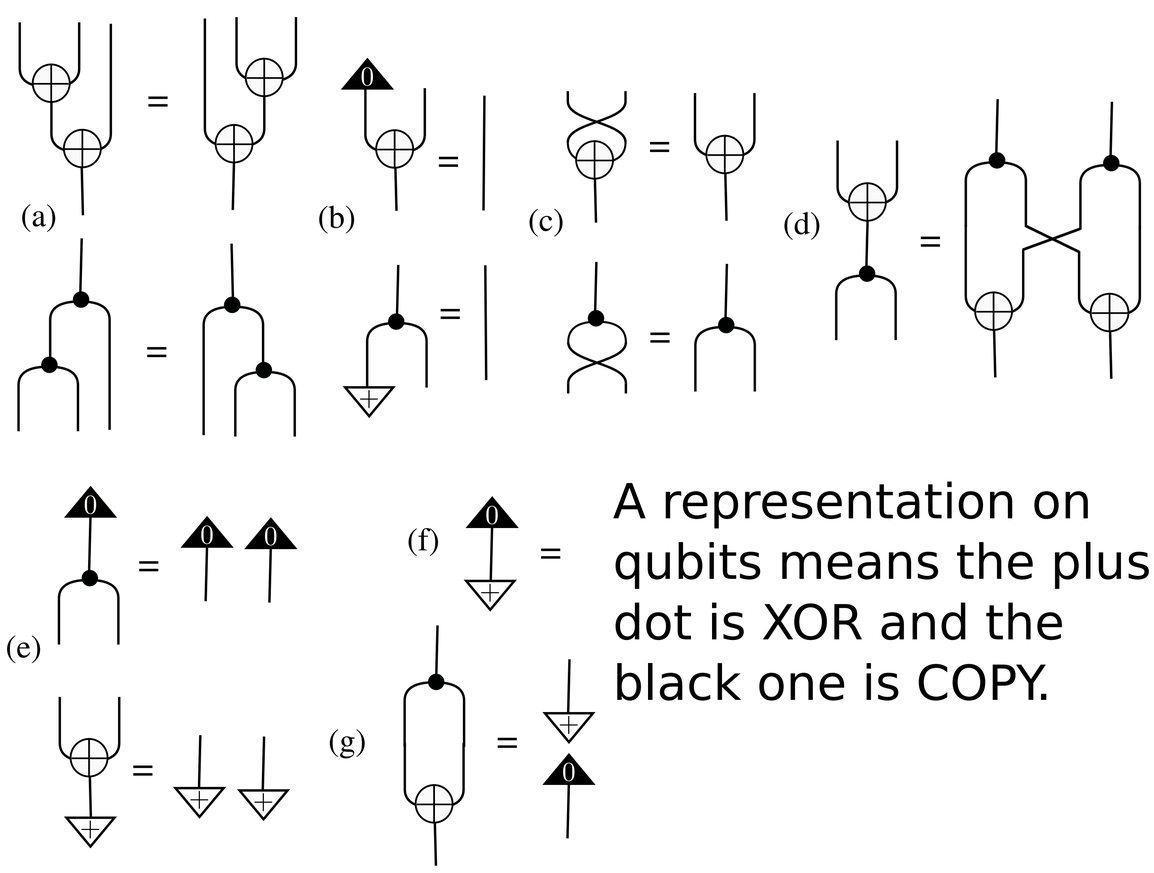


Results in a wide class of quantum states that are effecient to sample.

Called a CTNS

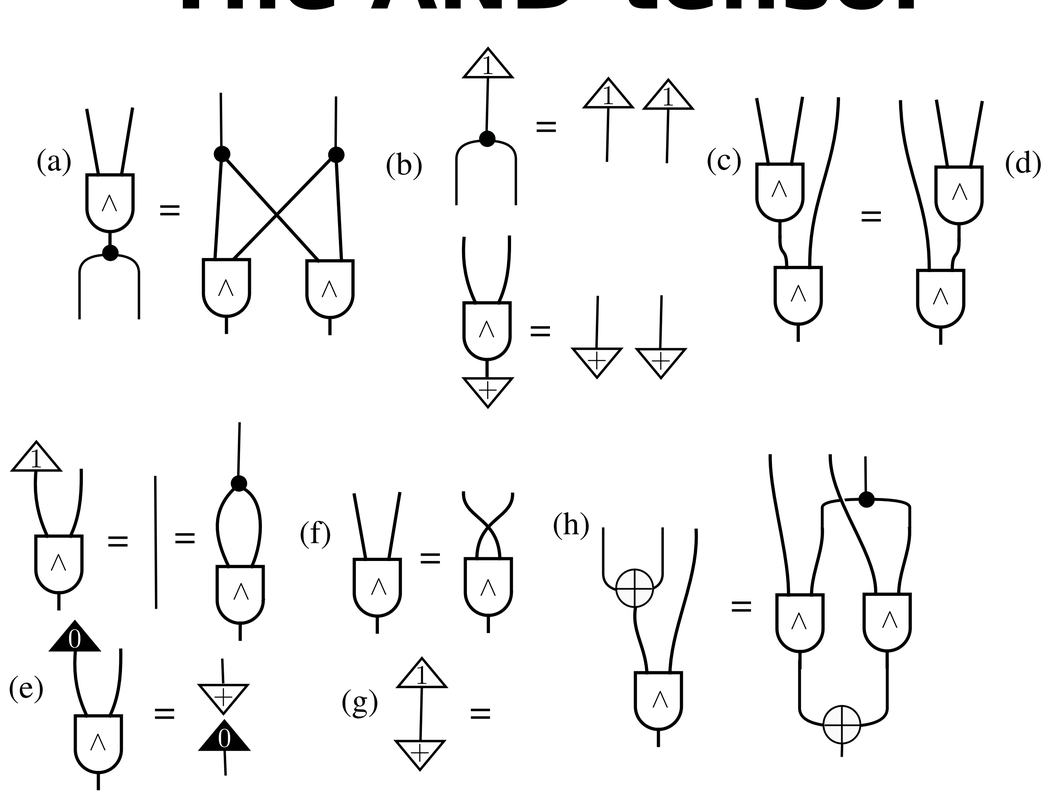
The tensors in a CTNS are fully defined

Representing algebras on quantum states

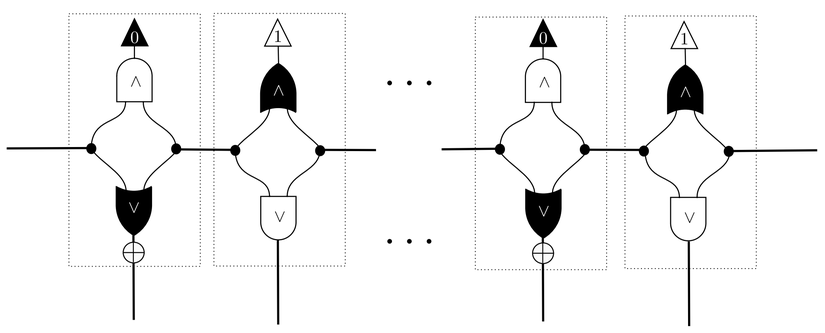


A representation on qubits means the plus dot is XOR and the black one is COPY.

The AND-tensor



W-state on n-qubits



Solve 3SAT by network contraction