

Reconfiguring staggered quantum walks with ZX

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HASLab - INESCITEC

Introduction to the Staggered Quantum Walk

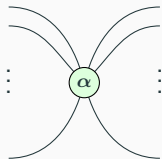
Staggered Quantum Walk

In contrast to conventional, coin-based quantum walks, which proceed straightforwardly from one vertex to another, the staggered variant takes advantage of forming partitions of graph cliques over the graph structure of the walking space.

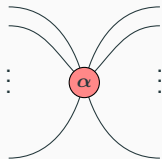
Introduction to the ZX-Calculus

The ZX-calculus is diagrammatic language for reasoning about linear maps between qubits and, as such, about quantum computation in general.

ZX-Calculus - Generators



$$:= |0 \dots 0\rangle \langle 0 \dots 0| + e^{i\alpha} |1 \dots 1\rangle \langle 1 \dots 1|$$



$$:= |+\dots+\rangle \langle +\dots+| + e^{i\alpha} |-\dots-\rangle \langle -\dots-|$$

ZX-Calculus - Rewrite Rules

- Spider Fusion



- Identity Removal



- Color Change



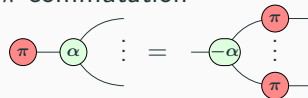
- Hadamard Identity



- Bialgebra



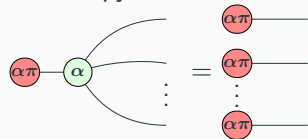
- π -commutation



- Hopf



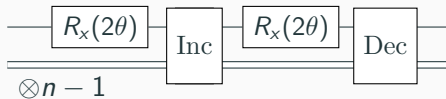
- State copy



Bringing ZX into the picture

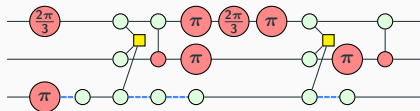
Staggered Quantum Walk - Circuit

A general implementation of a Staggered Quantum Walk for a line graph.



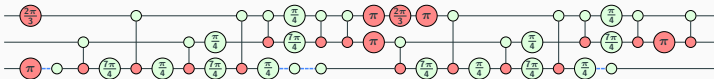
Staggered Quantum Walk - ZX-diagram

A concrete implementation of a Staggered Quantum Walk for a line graph with 3 qubits and the state $|4\rangle$ as the initial state.



Staggered Quantum Walk - ZX-diagram

The previous diagram utilizes a notation from the ZH-calculus for the Toffoli gates that greatly simplifies the diagram. Expanding the Toffoli gates it yields



Staggerd Quantum Walk - ZX-diagram

