Quantum circuit optimisation, verification, and simulation with PyZX

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PyZX: a Python library for manipulating large ZX-diagrams

Quantum computation

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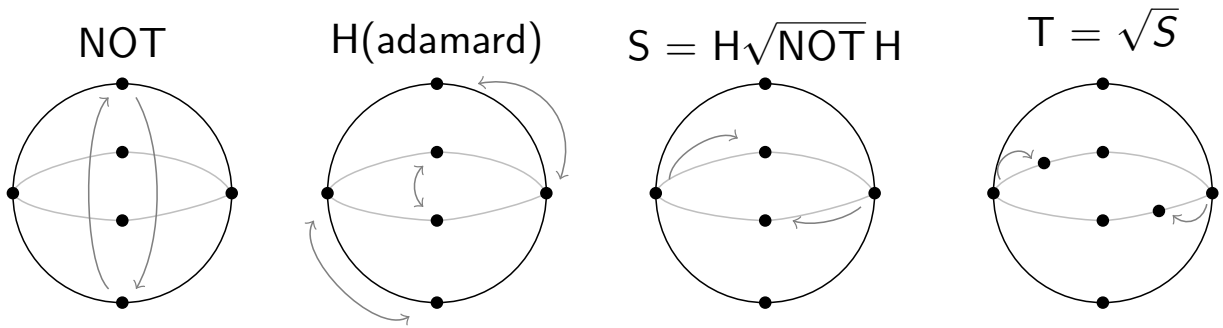

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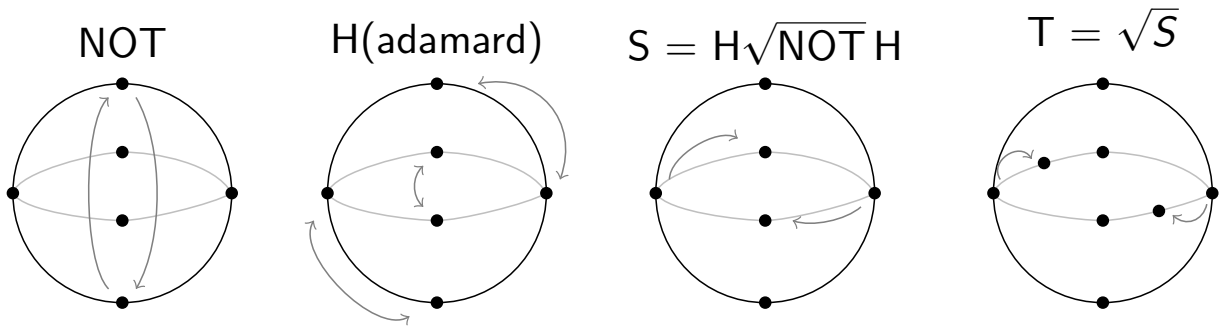

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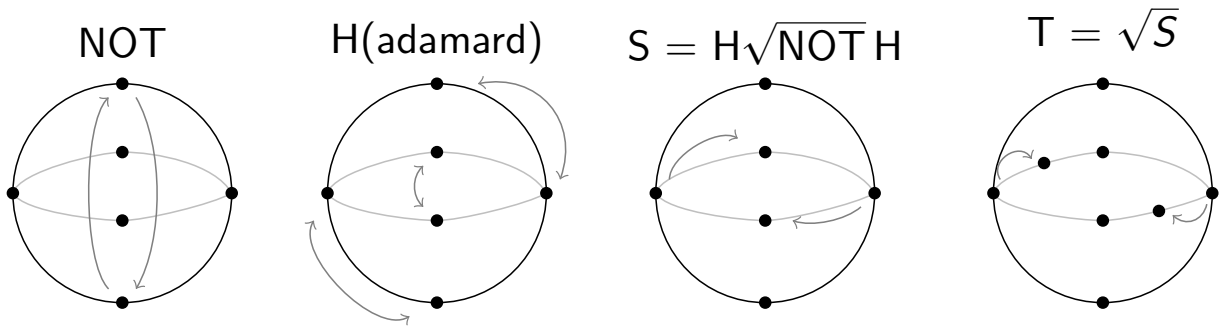

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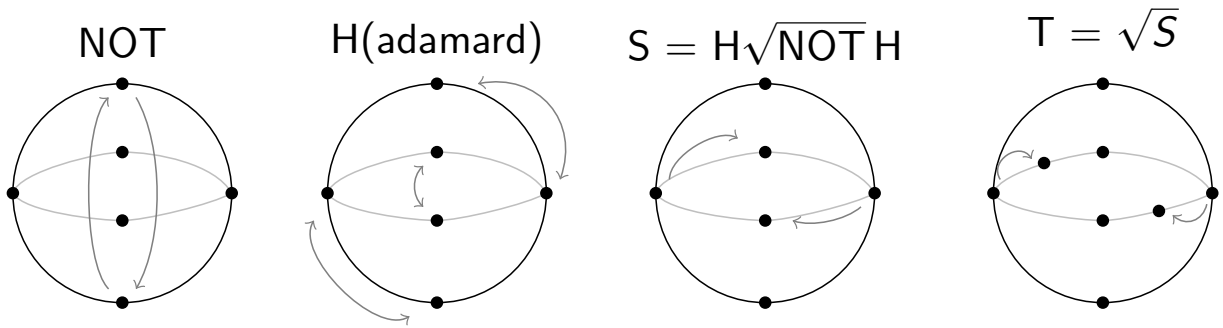

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- Our objective (for now) is to minimize number of gates needed

Circuit diagrams

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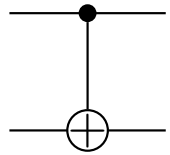
CNOT $=$ 

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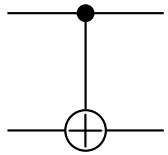
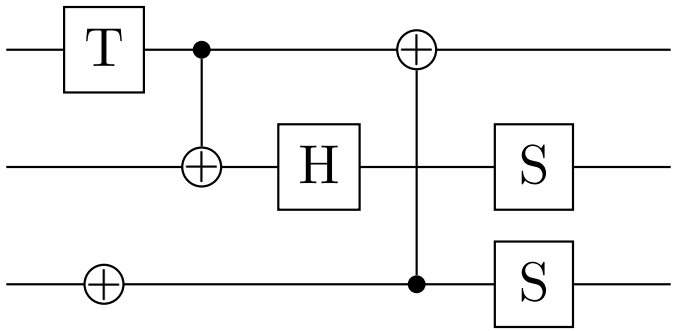
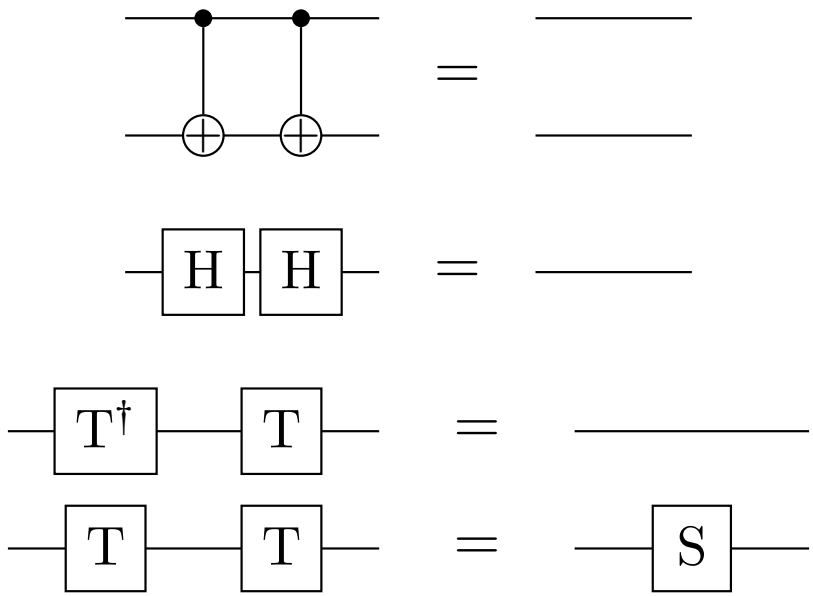
CNOT $=$ 

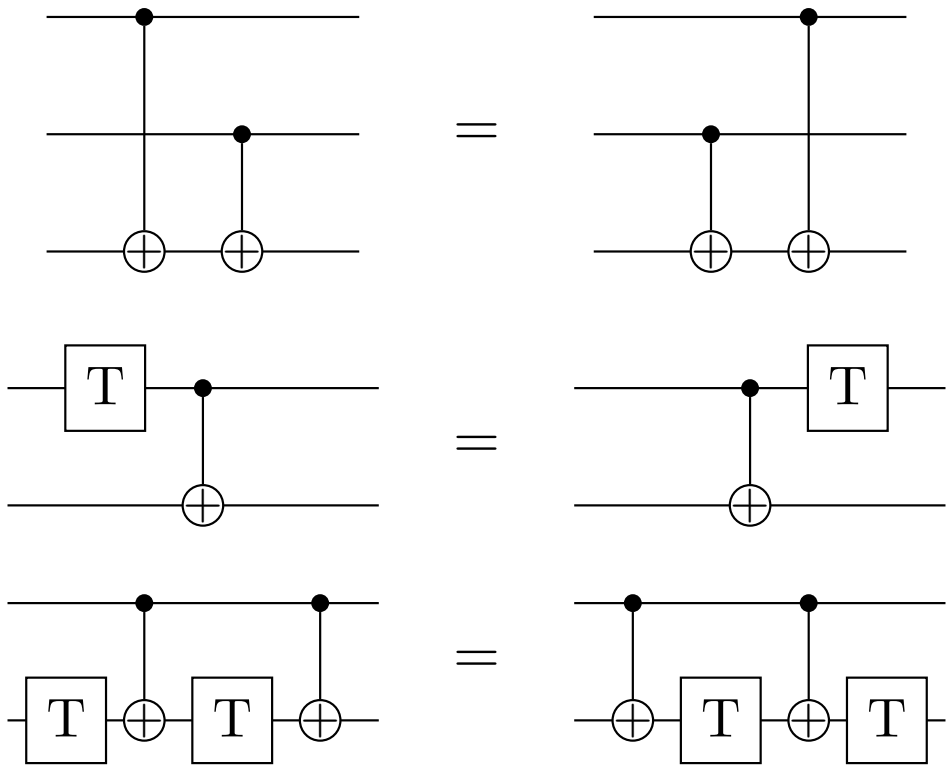
An example quantum circuit:



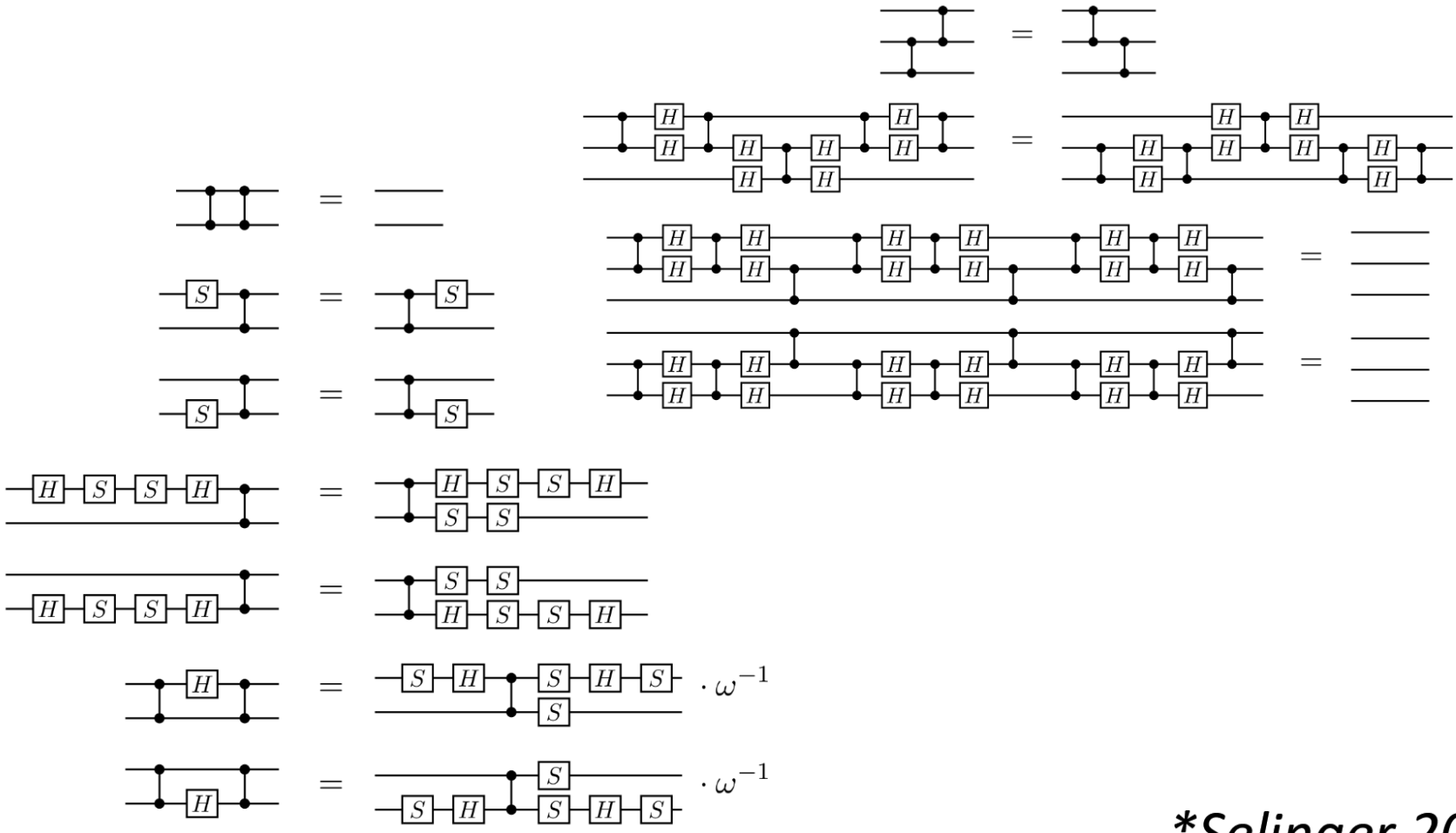
Circuit identities



Gate commutation



More circuit equalities



*Selinger 2015

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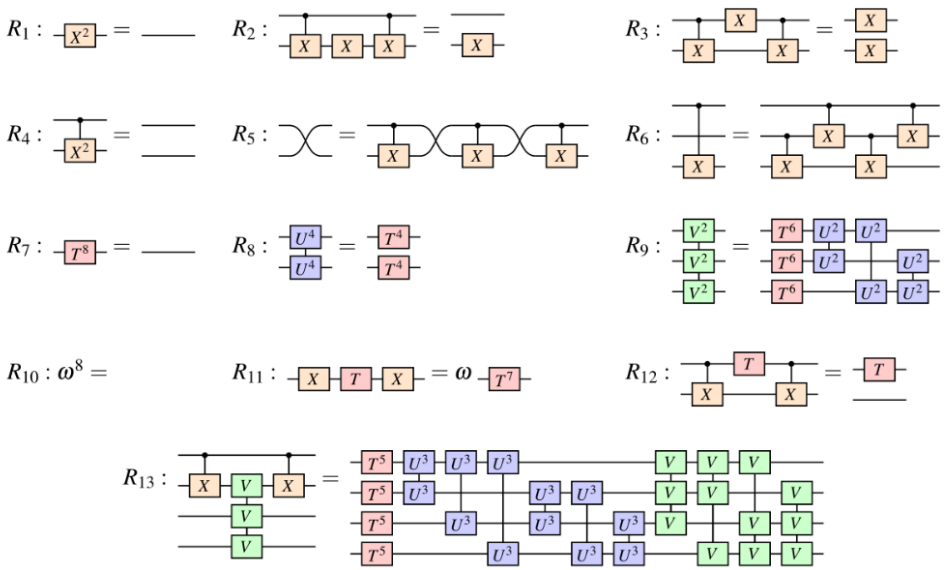
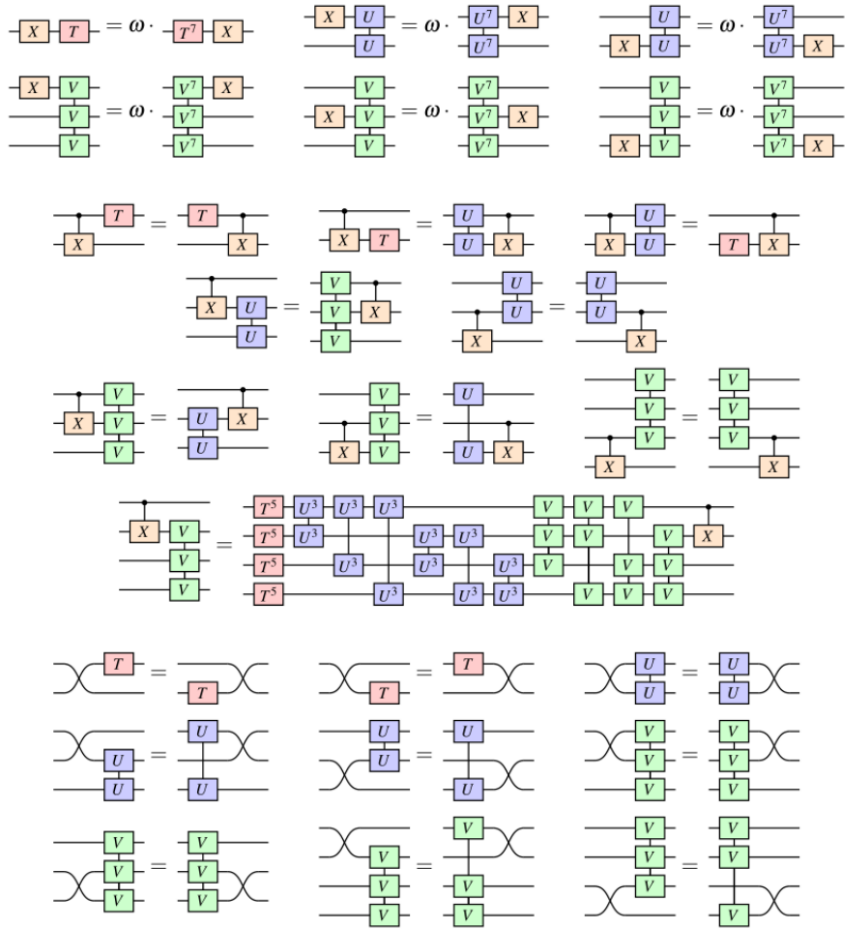
And even more circuit equalities





*Amy, Chen, & Ross 2018

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Enter ZX-diagrams

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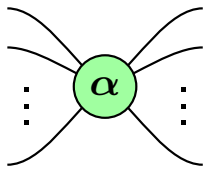
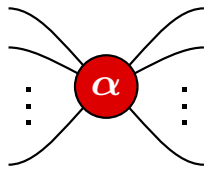
Z-spiders: 

X-spiders: 

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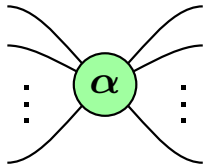
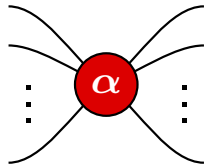
Z-spiders: 

X-spiders: 

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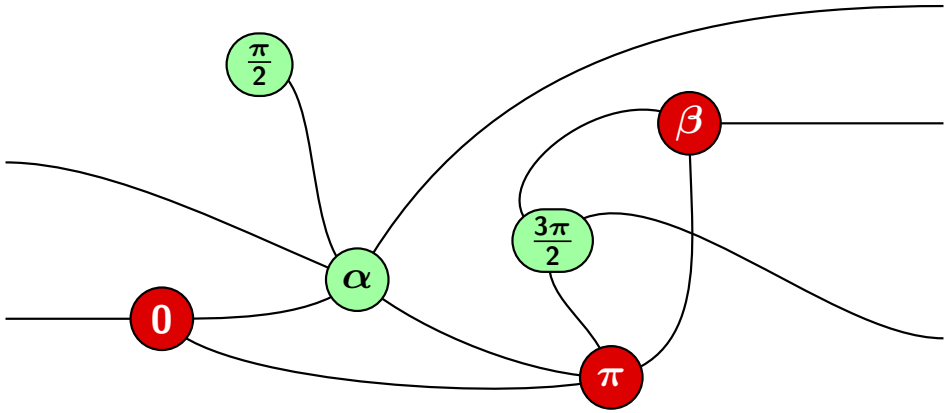
Spiders can be wired in any way:



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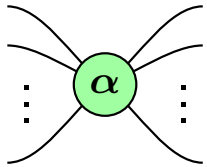
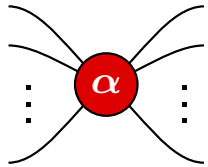
Z-spiders: 

X-spiders: 

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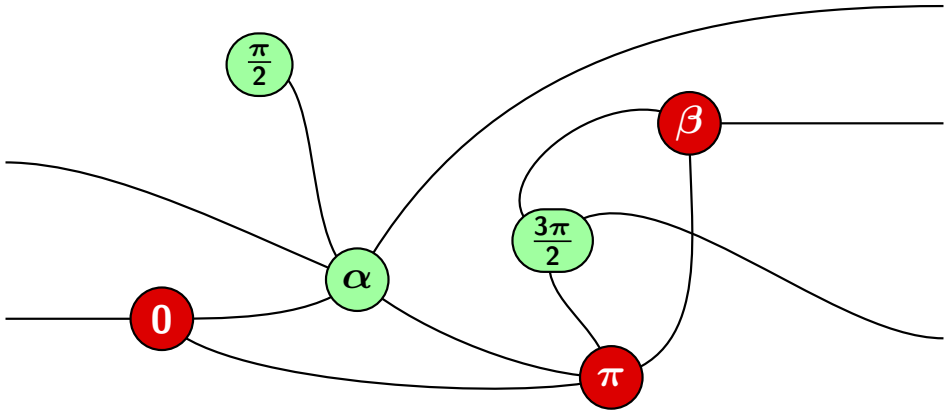
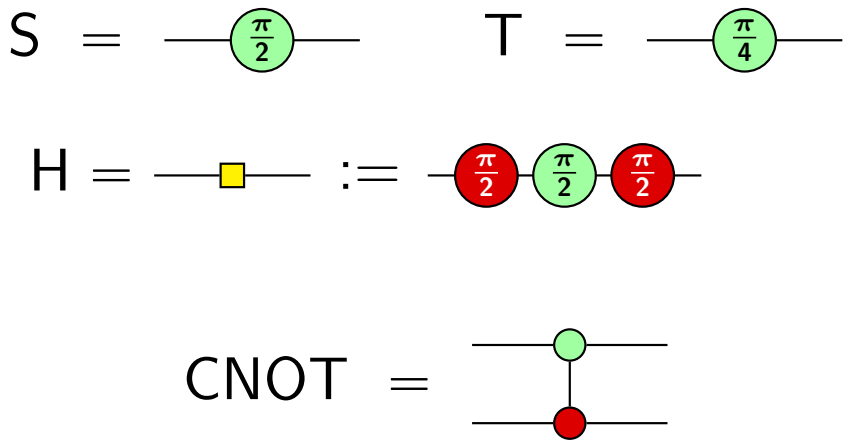


Note: "Only connectivity matters"

Quantum gates as ZX-diagrams

Every quantum gate can be written as a ZX-diagram:



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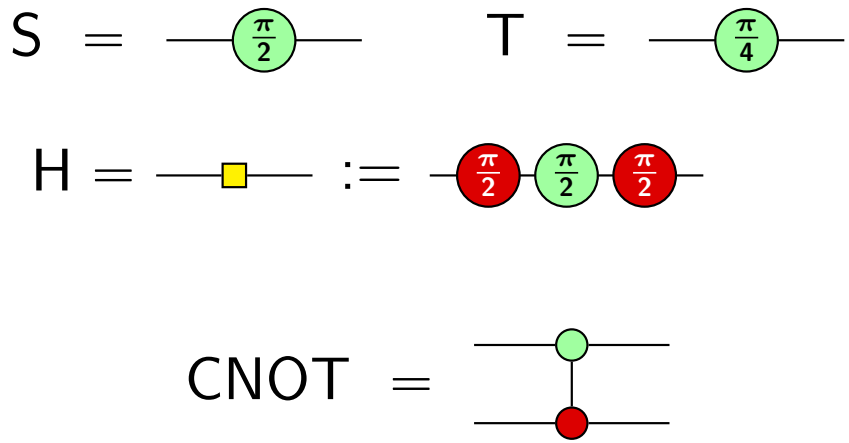
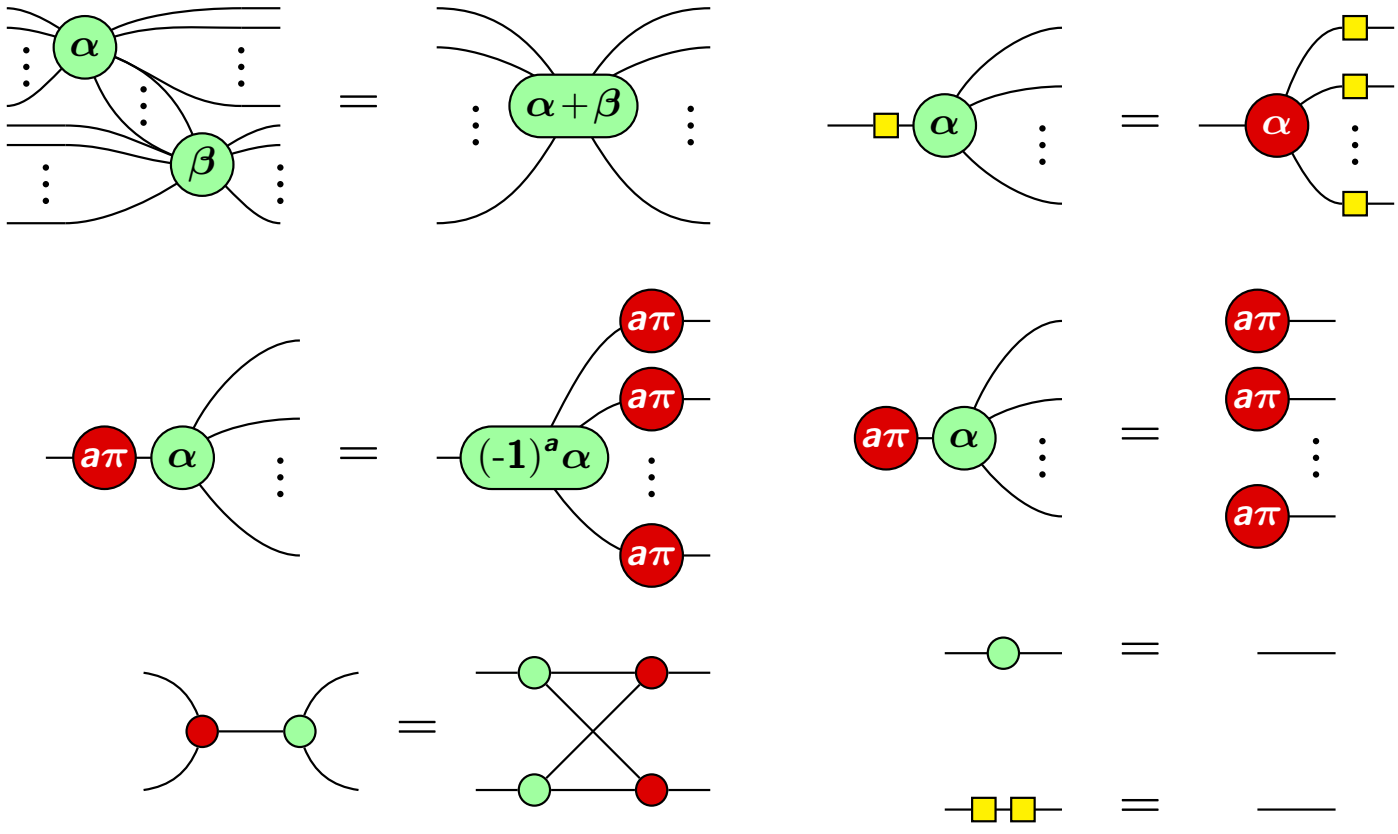


Theorem

Any linear map between qubits can be represented as a ZX-diagram.

Rules for ZX-diagrams: The ZX-calculus



$\alpha, \beta \in [0, 2\pi]$, $a \in \{0, 1\}$

Completeness of the ZX-calculus

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If two ZX-diagrams represent the same computation, then they can be transformed into one another using the previous rules (and one additional one).

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So instead of dozens of circuit equalities,
we just have a few simple rules.

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- Does circuit optimisation
- Does circuit verification
- Does circuit simulation (WIP)

Demonstration time

Want to learn more?

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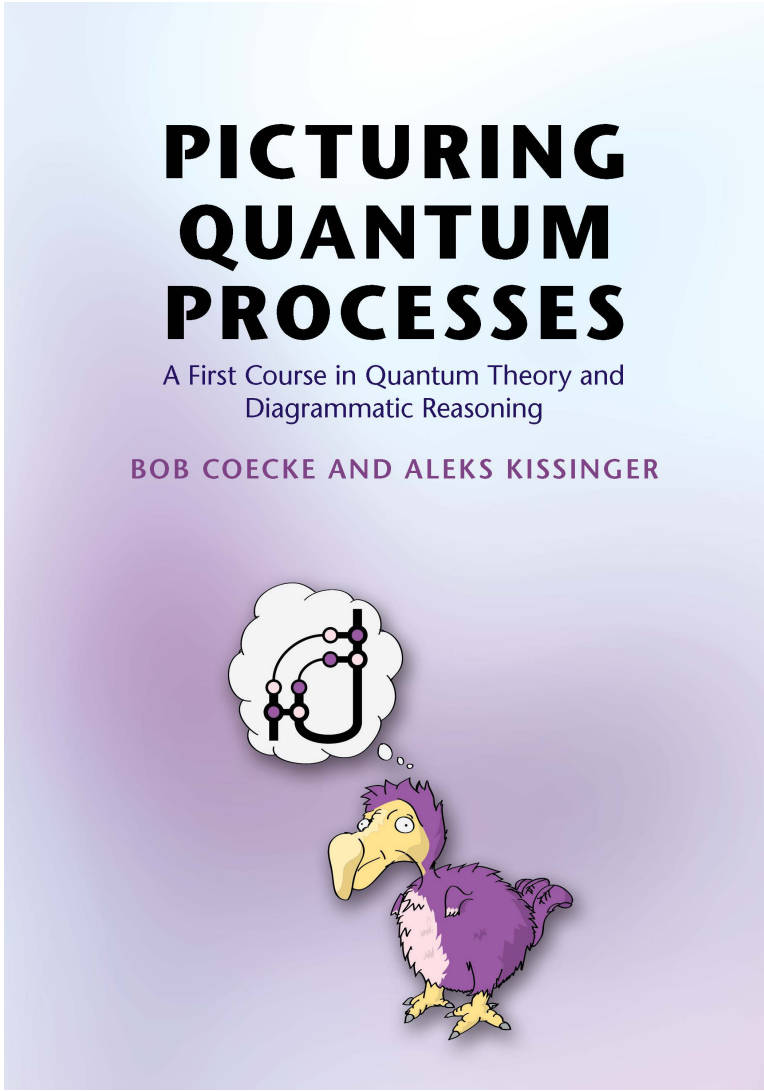

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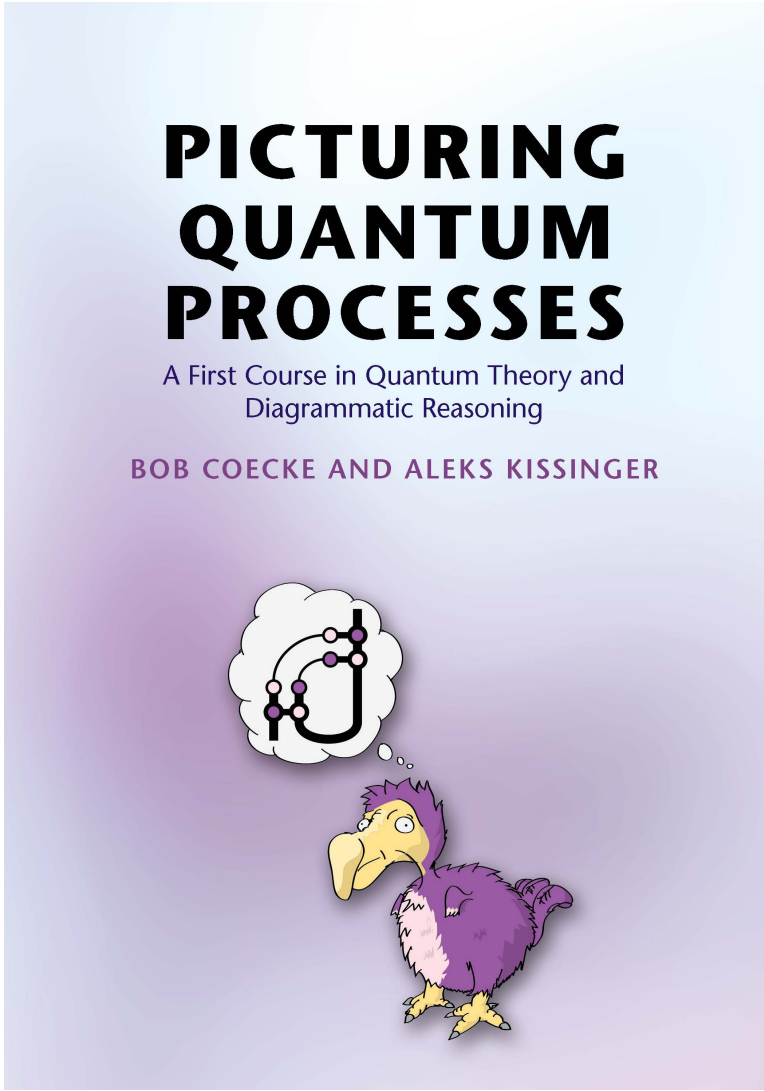

Thank you
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