Title: Alumni Stories: Robert Raussendorf

Speakers: Robert Raussendorf

Collection/Series: Beyond Perimeter - Alumni 25th Anniversary Event

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About me

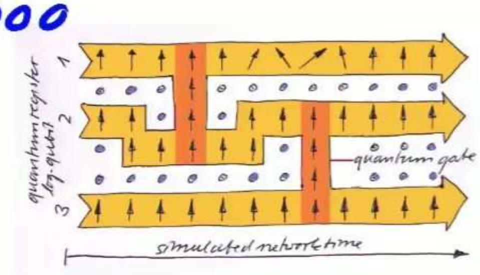
I'm Robert Raussendorf

- I did my PhD at Ludwig Maximilians University in Munich, Germany
- Before I came to PI I was postdoc at Caltech
- I was postdoc at PI 2006 – 2007
- Then I was Professor at UBC Vancouver for 16 years
- Since 2023 I'm Humboldt Professor at Leibniz University Hannover, Germany

My business card

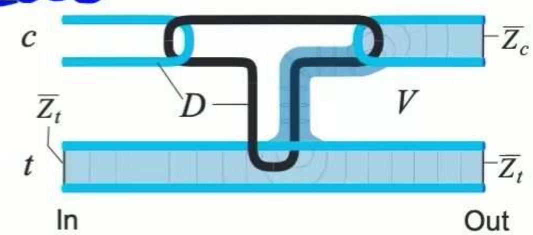
- I work on the foundations of quantum computation

2000



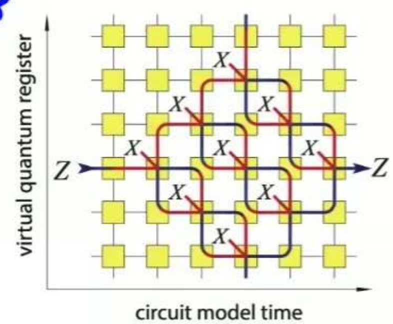
Measurement-based quantum computation

2006



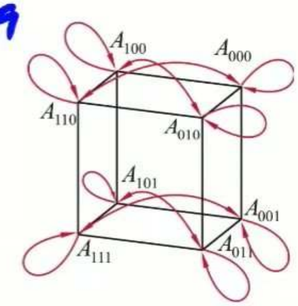
Fault-tolerant MBQC

2018



Computational phases of quantum matter

2019



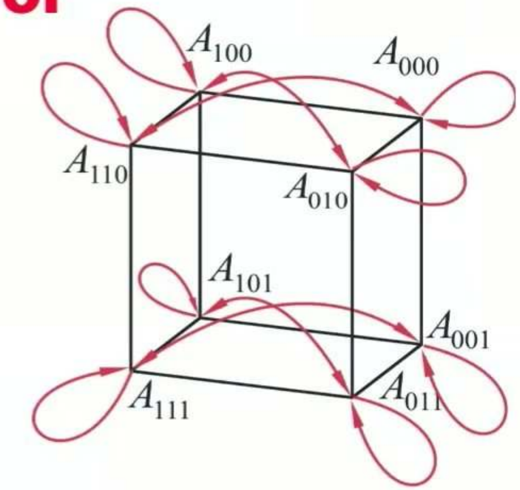
Wigner functions and HVMs

My hometown of Bautzen, Saxony, Germany

My first glimpse of Toronto in 2004

Break from work at PI (2006)

Is negativity in quasiprobability functions necessary for universal quantum computation with magic states?



Robert Raussendorf, Leibniz Universität Hannover

@PI

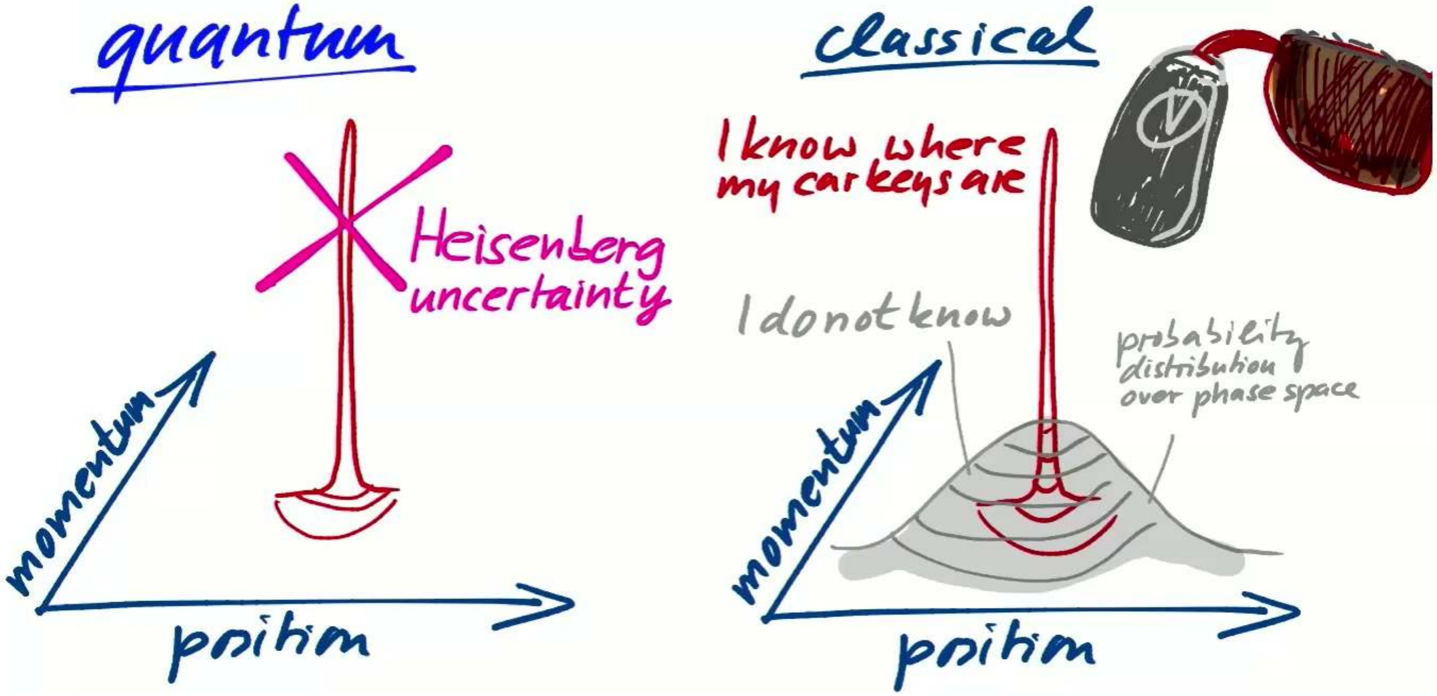
Joint work with Michael Zurel, Cihan Okay, and Polina Feldmann

Michael Zurel, lead author of [1], and no stranger to PI.

[1] M. Zurel, C. Okay and RR, *Hidden Variable Model for Universal Quantum Computation with Magic States on Qubits*, Phys. Rev. Lett. 125 (2020).

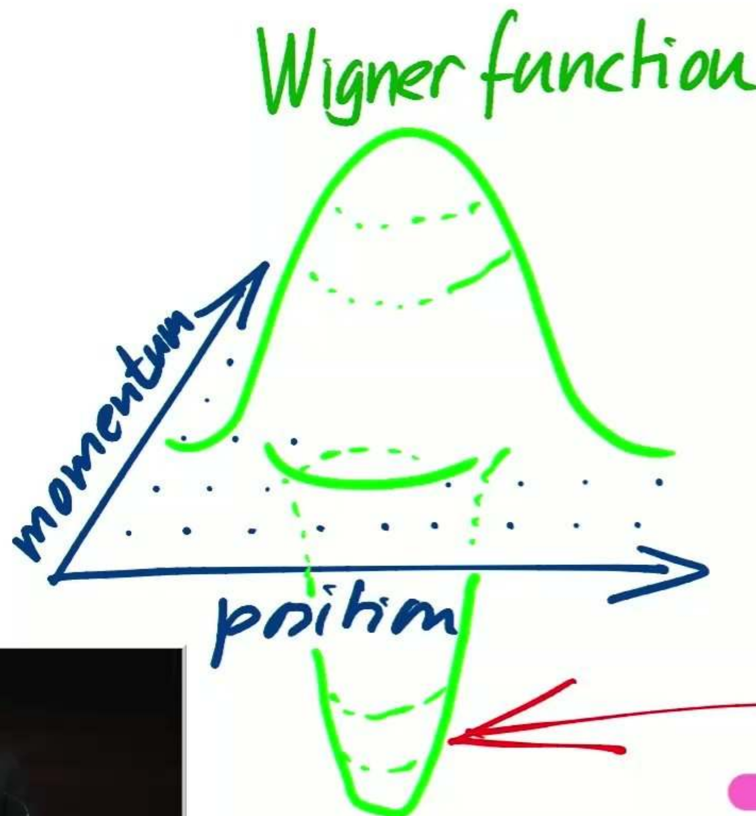
Wigner functions

$$P[a \le X \le b] = \int_a^b \int_{-\infty}^{\infty} W(x,p)\,dp\,dx$$



Wigner functions are the closest quantum analogue to the classical probability distribution over phase space.

Wigner negativity

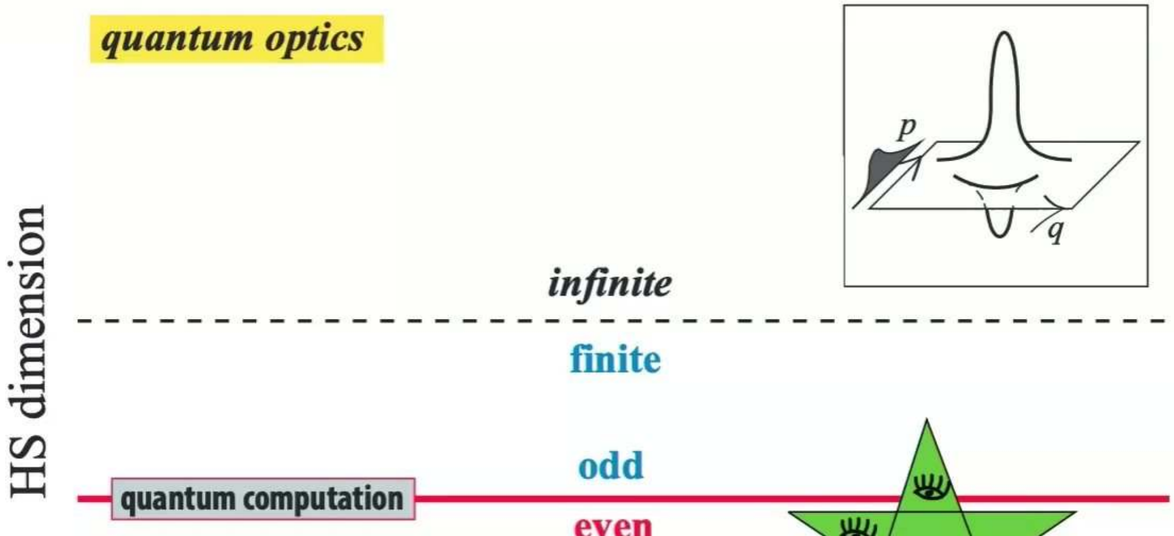


Wigner negativity
* is quantum
* is a resource

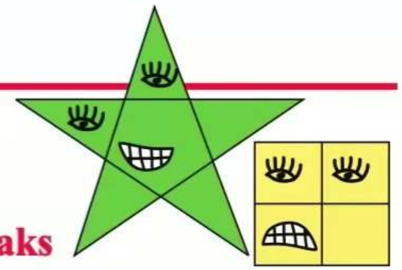
negative values

Joseph Emerson and Stephen Bartlett at UBC (2013)

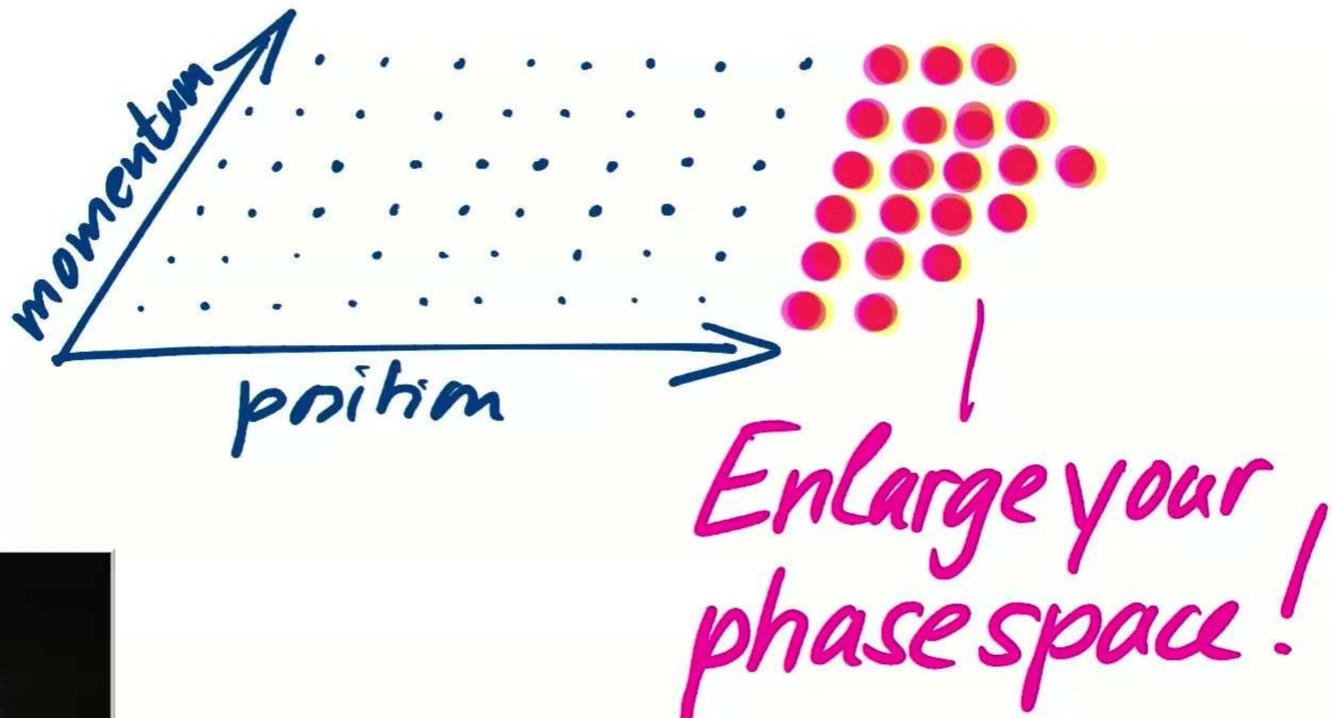
The trouble with qubits

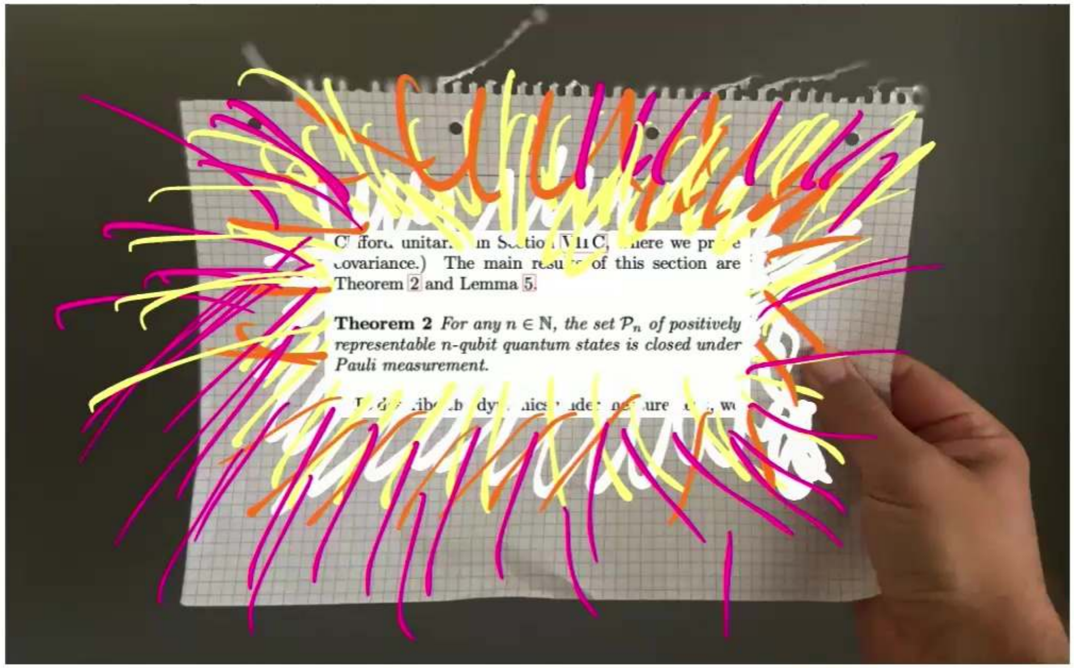


* Clifford covariance breaks
* Positive representation of Pauli-M breaks



Resolution for qubits

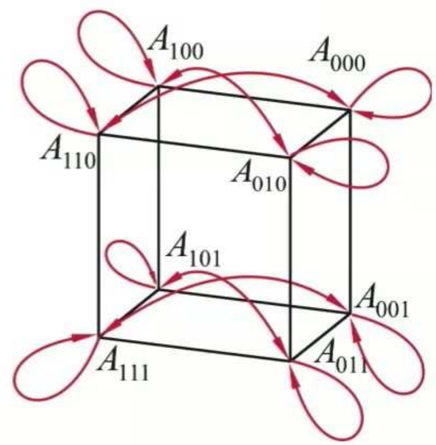




The question to ask is: *What is the largest set of states that is closed under Pauli measurement?*

Summary of the result

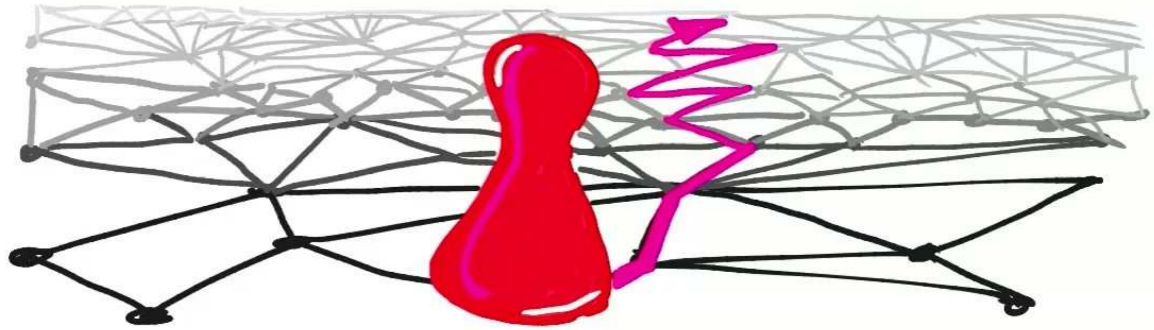
We have constructed a hidden variable model with positive representation for



- All quantum states
- Quantum computation:
  - Clifford unitary gates
  - Pauli measurements

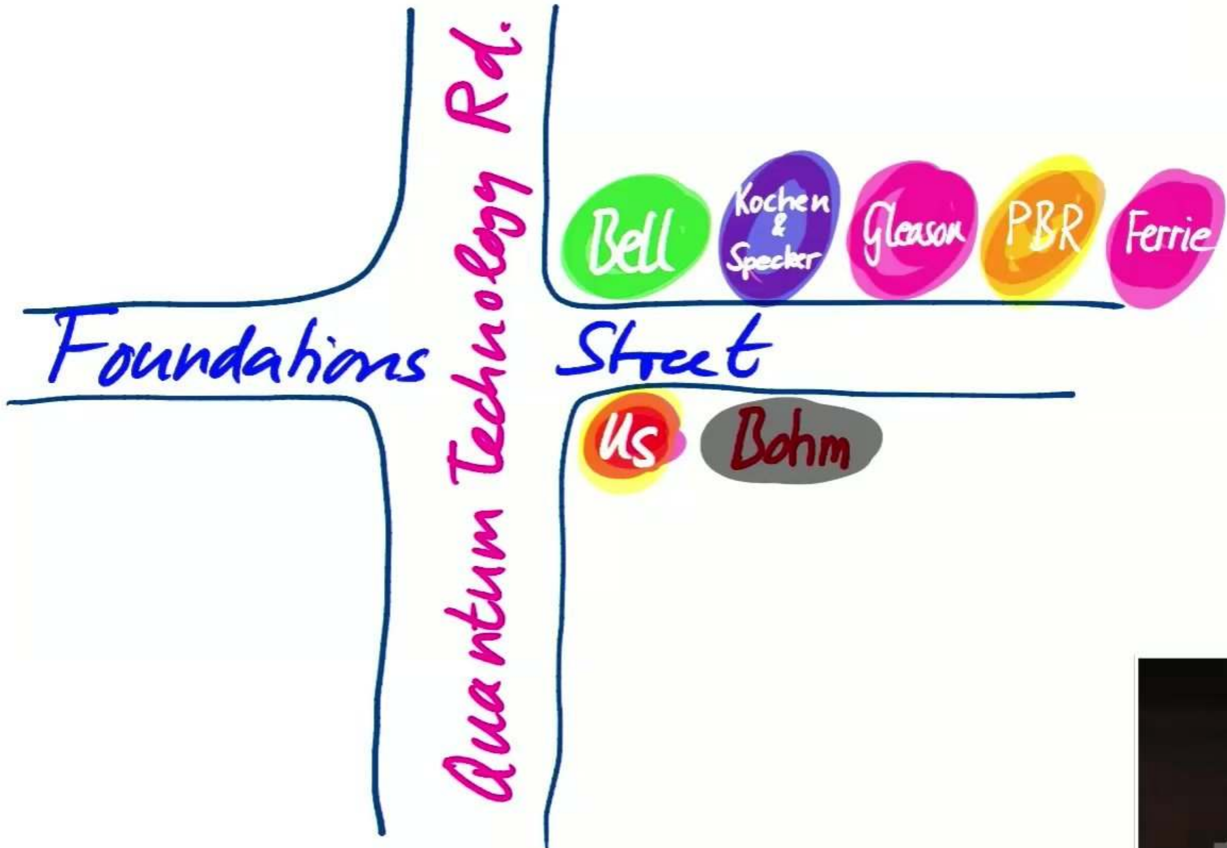
Those operations suffice for universal quantum computation.

What?



- Foundations: We construct a hidden variable model for all quantum mechanics in finite-dimensional Hilbert spaces.
- Quantum computation suddenly looks like a random walk!
- *We don't know where efficiency of simulation ends.*

The hood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Us
Bohm

Where does efficient simulation end?

This question is open. Wherever efficient simulation ends, it has to do with the complications of classical sampling.