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Research opportunities in Quantum Information and InstituteQ

Esko Keski-Vakkuri

Particle Physics Day 2022

Aalto University

HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI

VTT

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“Quantum computer revolution will change everything”

[We will see … but there is a lot more going on than quantum computing!!]

PICTURE: SHUTTERSTOCK

Quantum information science: subfields

Quantum computing: hardware, software, algorithms, applications

Quantum communication: quantum networking, quantum Internet, quantum cryptography, quantum information theory

Quantum metrology and quantum sensing: quantum assisted measurements, detection of objects, ...

Other: quantum chemistry, quantum biology, ...

Particle physics / astronomy experiments:

Quantum metrology, quantum sensing

(E.g. squeezed states of light for quantum-enhanced sensitivity at LIGO)

Particle physics / quantum field theory:

Quantum computing for QFTs, quantum simulations, role of quantum information (entanglement), quantum thermodynamics, ...

Quantum Fields, Gravity & Information group

Senior members:
- Oscar Henriksson
- Niko Jokela
- E K-V

Next slides: samples of some ongoing activities

Quantum information geometry and driven CFTs

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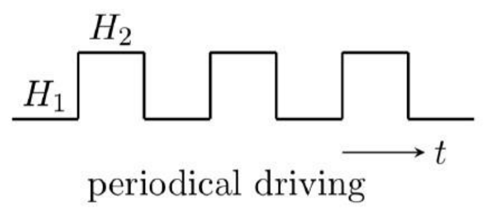
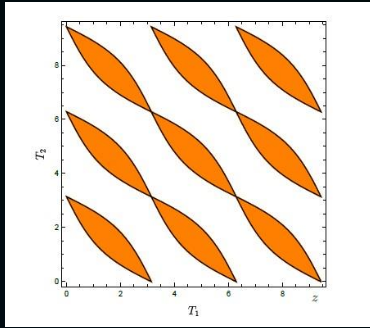
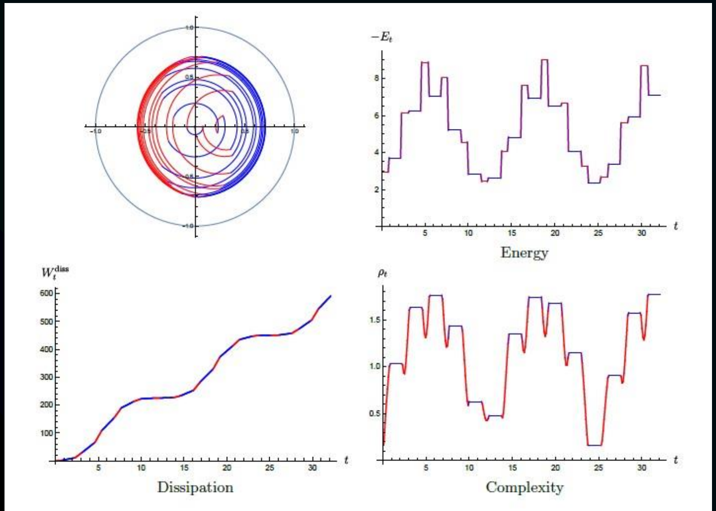


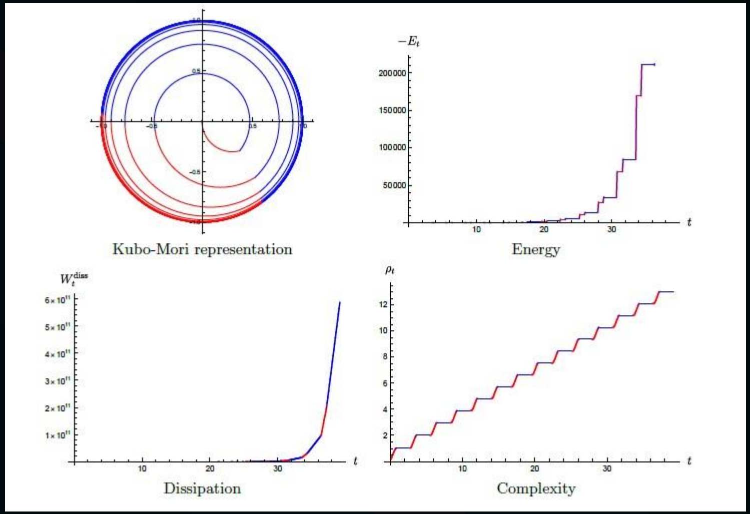


Xueda Wen et al.

No heating, quasiperiodic

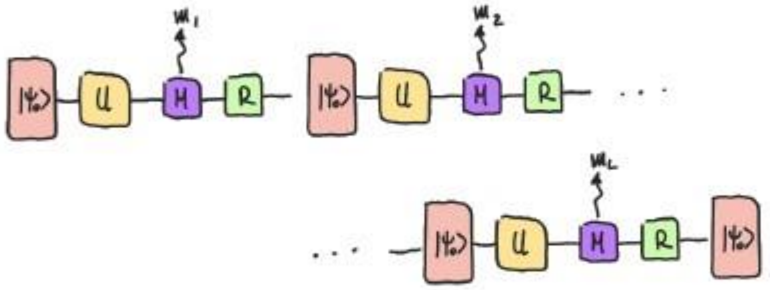


Heating, exponential

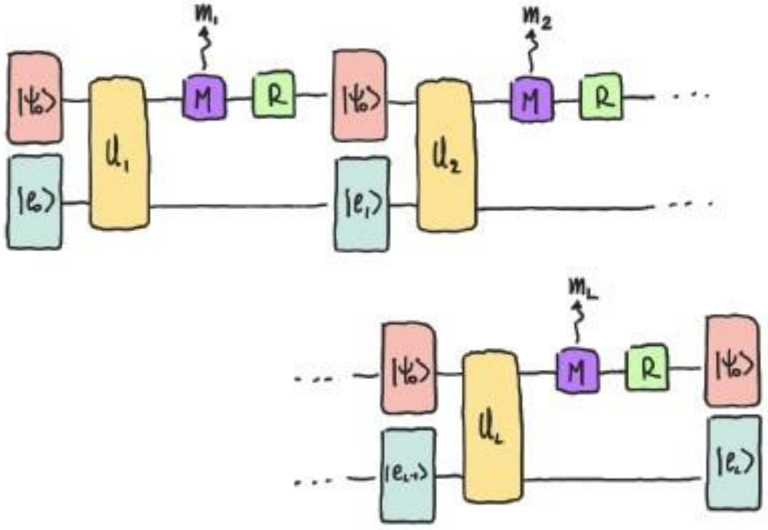


J. de Boer, V. Godet, Jani Kastikainen, E. K-V.

Born rule, repeated measurements & Unruh-DeWitt detectors



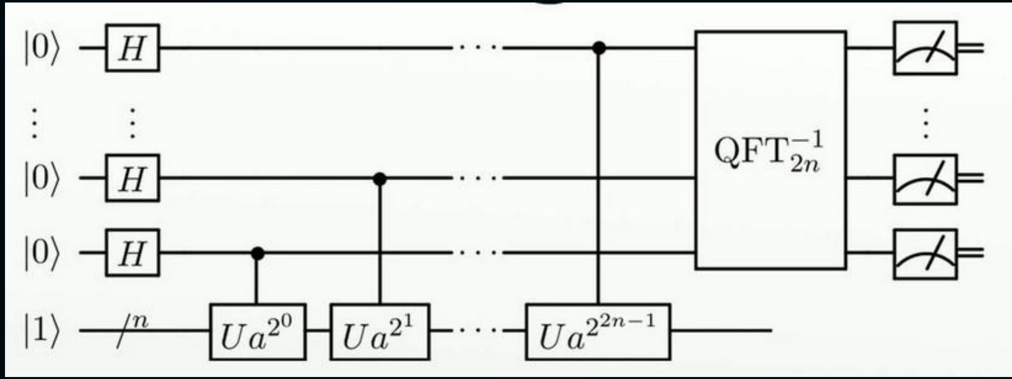
(b) Alternative procedure for testing the Born rule via resets.

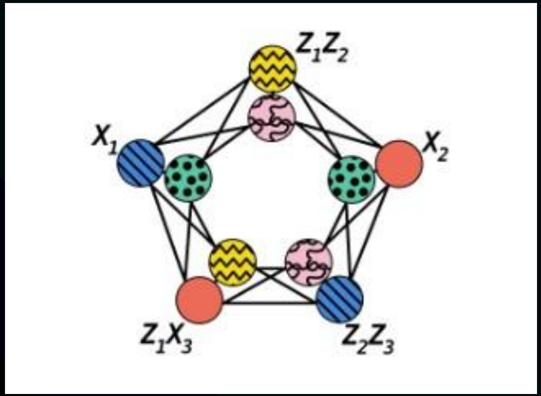


(c) RM scenario.

Nicola Pranzini, G. García-Pérez, E. K-V., S. Maniscalco

MSc thesis: Quantum tomography via graph theory





Algorithm 1 Measurement with commutation graphs - Quantum part

Inputs: (1) Quantum state ρ, (2) All the inputs and outputs from the classical part
Output: Estimates of $\langle O_i \rangle$ for all of the observables.

for $i = 1$: number of colours **do**
  $S = \emptyset$
  for $j = 1$: number of vertices **do**
    if vertex j is coloured with colour i **then**
      Add the observable corresponding to vertex j into set S
    end if
  end for
  for $j = 1 : c$ **do**
    Measure all of the observables in set S at the same time and adjust their estimates accordingly
  end for
end for

Otto Veltheim

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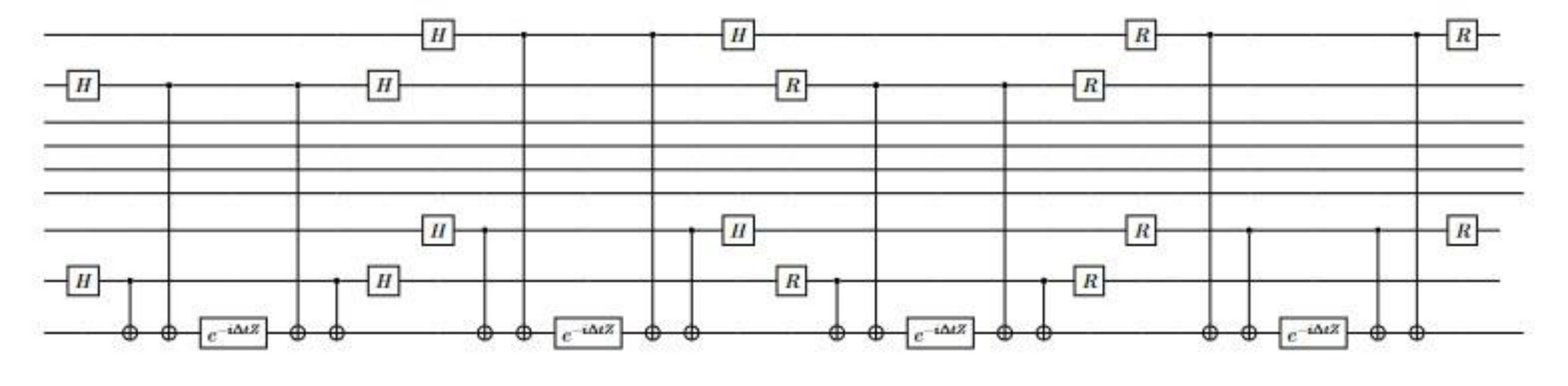
MSc thesis: Hamiltonian simulation of Gross-Neveu

$$\mathcal{L} = \sum_{i=1}^{N} \overline{\psi}_i (i\gamma^\mu \partial_\mu - m)\psi_i + \frac{g^2}{2}\Big(\sum_{i=1}^{N} \overline{\psi}_i \psi_i\Big)^2$$



Anastasia Enckell

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The Finnish Quantum Institute

To accelerate development of quantum science and technologies in Finland

Collaboration shaping the national landscape

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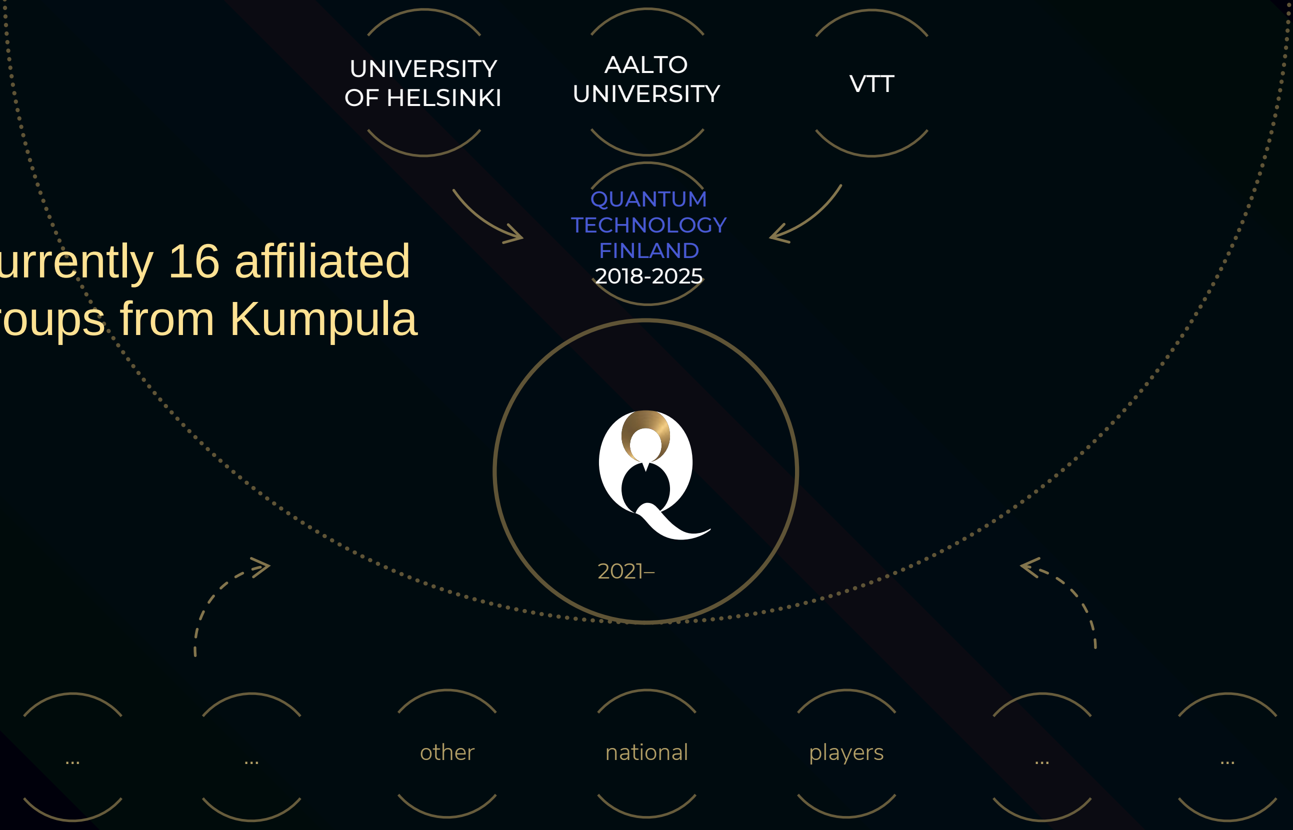
Currently 16 affiliated groups from Kumpula



ResQ: research, infrastructures, visitors, postdocs, seminars, drafting of Finnish Quantum Agenda (2023): 90 M€ for new infra? 1000 m^2 new cleanroom space, micro/nanofabrication, …

EduQ: education, training, outreach

BusinessQ: business from quantum technologies

algorithmiq IQM QUANTASTICA QuantrolOx Unitary Zero Space QUANSCIENT

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