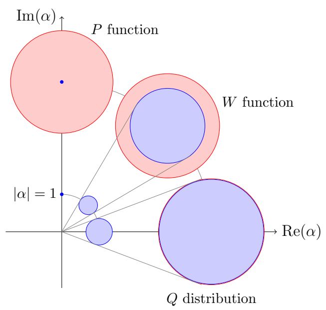
Recent and ongoing projects + speculation

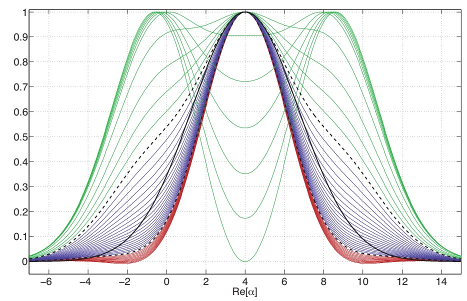
Josh Combes
21 June 2012
Center for Quantum Information and Control (UNM)

Recent, ongoing, and speculative projects

Quantum limits to amplifiers

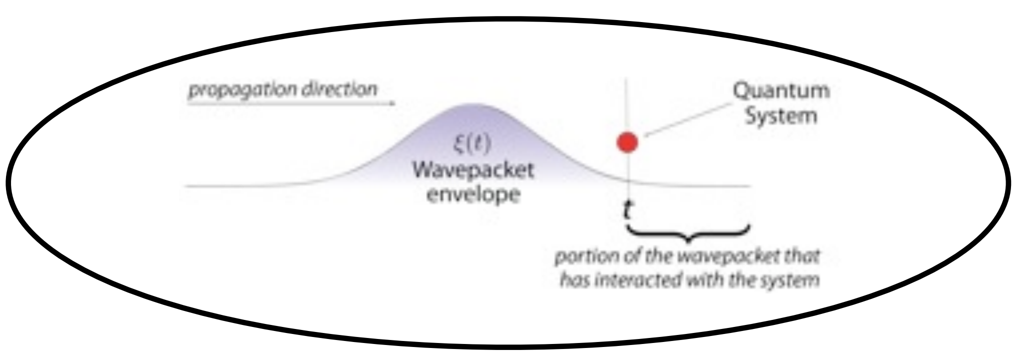
Pandey, Jiang, Combes, Caves





N photon wavepackets interacting with arbitrary quantum systems

Baragiola, Cook, Branczyk, Combes
arXiv:1202.3430 (PRA June 2012)



Applications:
- QND single photon detectors a microwave freq,
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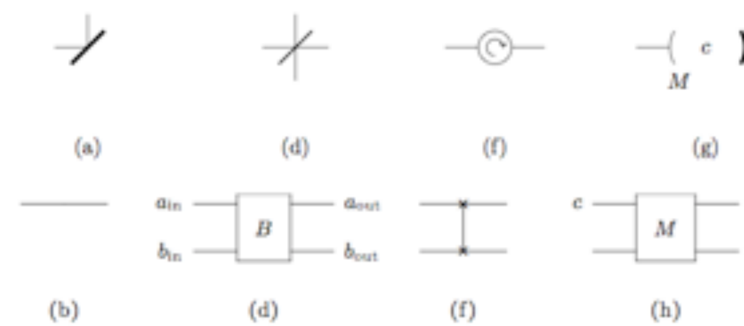
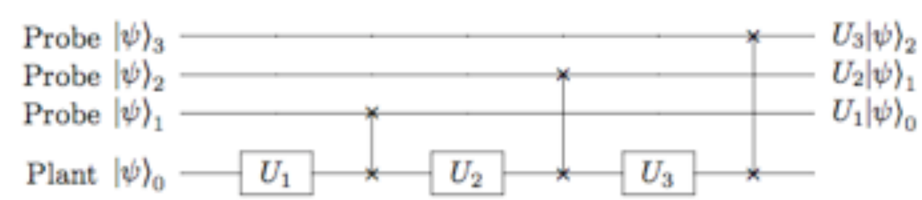
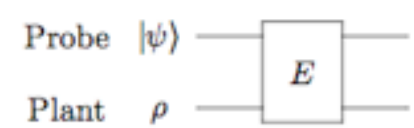
- Gradient Echo Memories

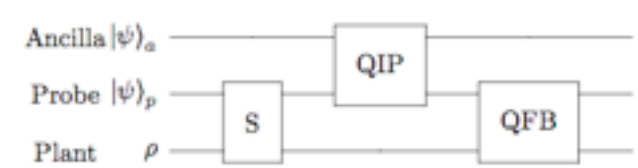
Defining classical control, coherent control, quantum control

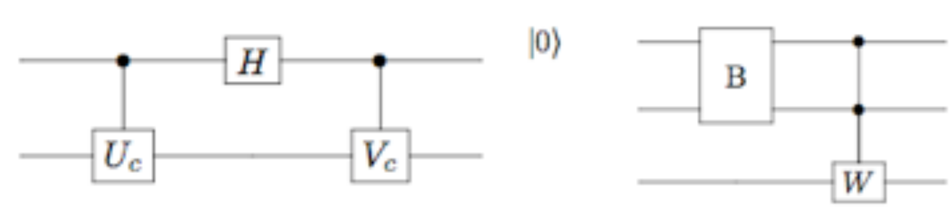
Combes, Caves
Combes, Caves, Milburn











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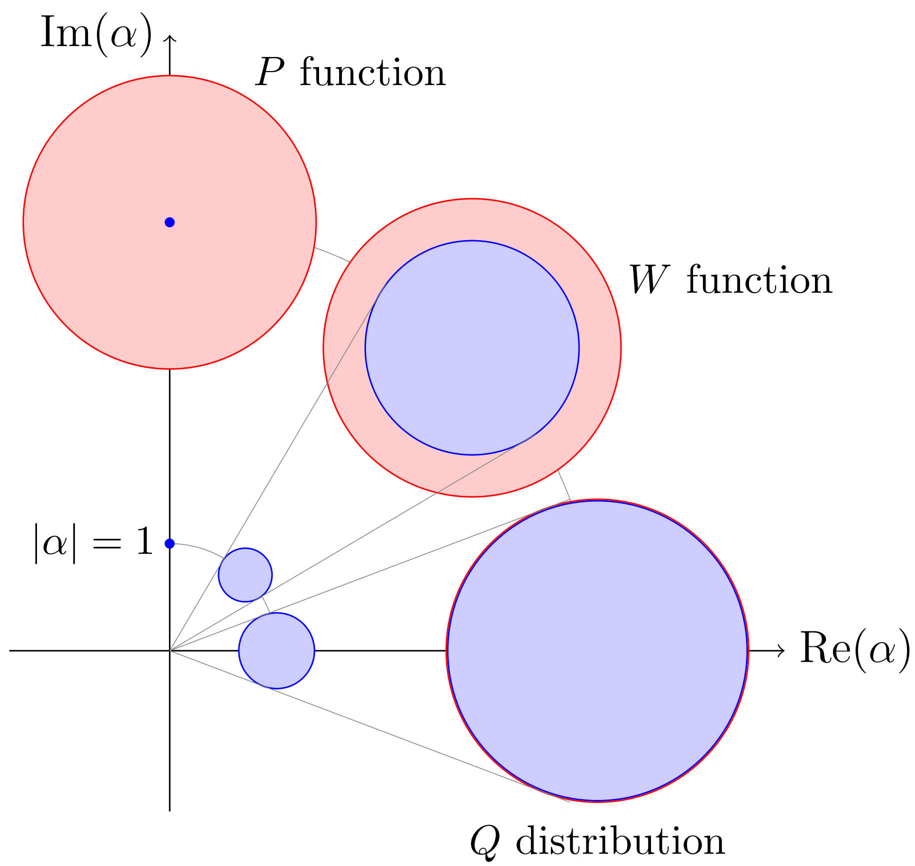

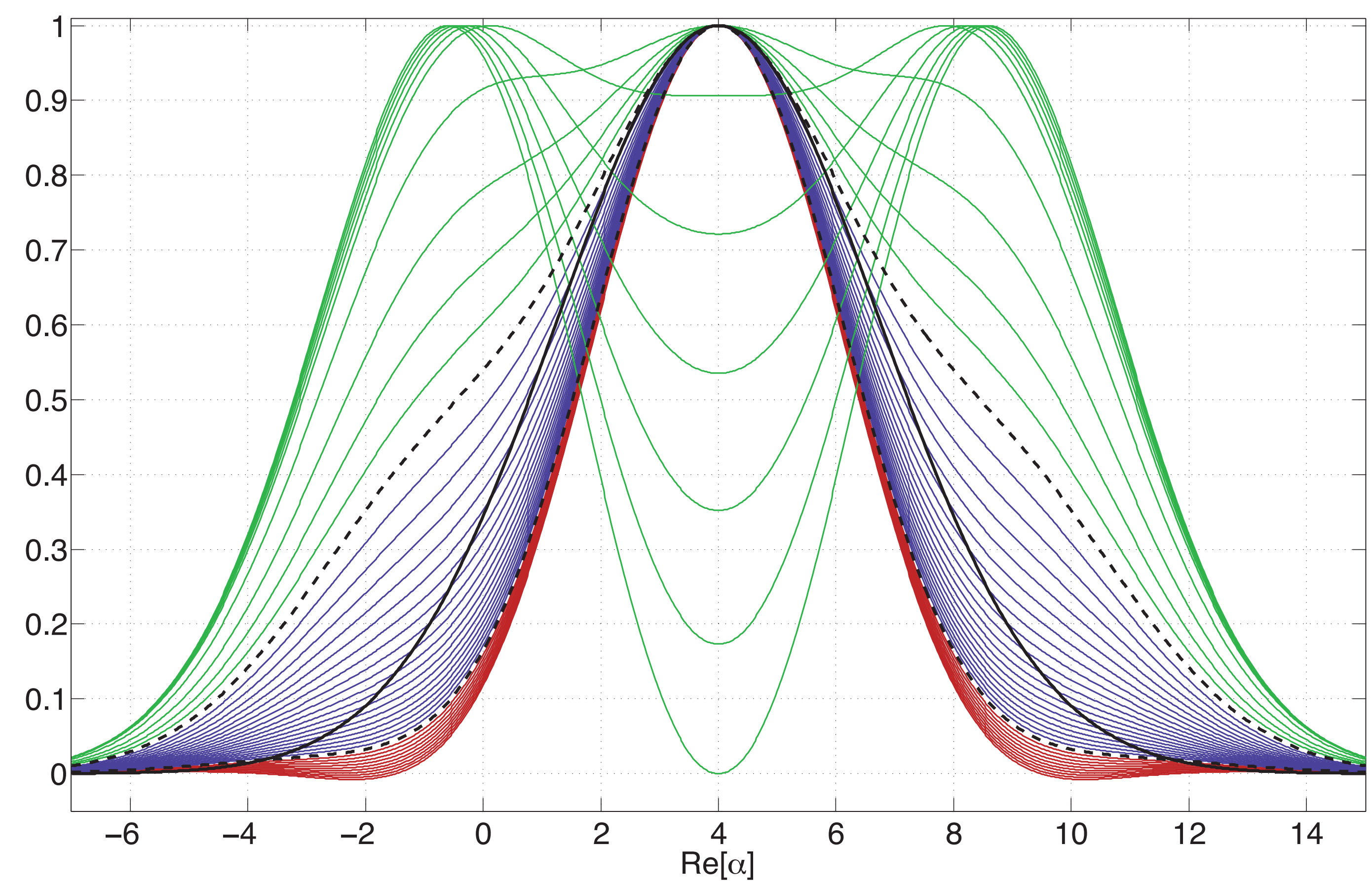

Recent, ongoing, and speculative projects

Defining classical control, coherent control, quantum control

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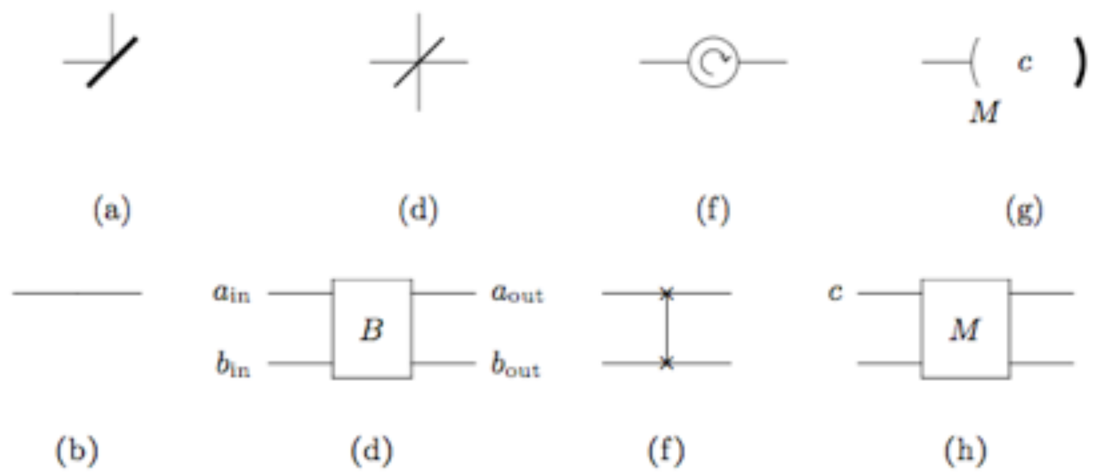

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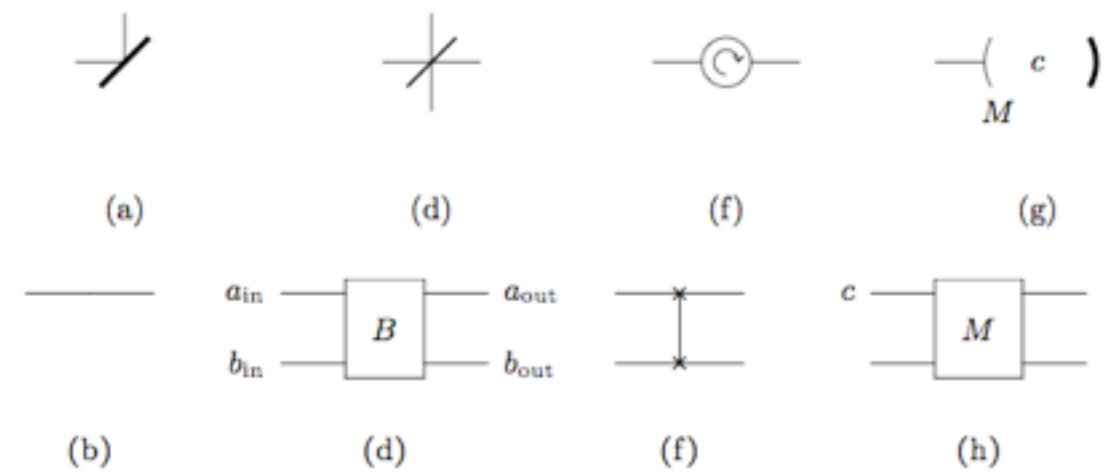

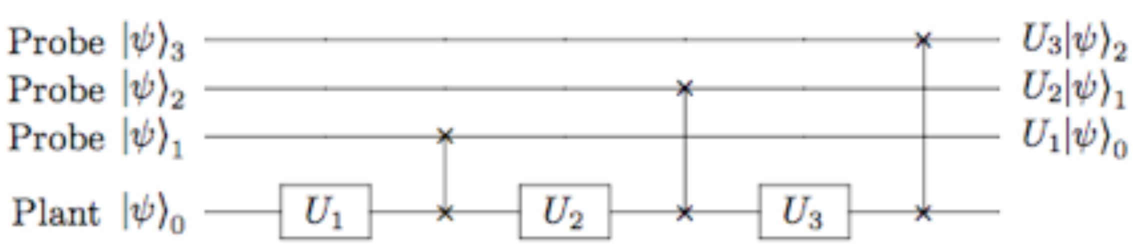

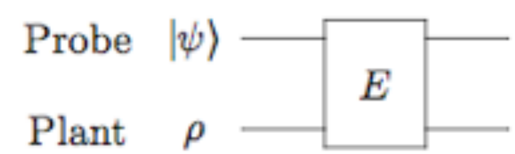

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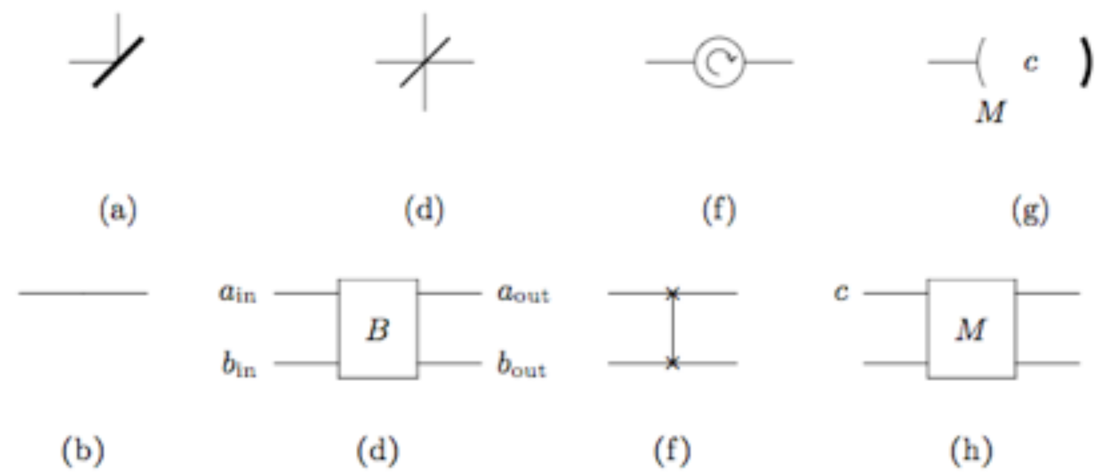

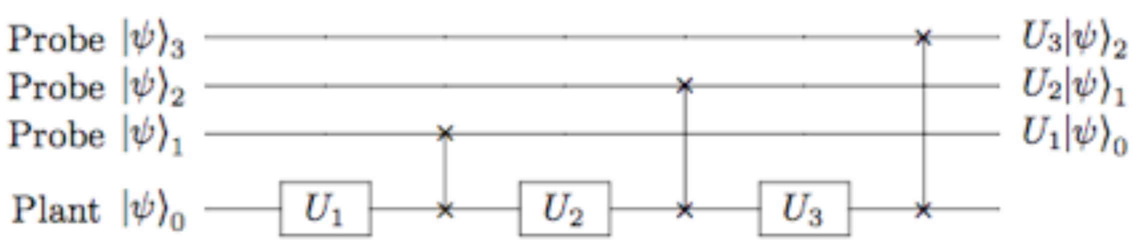

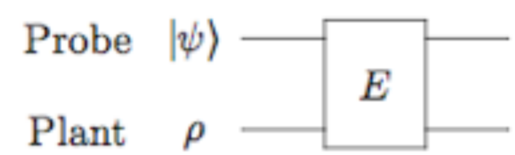

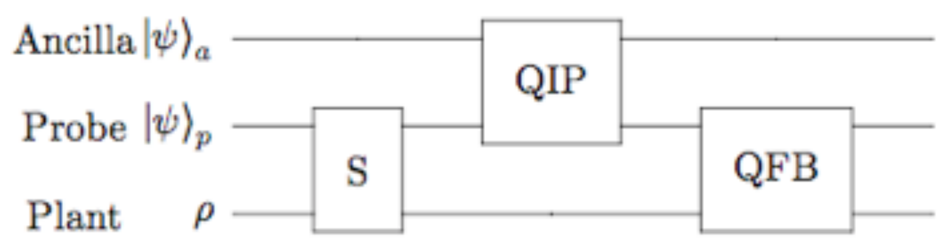

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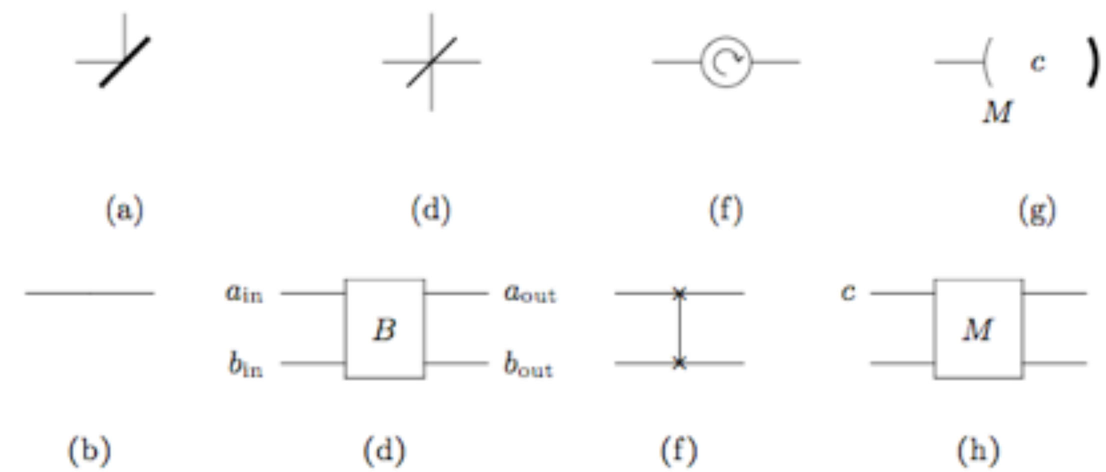

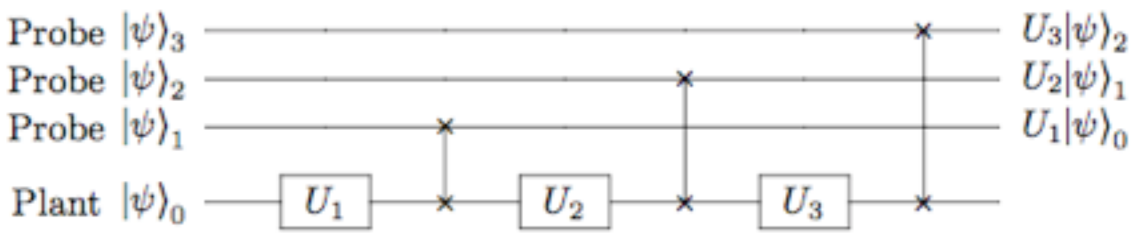

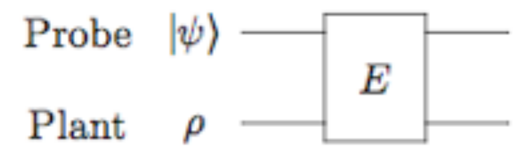

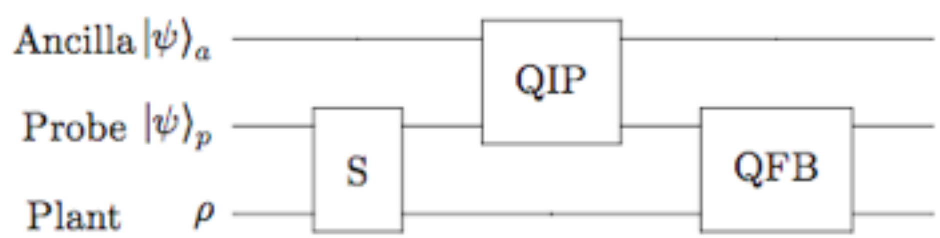

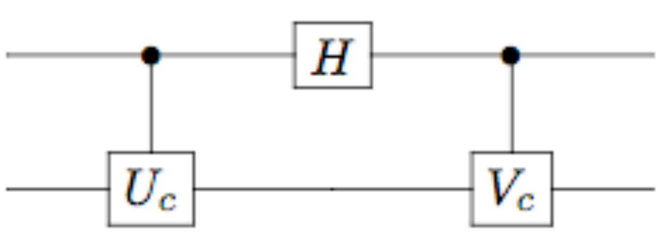

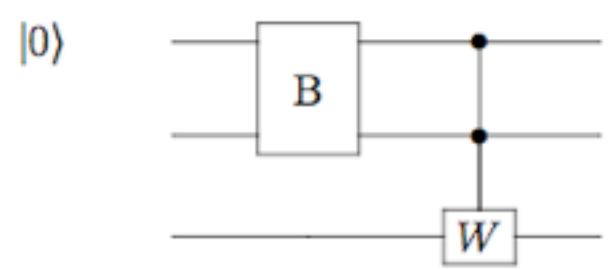

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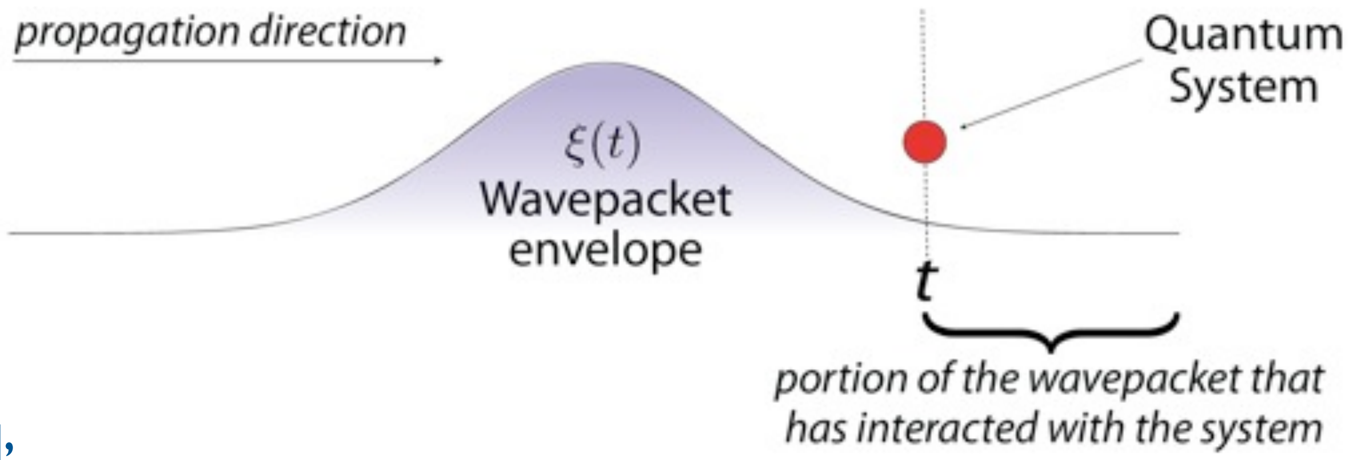
Baragiola, Cook, Branczyk, Combes
arXiv:1202.3430 (PRA June 2012)



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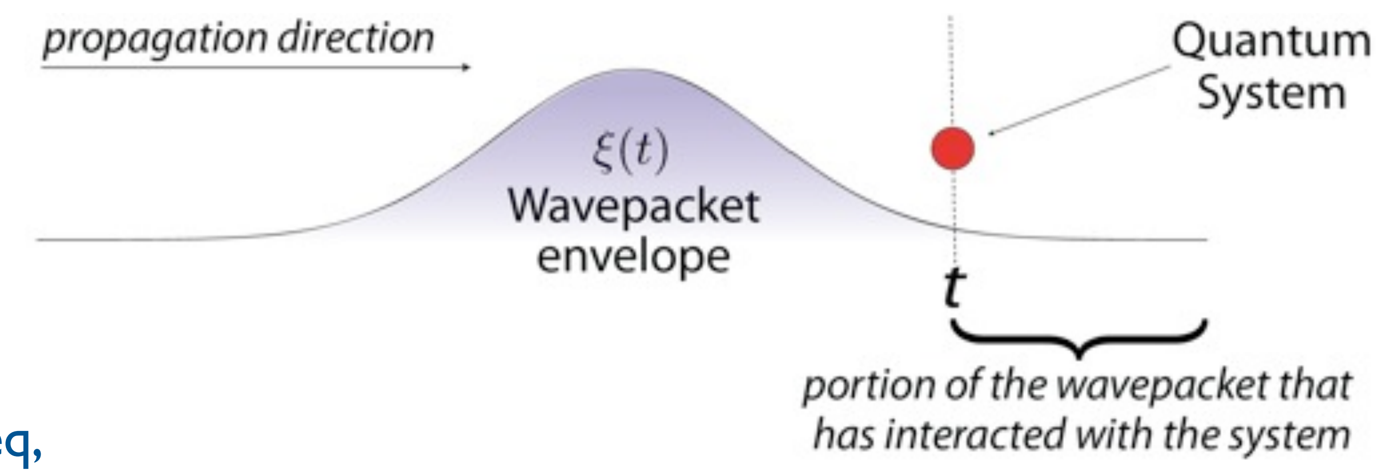

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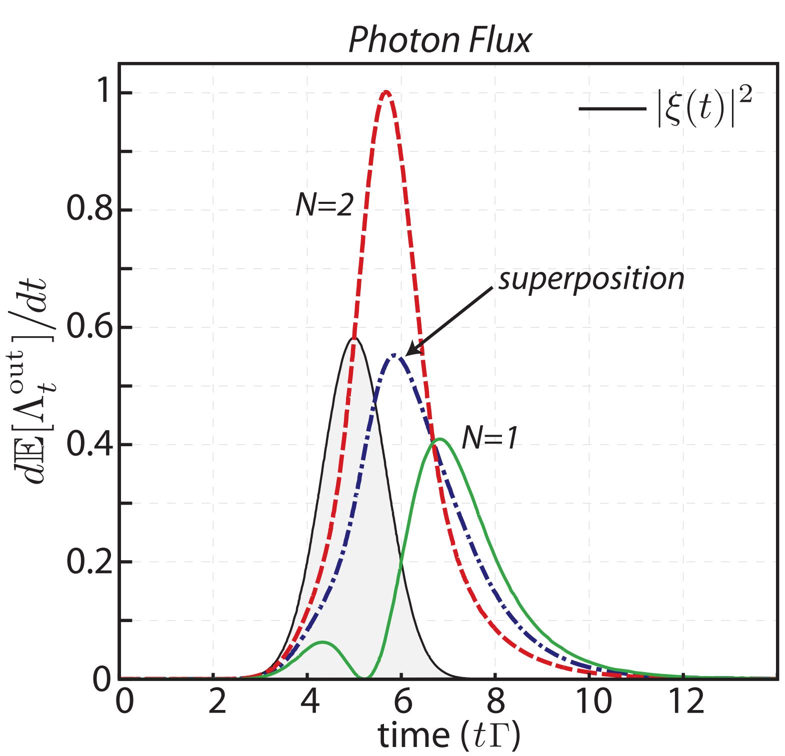

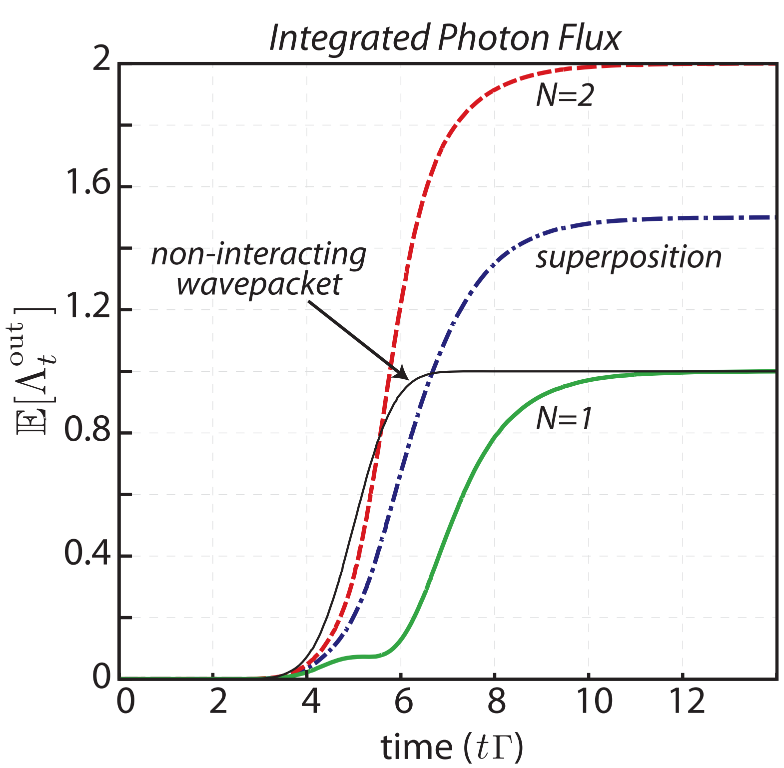

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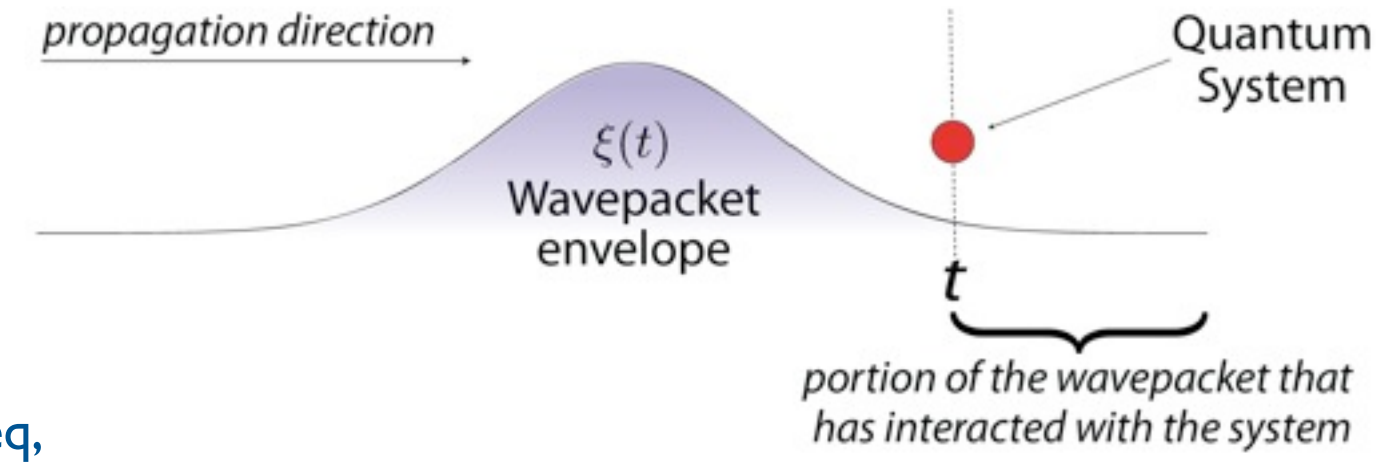

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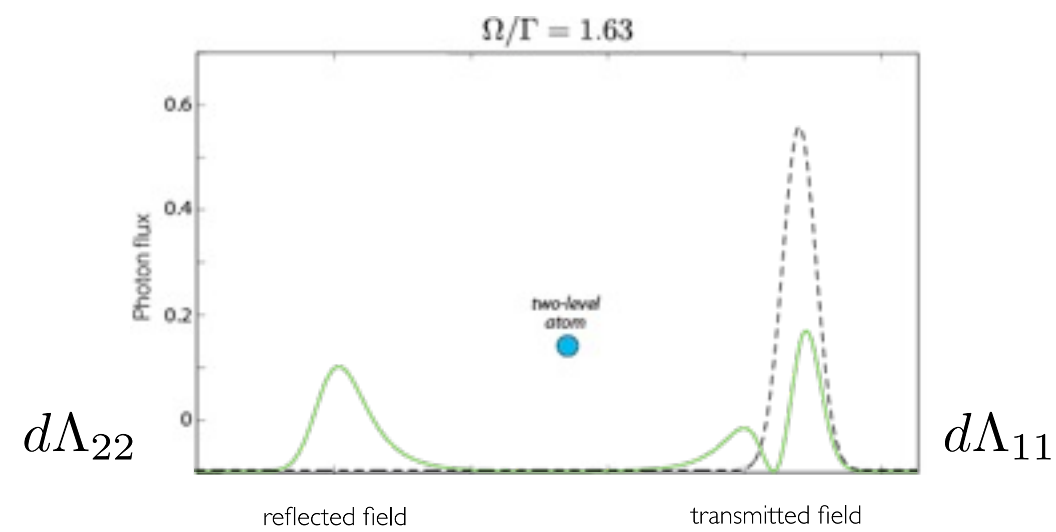

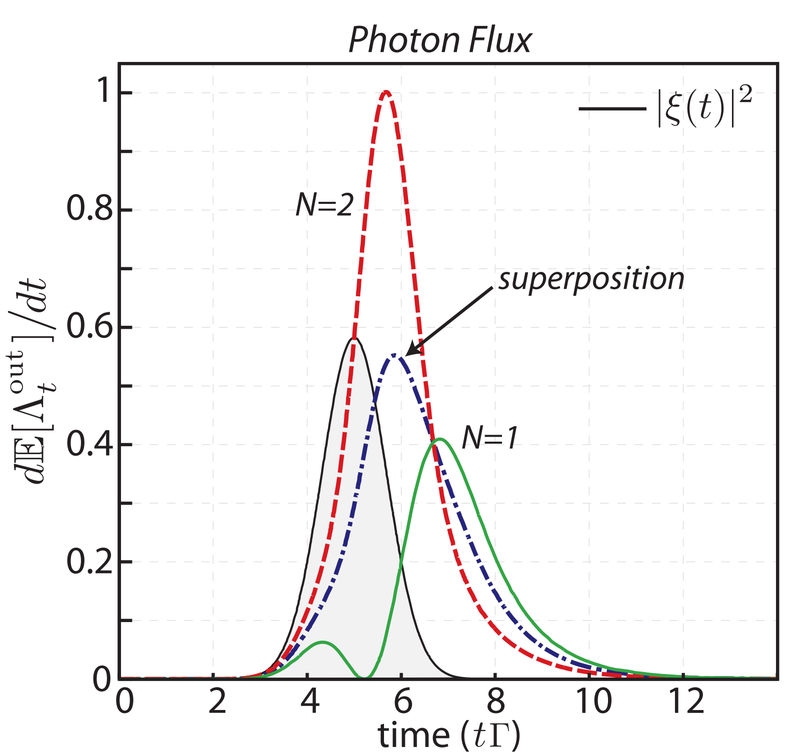

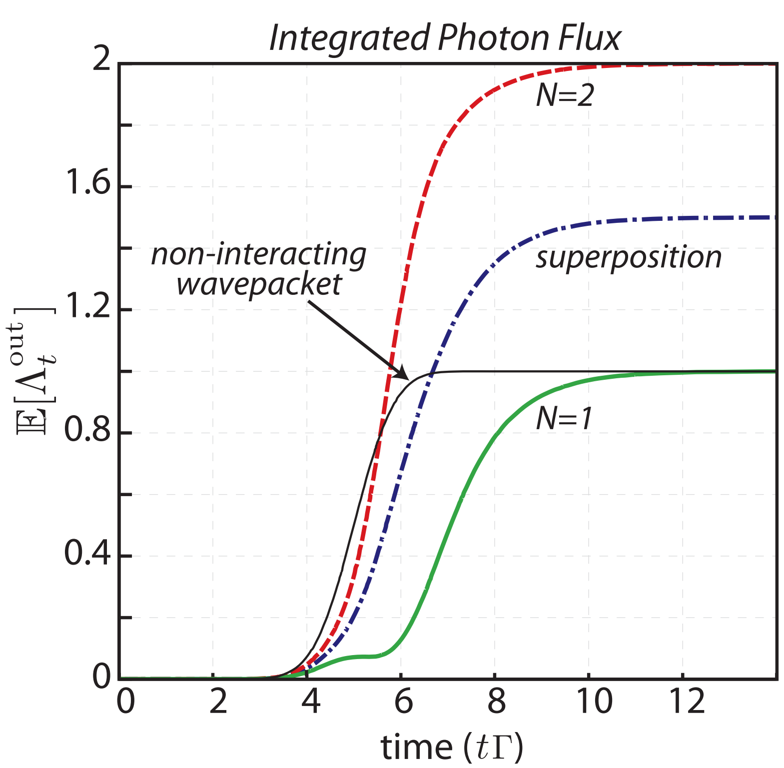

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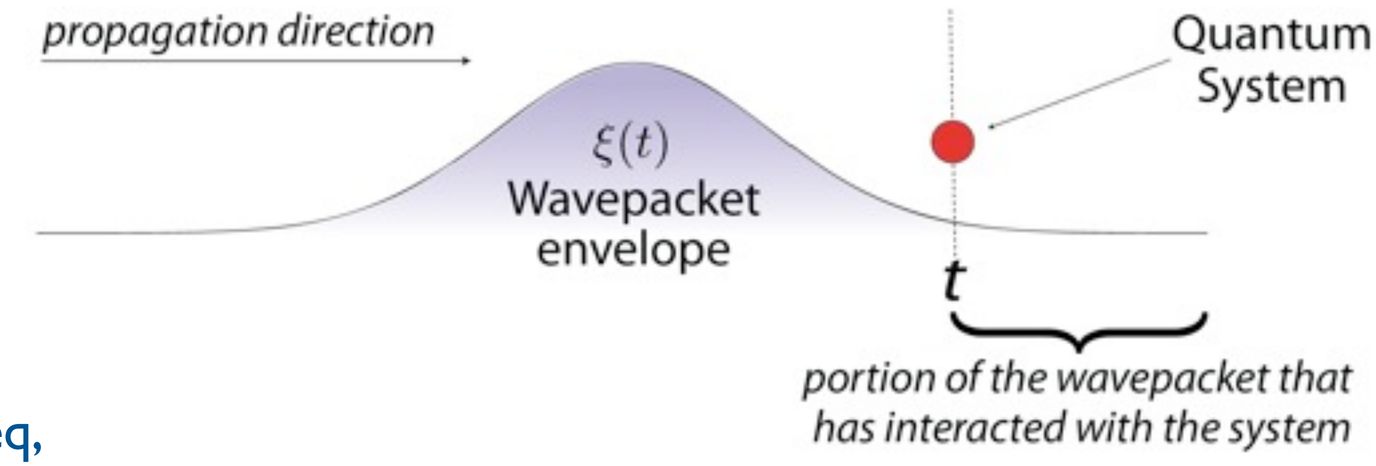

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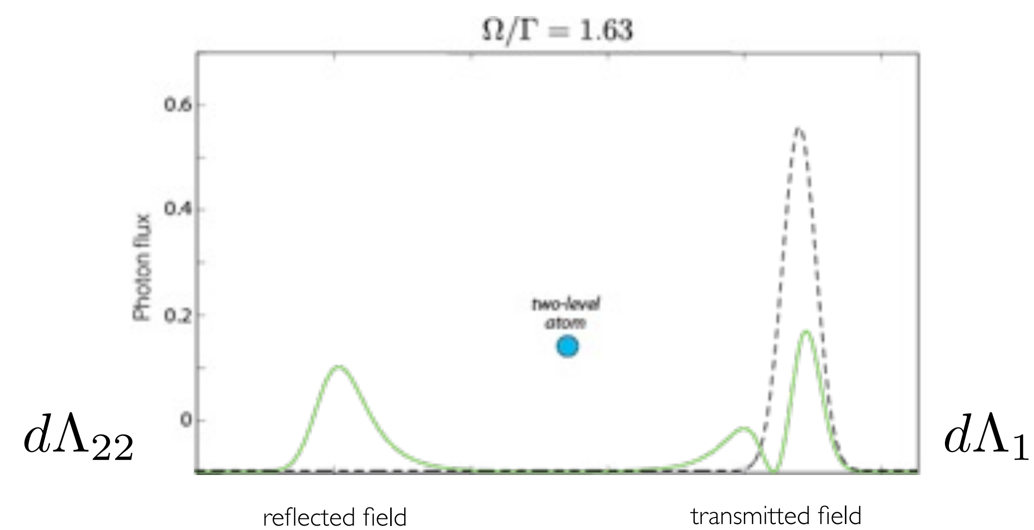
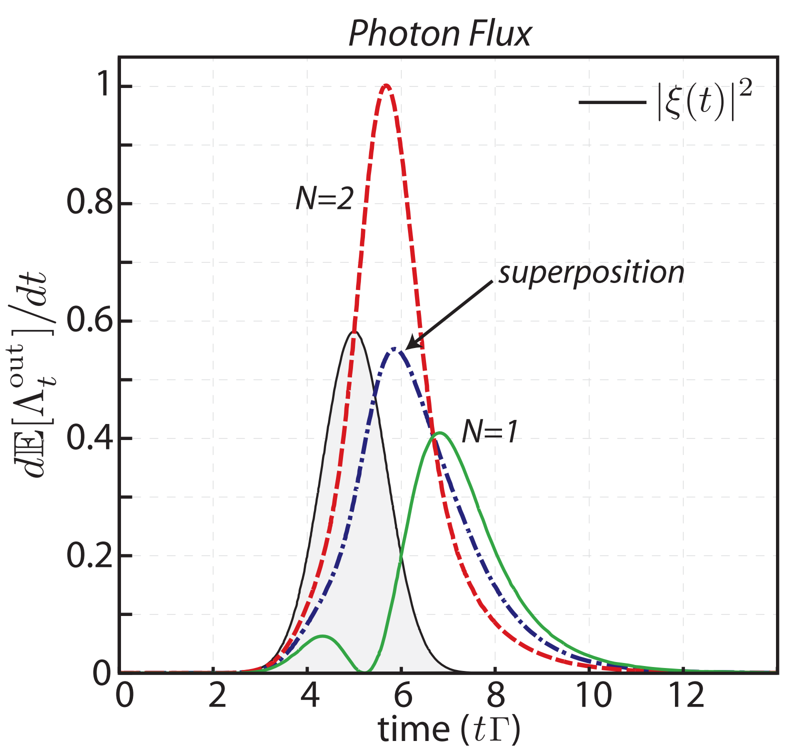
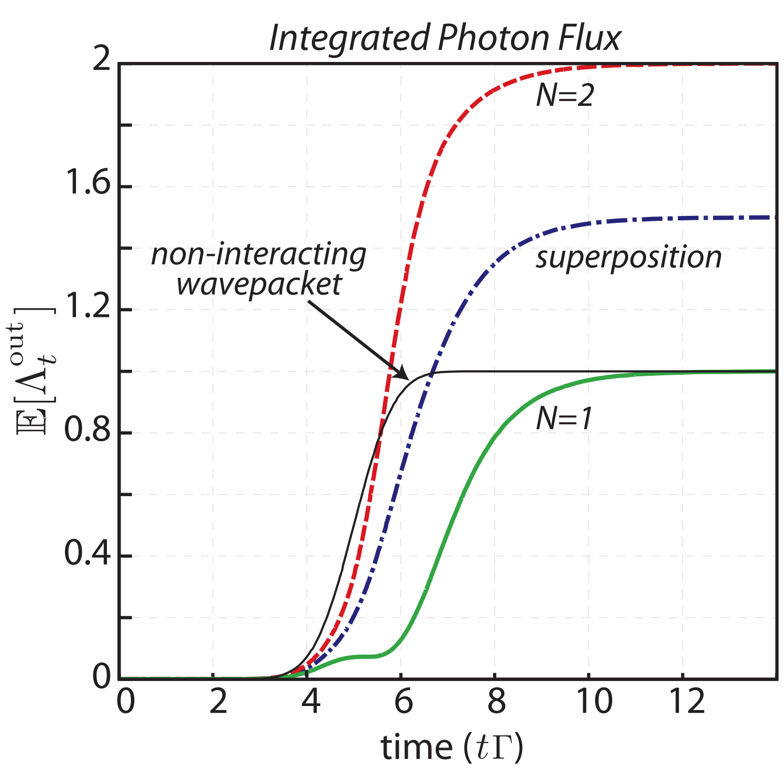




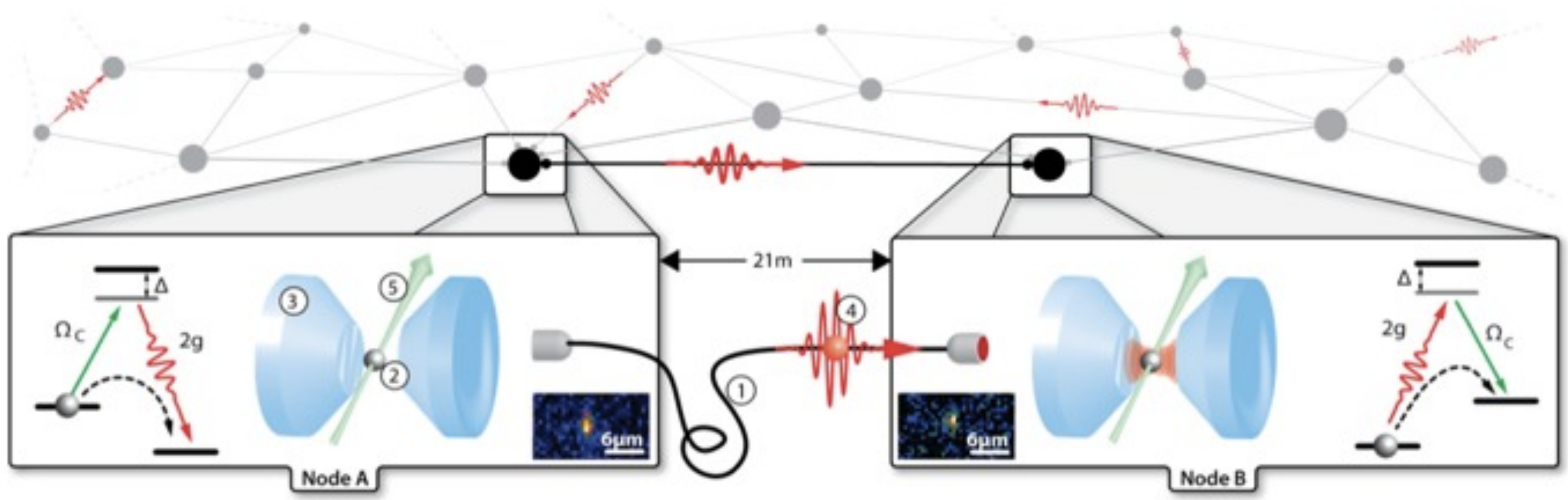


Generalizations:
- Multiple spatial / polarization modes
- Arbitrary spectral distributions
  - therefore arbitrary states of light
- Direct, homodyne, hetrodyne detection

Why states of definite photon number?

An Elementary Quantum Network of Single Atoms in Optical Cavities

Stephan Ritter,* Christian Nölleke, Carolin Hahn, Andreas Reiserer, Andreas Neuzner, Manuel Uphoff, Martin Mücke, Eden Figueroa, Jörg Bochmann,† and Gerhard Rempe
Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Strasse 1, 85748 Garching, Germany



Nodes must be able to send, receive, and store quantum information efficiently

Photonic channels as transmitters of quantum information

arXiv:1202.5955

Why states of definite photon number?

Motivation: Quantum Networks

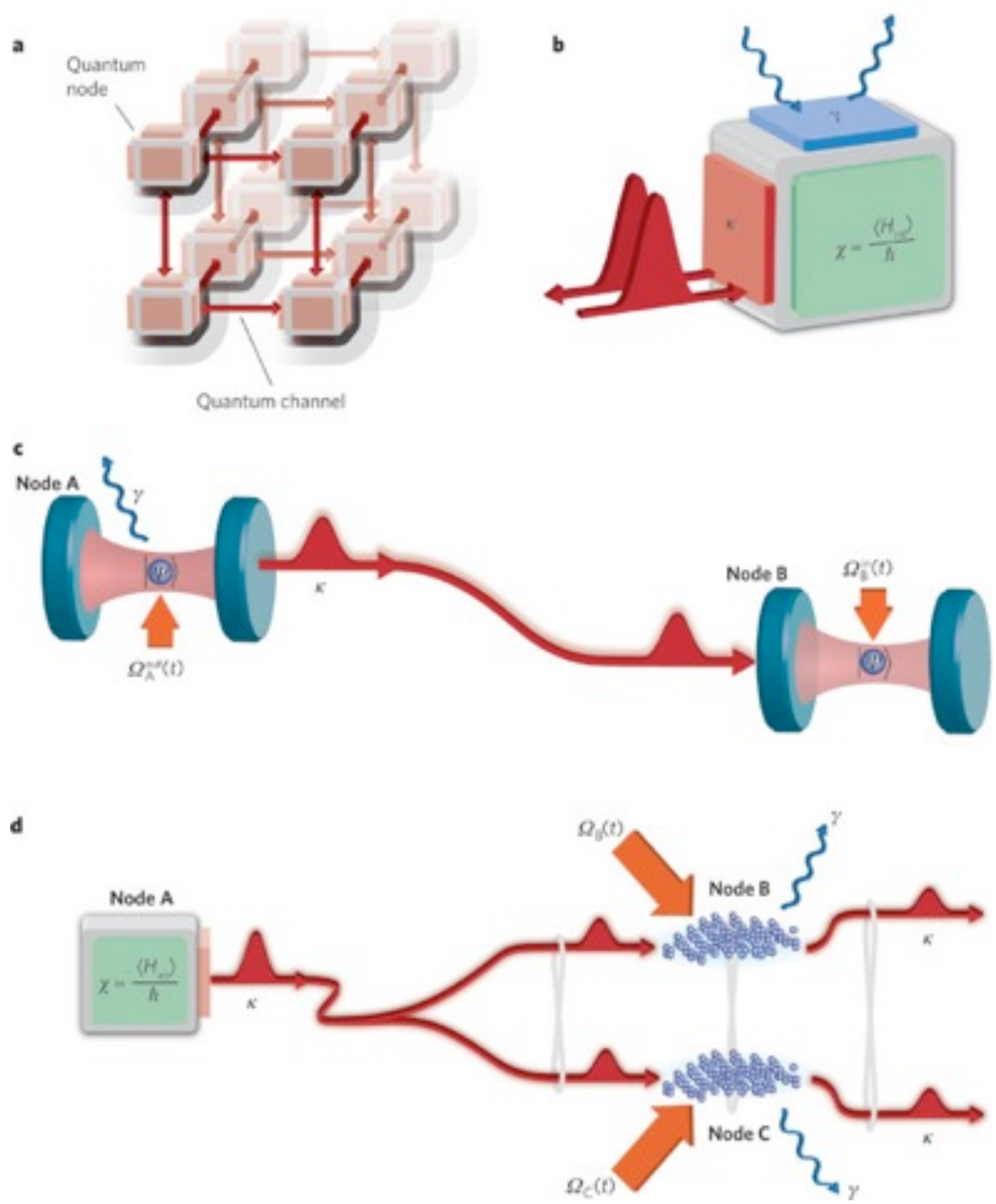


Image: H. J. Kimble, Nature 453, 1023 (2008).

- Quantum Communication
- Entanglement distribution
- Hybrid quantum computing
- Quantum Metrology

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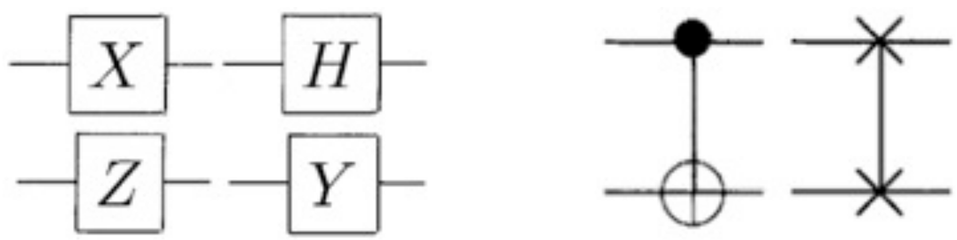
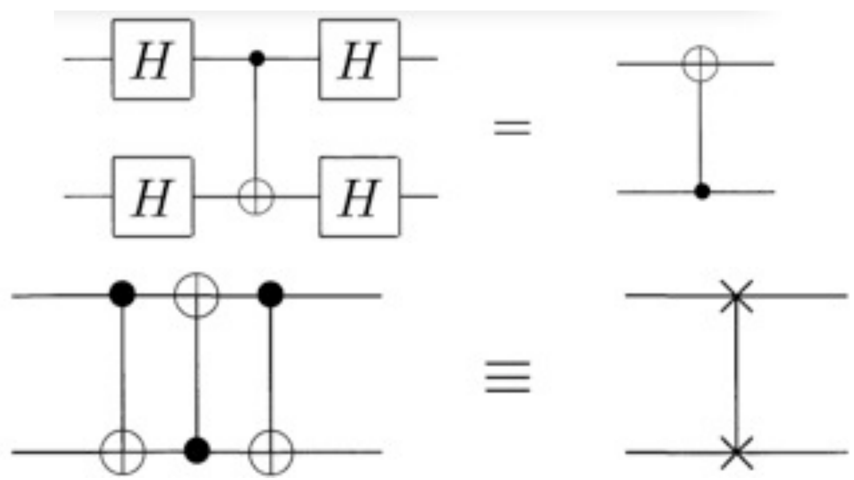
Photonic channels as transmitters of quantum information

An Analogy

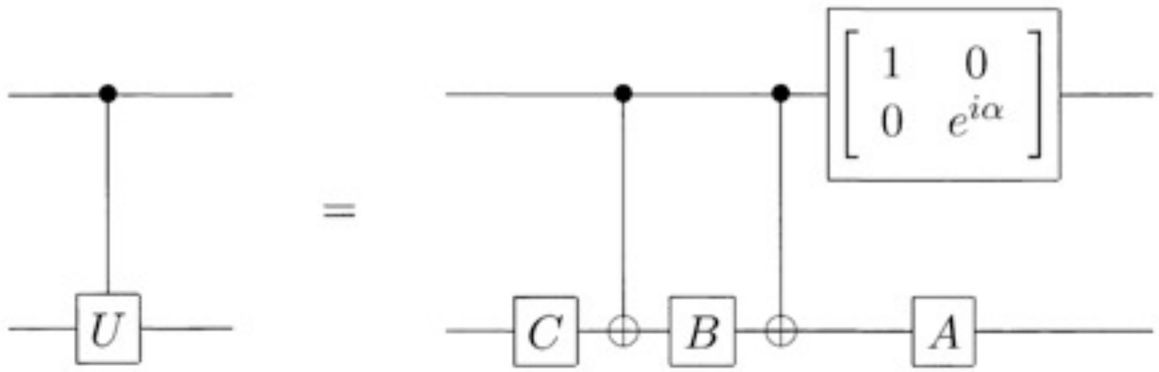
Quantum Circuits



- Base elements



- Network simplification



- Network synthesis

Images: Nielsen and Chuang (2000)

An Analogy

Networks of Open Quantum Systems

$G=(S, L, H)$

- Base elements
- Network simplification
- Network synthesis

Yurke & Denker, PRA 29, 1419 (1984).
Gardiner, PRL 70, 2269 (1993).
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An Analogy

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$G=(S, L, H)$

e.g

Beam splitter
Waveplate

cavity
dipole coupling

Squeezer
Control

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	S	L	H
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Cascading $G_T = G_2 \lhd G_1$

Combining $G_T = G_2 \boxplus G_1$

Adiabatic elimination ...

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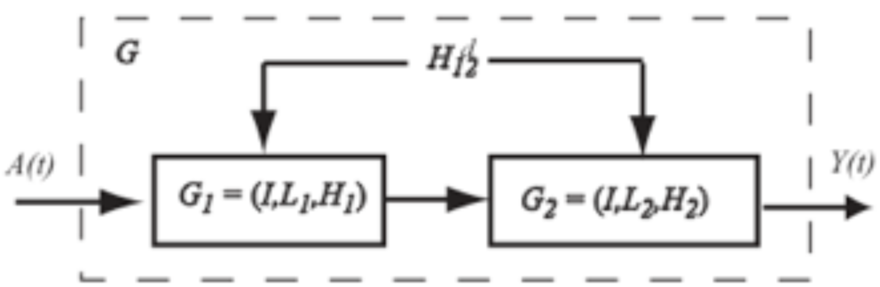

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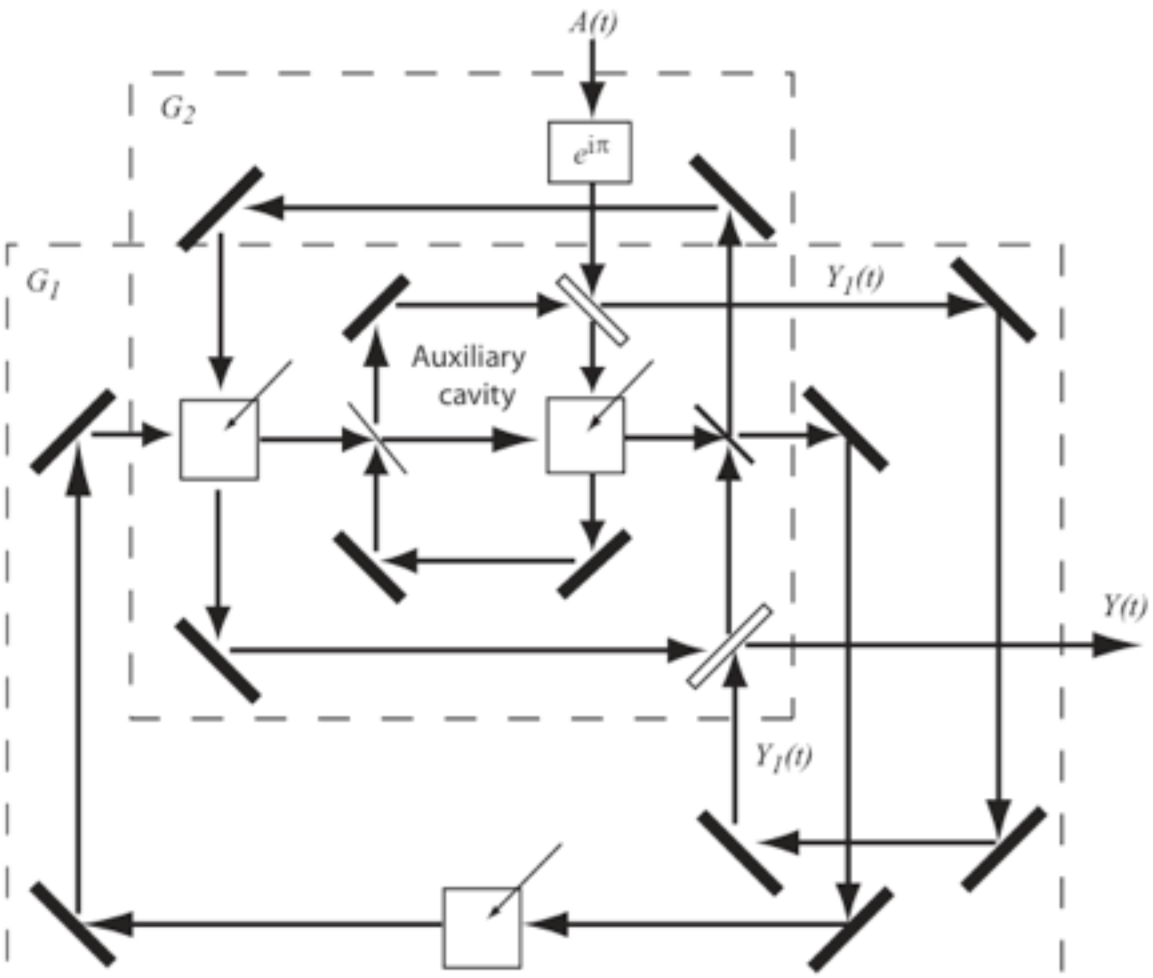

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proposals, speculation and studies

Quantum process tomography
in and of space

Adaptive measurements

Entanglement of small frequency bands
(when the instantaneous conditional state has no entanglement)