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Envisioned team (tentative)

- Univ. of Virginia Physics: Highly-scalable photonic cluster-state entanglement
  - Olivier Pfister
- Perimeter Institute for Theoretical Physics: Theory
  - Nick Menicucci, Steve Flammia
- BBN Technologies: Quantum network implementation
  - Jon Habif, Zac Dutton
- AdvR, Inc.: Nonlinear materials for entangled sources
  - Philip Battle, Tony Roberts, Chris Kaleva
- Univ. of Virginia ECE: High-efficiency photodetectors
  - Archie Holmes

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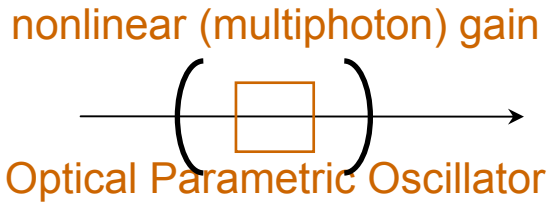
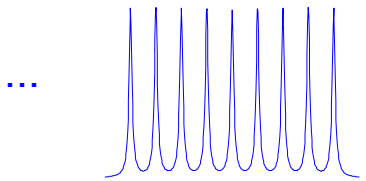
Quantum frequency comb: an inherently scalable quantum register





Multimode squeezing
↓
TOP-DOWN multipartite entanglement

- Quantum continuous-variable modes ("qumodes") labeled by frequency and polarization
- Entangled by concurrent nonlinear interactions in photonic crystals
  (Photon-pair emission process knits up a square-grid cluster out of comb in constant time)
- Photon-number-resolving (nonGaussian) detection enables universal quantum computing

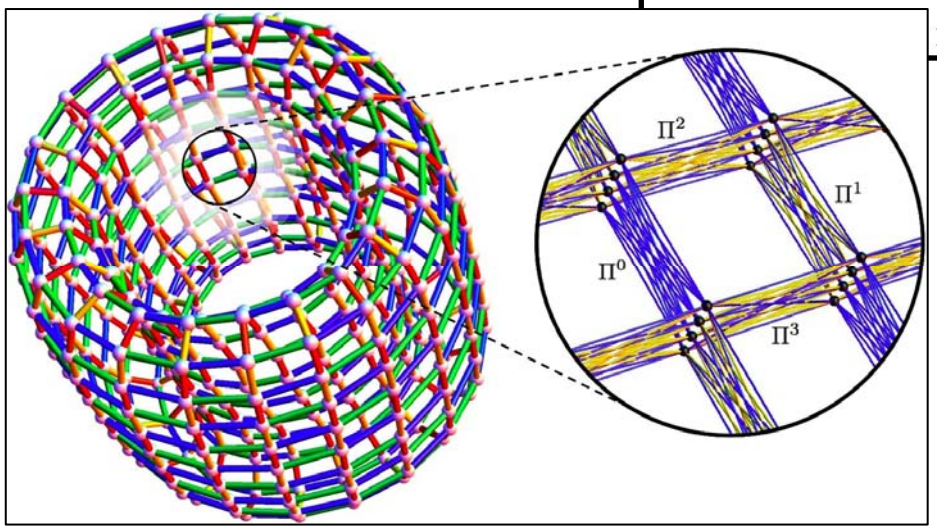
(Menicucci et al., PRL 2006)

Selected for a Viewpoint in *Physics*

PRL **101,** 130501 (2008) PHYSICAL REVIEW LETTERS week ending 26 SEPTEMBER 2008

One-Way Quantum Computing in the Optical Frequency Comb

Nicolas C. Menicucci,[1,2] Steven T. Flammia,[3] and Olivier Pfister[4]



- Constant-time generation, constant pump spectrum
- Cluster graph scales linearly with pump power and phasematching bandwidth
- Ordinary-OPO estimates yield potential for 1000-qumode cluster

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What we have

- Ultrastable quantum optical sources of bright squeezed and entangled light

(e.g. OPO emitting phaselocked cw twin beams @ 1064 nm, 7 dB squeezed, 10 kHz emission linewidth, subhertz frequency difference noise)

- Theoretical understanding of CV cluster states and CV one-way quantum computing

- A novel proposal for the generation of photonic cluster-state entanglement over a very large scale
  - Test of Quantum Mechanics on the mesoscopic scale
  - Preliminary networked quantum algorithms

  (quantum secret sharing, gate teleportation)

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What we need

- Highly nonlinear media, nonlinear waveguides (NLWG)?
- High-efficiency photodetectors: QE=1 @ 1550, 1064 nm
- Integrated optics approach to scalability: integrate NL medium / OPO, VIPA, photodiodes all in guided optics?
- Photon-number-resolving detectors for QEC, universal QC

(QE=1 @ 1550, 1064 nm)

- Theoretical analysis of multipartite continuous-variable entanglement: Fault tolerance threshold? Min. squeezing?
- Viable entanglement-sharing network procedures: e.g. quantum secret sharing and distributed teleportation/one-way QC over a physical network

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