Quantum Science at
The Joint Quantum Institute

The Premier Institute for Quantum Science & Technology in the US

Dr. Gretchen Campbell
Co-Director Joint Quantum Institute
National Institute of Standards and Technology

UNIVERSITY OF MARYLAND 1856

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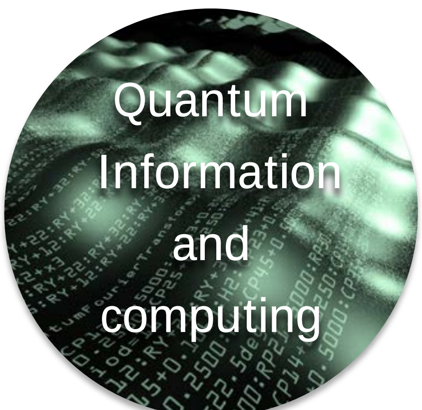
NIST

Scientific Mission



- *Coherent Quantum Phenomena*
  - Intersection of Condensed Matter, AMO, and Quantum Information
- Understand Quantum Mechanics in the context of information science
- Exploit Quantum Mechanics for new technologies

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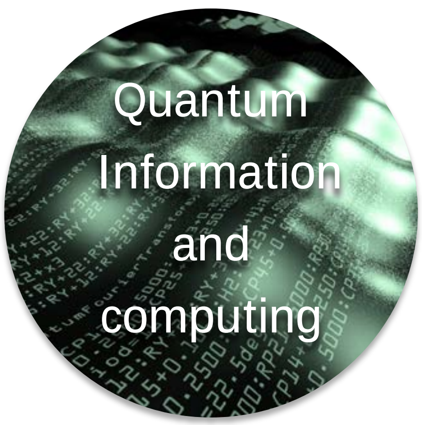
JQI Areas of Research



- Quantum Information Science including:
  - Q. Communication (QKD, single photon technologies, …)
  - Q. Information and Q. Algorithms
  - Q. Computing
  - Q. Sensors and Q. Based Measurements
- Other Coherent Quantum Phenomena
  - Q. Materials and Q. Matter (topological insulators)
  - Q. Phase Transitions and Phase Diagrams
  - Cold Atom Collisions
  - Condensed Matter Theory (nonequilibrium dynamics of open systems)
  - …

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JQI Overview

Established in 2006 as a Joint Institute of NIST and the University of Maryland

31 Principal Investigators

- 13 NIST, 17 UMD, and 1 LPS
- Theory/Experiment

~180 postdoctoral & graduate researchers

- ~40 graduate students work for NIST fellows
- ~15 PhDs per year

Leading Center for Quantum Science

Students and post-docs go to:

Honeywell, Intel, Northrop-Grumman, IBM, Microsoft, Google, AOSense, IonQ, Booz-Allen-Hamilton…

Physical Science Complex, College Park, Md

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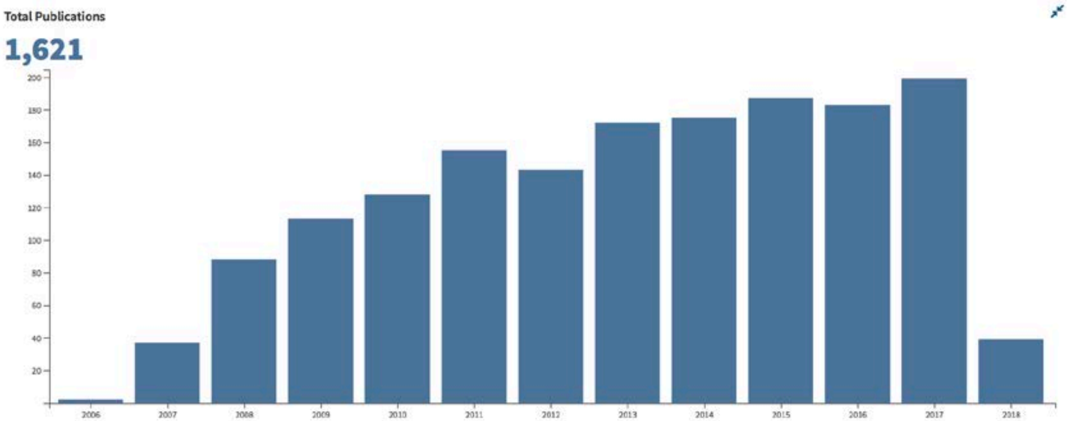
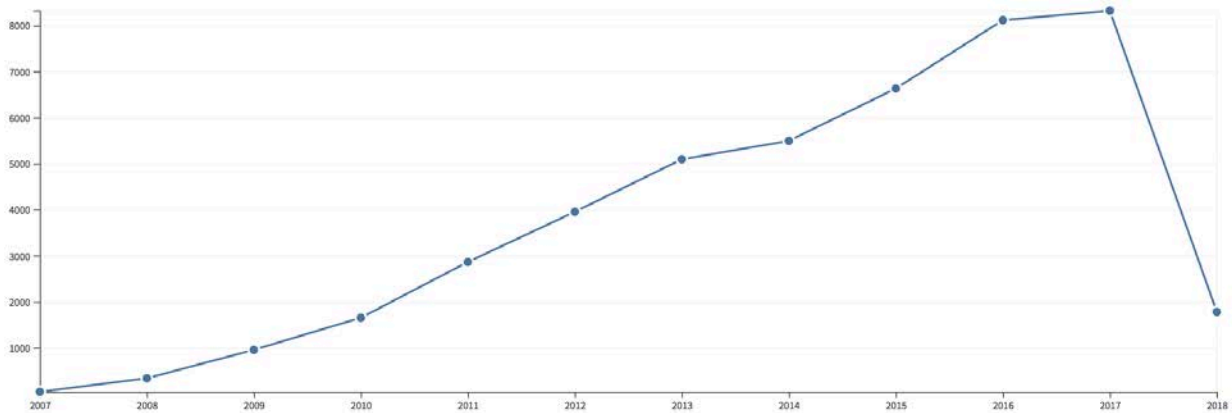
JQI Publication Statistics



Publications:
~ 200 papers in 2017
Over 1500 papers since 2011



Citations:
Total: (1621; 199 in 2017):
h-index=94,
45203 total cites, avg.=28
QIS articles (722; 107 in 2017):
    h-index=73,
    27042 total cites, avg.=37
QC articles (430; 74 in 2017):
    h-index=54, 15412 total cites, avg.=36

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QUICS overview

JOINT CENTER FOR
QUANTUM INFORMATION
AND COMPUTER SCIENCE

Established in 2014 as a Joint Institute of NIST and the University of Maryland

13 Principal Investigators

- 6 NIST, 6 UMD, and 1 NSA

20-30 postdoctoral & graduate researchers

Goal to become a leading center for quantum information in computer science

Physical Science Complex,
College Park, Md

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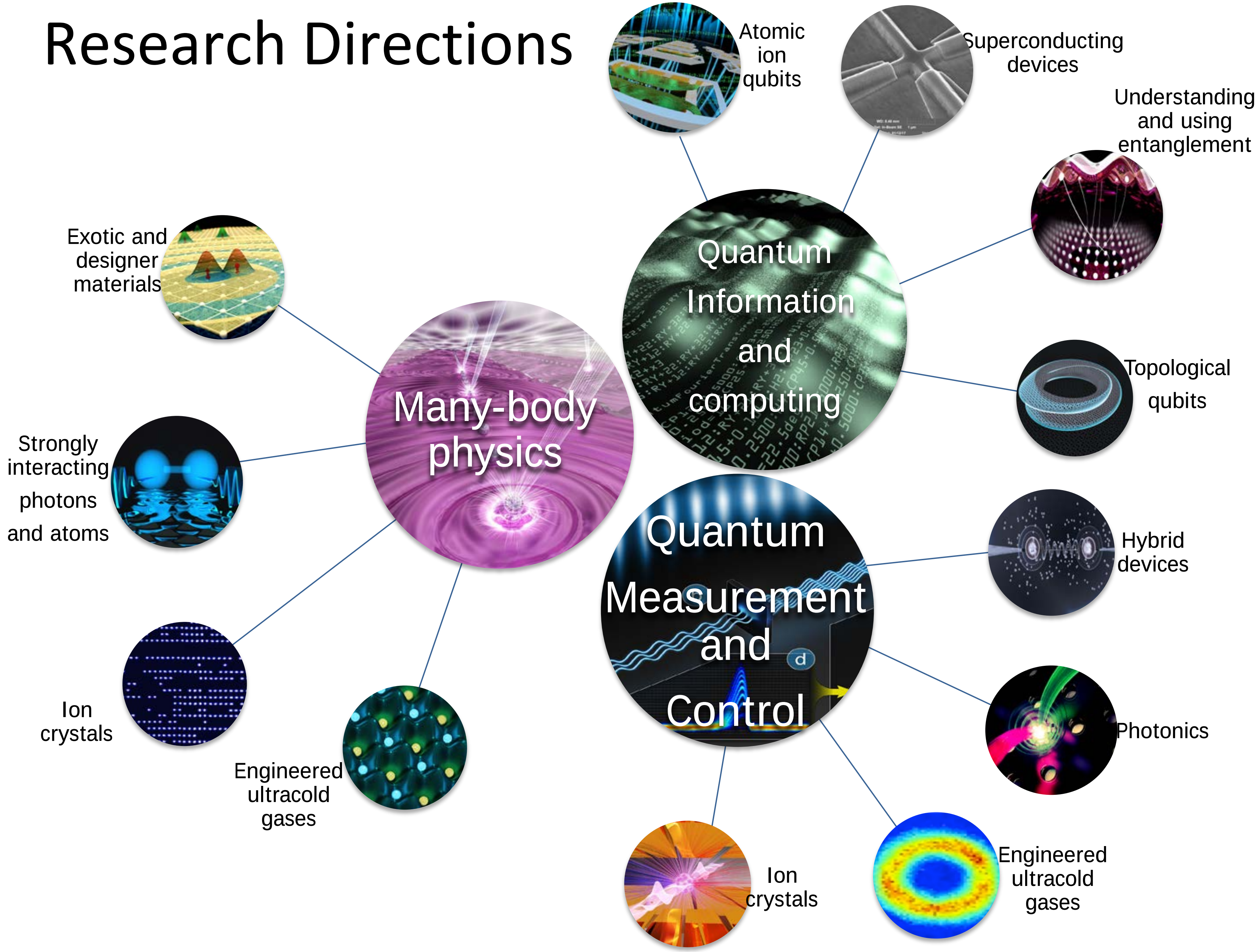
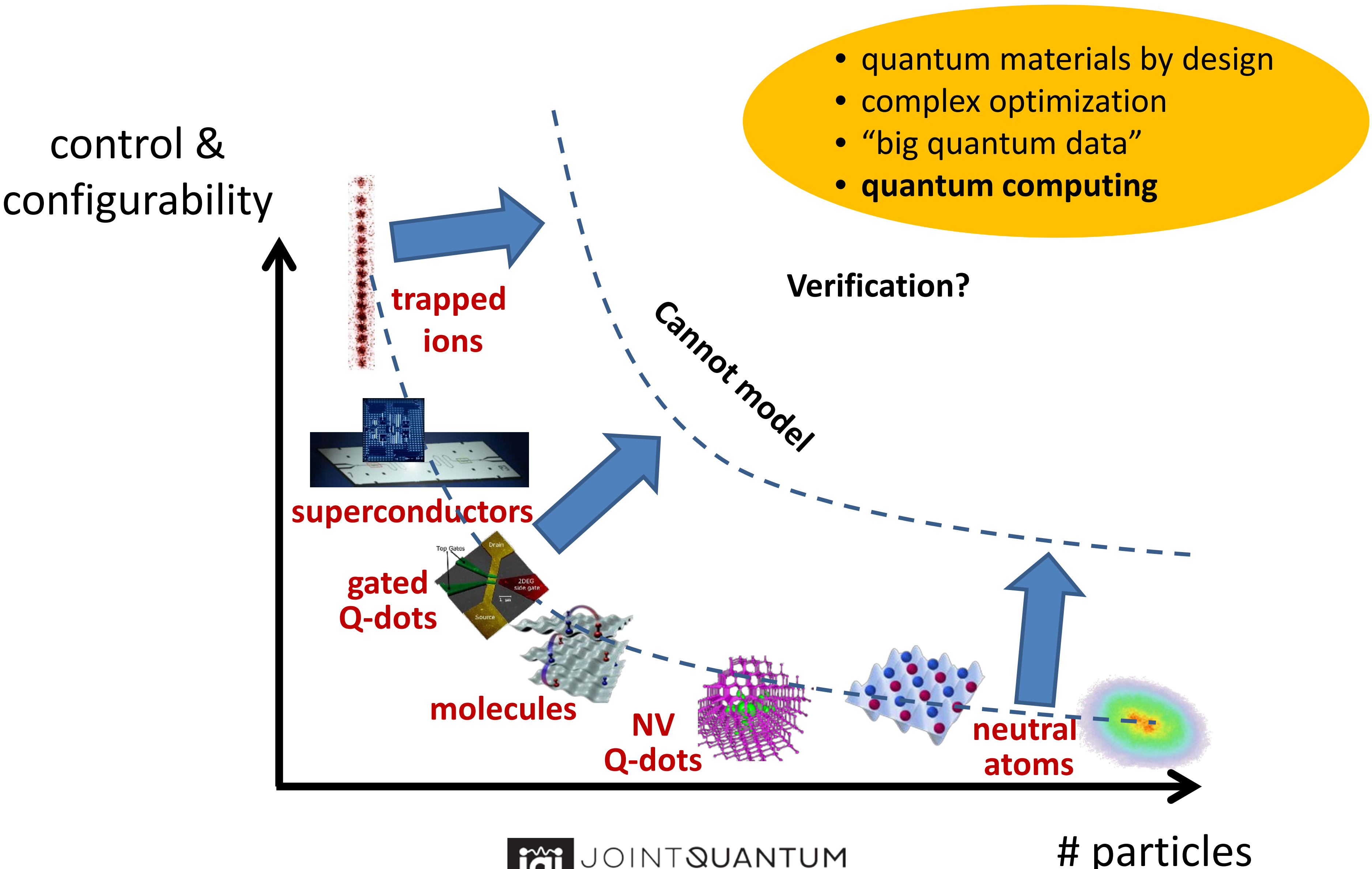
Research Directions



Development of “Quantum” Hardware



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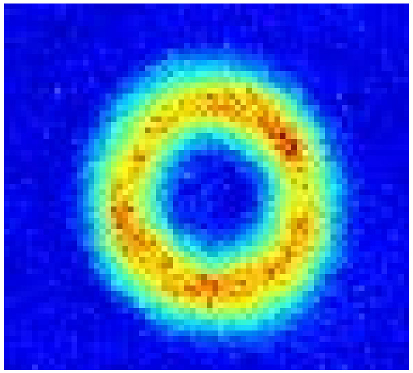
Ultracold atom "circuits"



BEC in toroidal trap

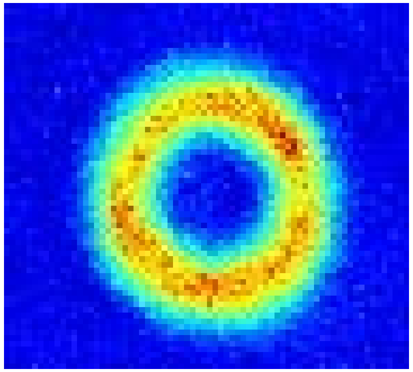
Interesting effects in toroidal traps:

Reduced dimensionality or topological constraints can give rise to different collective phenomena such as:

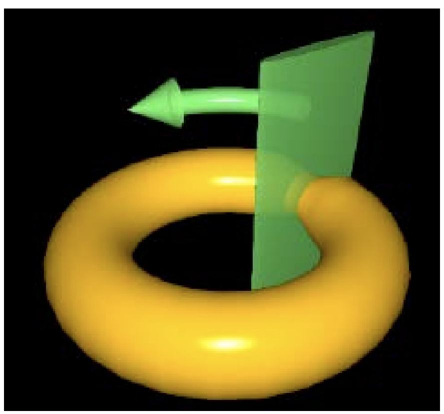
- Superfluidity
- Superflow

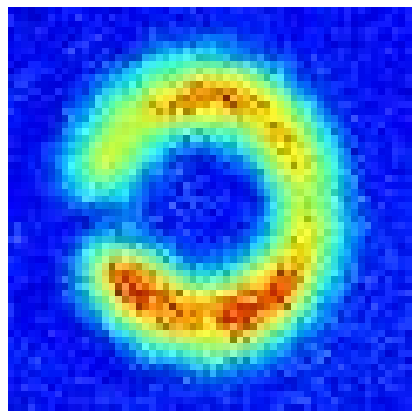
Engineered ultracold gases

Ultracold atom "circuits"

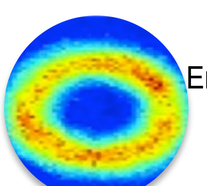


BEC in toroidal trap





BEC in toroidal trap
with barrier



Engineered
ultracold
gases

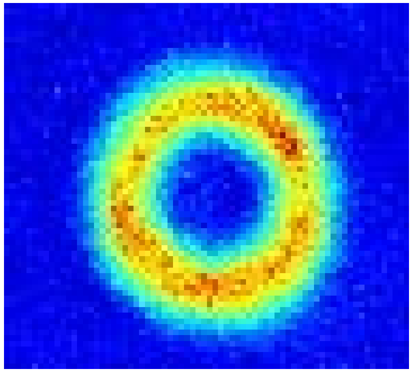
Interesting effects in toroidal traps:

Reduced dimensionality or topological constraints can give rise to different collective phenomena such as:

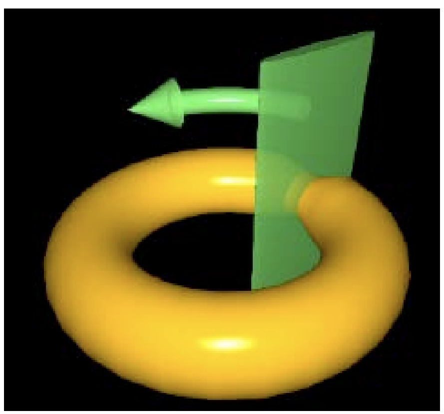
- Superfluidity
- Superflow
- Atomtronic circuits
- SQUID analog (Josephson junction)
- Interferometry/Quantum Sensors

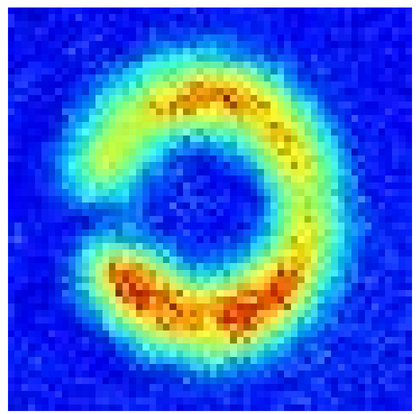
Chris Lobb

Ultracold atom “circuits”

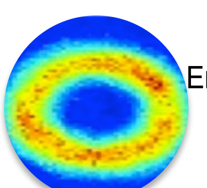


BEC in toroidal trap





BEC in toroidal trap with barrier



Engineered ultracold gases

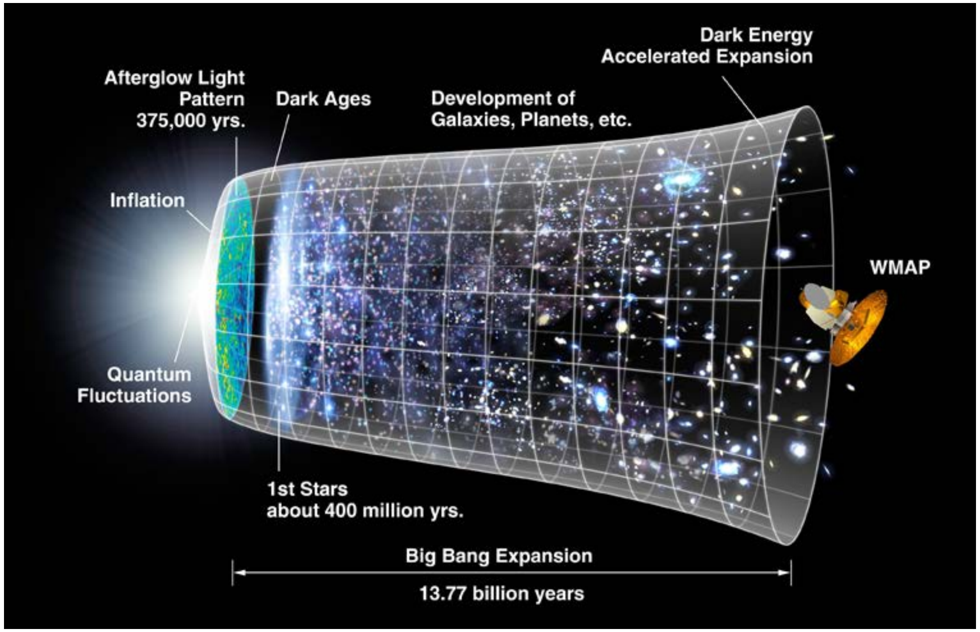
Interesting effects in toroidal traps:

Reduced dimensionality or topological constraints can give rise to different collective phenomena such as:

- Superfluidity
- Superflow
- Atomtronic circuits
- SQUID analog (Josephson junction)
- Interferometry/Quantum Sensors
- Cosmological Physics??

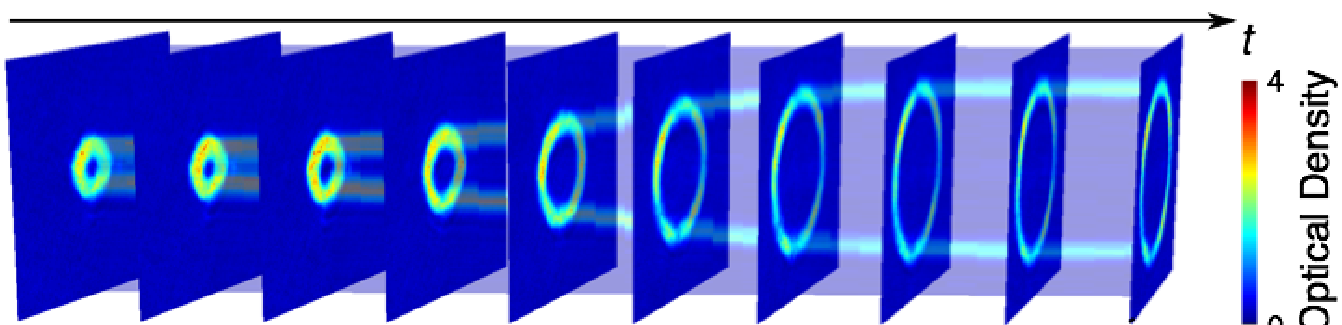
Cosmology in the Lab?

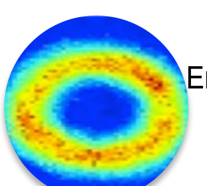
Can we learn something about this ....



Ian Spielman

Ted Jacobson



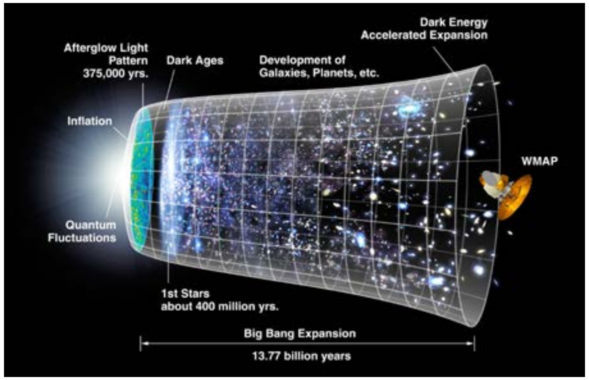


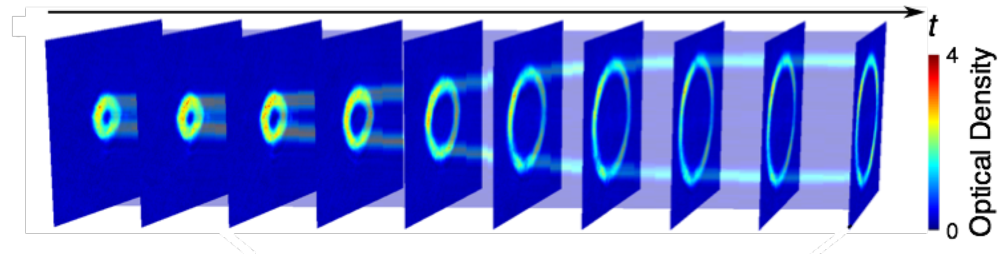
Engineered ultracold gases

... using something like this?

S. Eckel, *et.al.*, Phys. Rev. X **8**, 021021 (2018)

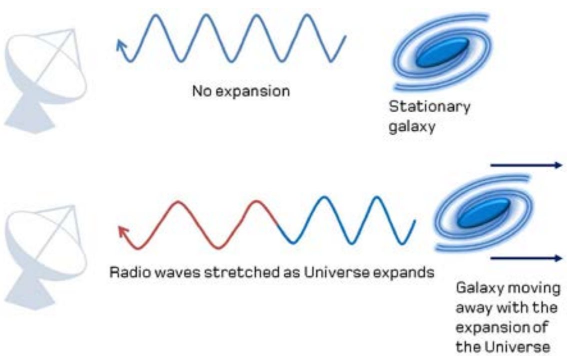
Cosmology in the Lab?



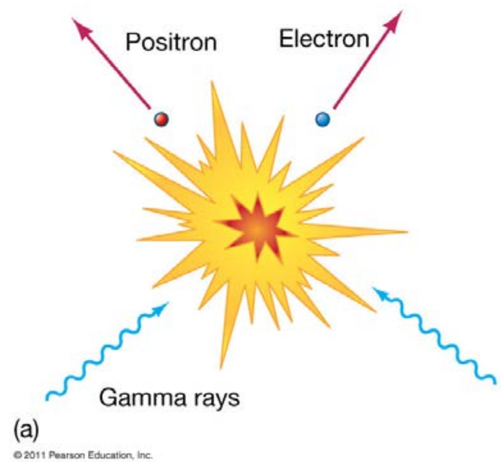


... using something like this?

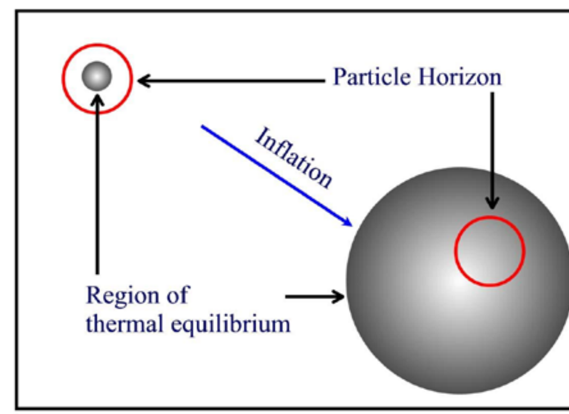
Both systems experience:



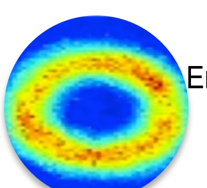
Redshift



Particle Creation



Horizons?



Engineered ultracold gases

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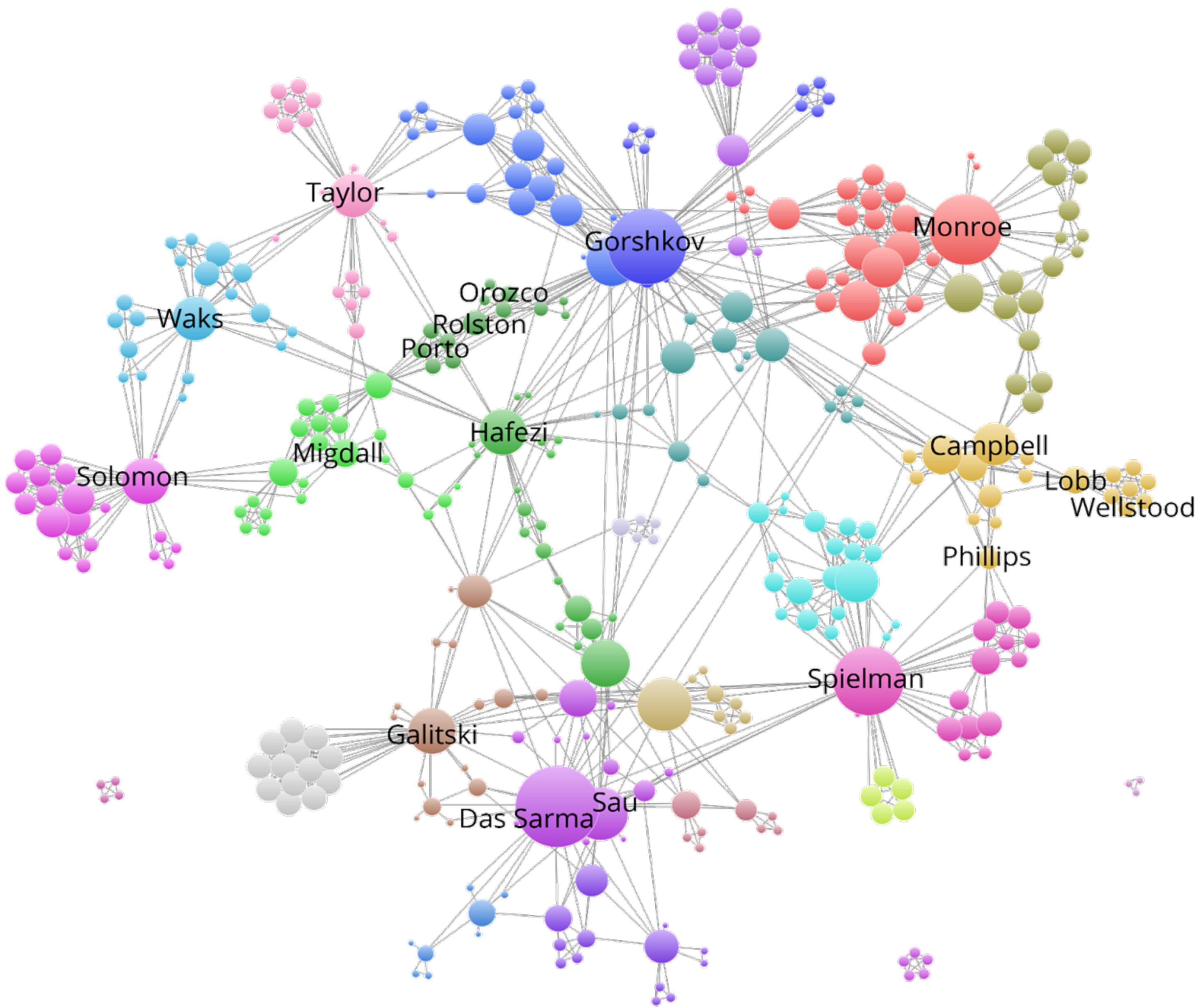
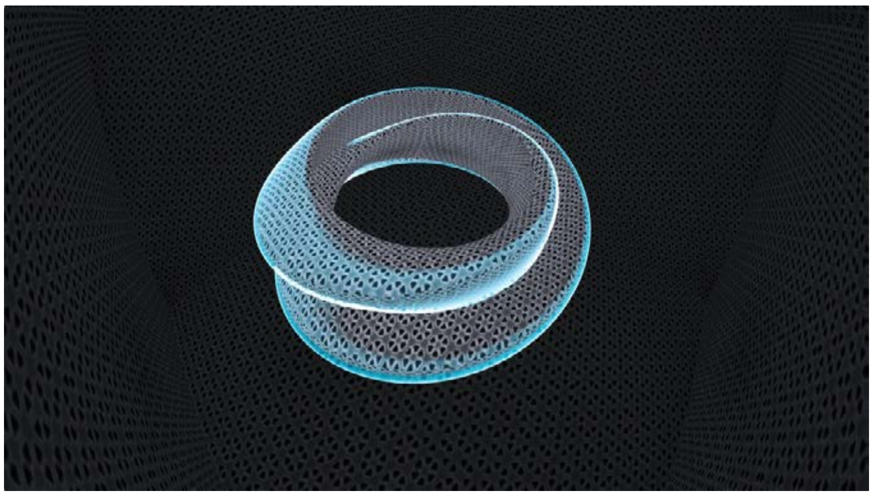
JQI Connectivity from publications, April 2017



Research Highlights:

Photonic Chip Guides Single Photons, Even when there are bends in the Road:



Optical highways for light are at the heart of modern communications. But when it comes to guiding individual blips of light called photons, reliable transit is far less common. A collaboration of researchers from the Joint Quantum Institute (JQI), led by JQI Fellows Mohammad Hafezi and Edo Waks, has created a photonic chip that both generates single photons, and steers them around.

Science **359**, 666-668, 2018

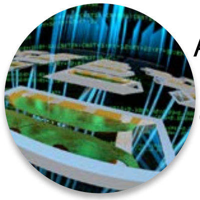
Topological qubits

Research Highlights:

Quantum Simulators Wield Control over more than 50 Qubits

Two independent teams of scientists, including one from the Joint Quantum Institute, have used more than 50 interacting atomic qubits to mimic magnetic quantum matter, blowing past the complexity of previous demonstrations.

Observation of a many-body dynamical phase transition with a 53-qubit quantum simulator; Nature 551, 601–604 (2017)



Atomic ion qubits

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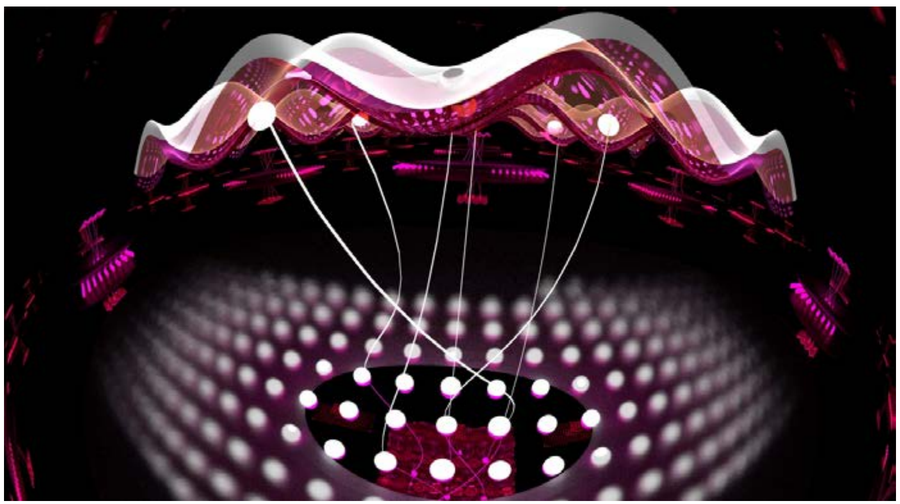
Research Highlights:

Neural Network Techniques that enable computers to learn can describe complex Quantum Systems:



Researchers at the Joint Quantum Institute showed that certain neural networks—abstract webs that pass information from node to node like neurons in the brain—can succinctly describe wide swathes of quantum systems. The networks can efficiently represent quantum systems that harbor lots of entanglement.

Quantum Entanglement in Neural Network States," Dong-Ling Deng, Xiaopeng Li, Das Sarma, Physical Review X, 7, (2017)

Understanding and using entanglement

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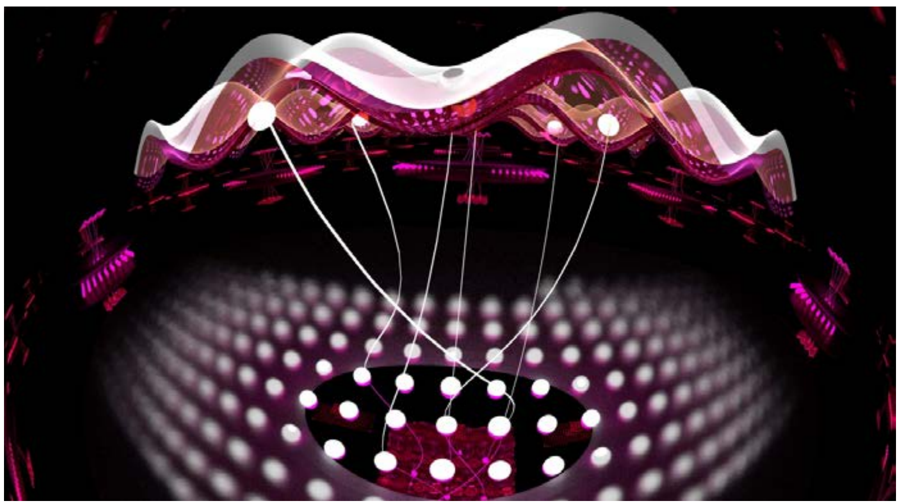
Research Highlights:

Neural Network Techniques that enable computers to learn can describe complex Quantum Systems:



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Understanding and using entanglement

More information and highlights are available from http://jqi.umd.edu

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