http://www.aps.org/units/gqi

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Topical Group on Quantum Information

- Governance
- Newsletters
- Meetings
- APS Fellowship
- Prizes & Awards
- Careers
- Image Gallery
- About GQI
- Resources

Email Print Share

Topical Group on Quantum Information

The mission of the Topical Group on Quantum Information is to promote the advancement and diffusion of knowledge concerning the physics of quantum information, computing, fundamental concepts, and foundations. The Topical Group will serve as a focus for theoretical and experimental research in these and related areas. Research topics of direct interest include quantum entanglement, quantum communication, quantum cryptography, quantum algorithms and simulations, physical implementations of qubits, quantum error correction, fault-tolerant quantum computation, quantum measurements, open quantum systems, quantum coherence, control of quantum dynamics, the quantum-classical correspondence, and the conceptual and mathematical foundations of quantum theory.

▸ Full Mission Statement

Unit Contact

Ivan Deutsch, GQI Secretary-Treasurer
Professor, Regents Lecturer
Director, Center for Advanced Studies
University of New Mexico, Department of Physics and Astronomy
Email | Homepage
Phone: (505) 277-1502 FAX: (505) 277-1520

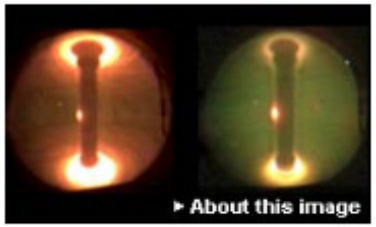
Upcoming Meetings

APS March Meeting 2012
February 27-March 2, 2012

APS April Meeting 2012 (Held in Conjunction with the Sherwood Fusion Theory Conference)
March 31-April 3, 2012

▸ More Meeting Information

▸ View APS Meeting Calendar



Quick Links

- Executive Committee

- APS Members
  - Join This Unit
  - Member Directory
- Join APS
- About APS

GQI Business Meeting Agenda

-- GQI mission and history

-- Election results

-- Membership statistics

-- APS Fellowships

-- March Meeting program planning process

-- Newsletter: Quantum Times

-- Treasury Report

-- GQI Prizes(?)

-- Virtual Museum of Quantum Information

-- Discussion and new business

GQI Mission Statement

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GQI History and Goals

2002: Danny Greenberger and Anton Zeilinger petition APS to establish a “Topical Group on Quantum Information, Concepts, and Computation”.

2005: GQI, chaired by Hideo Mabuchi, participates in APS March meeting for the first time.

-- Promote a deeper appreciation of our field’s motives and prospects among members of a broader scientific community.
-- Integrate the various sub-communities within quantum information science and quantum foundations research.
-- Improve job prospects (both academic and industrial) for young researchers in our field.
-- Address problems and uncertainties in the long-term funding outlook for research in our field.

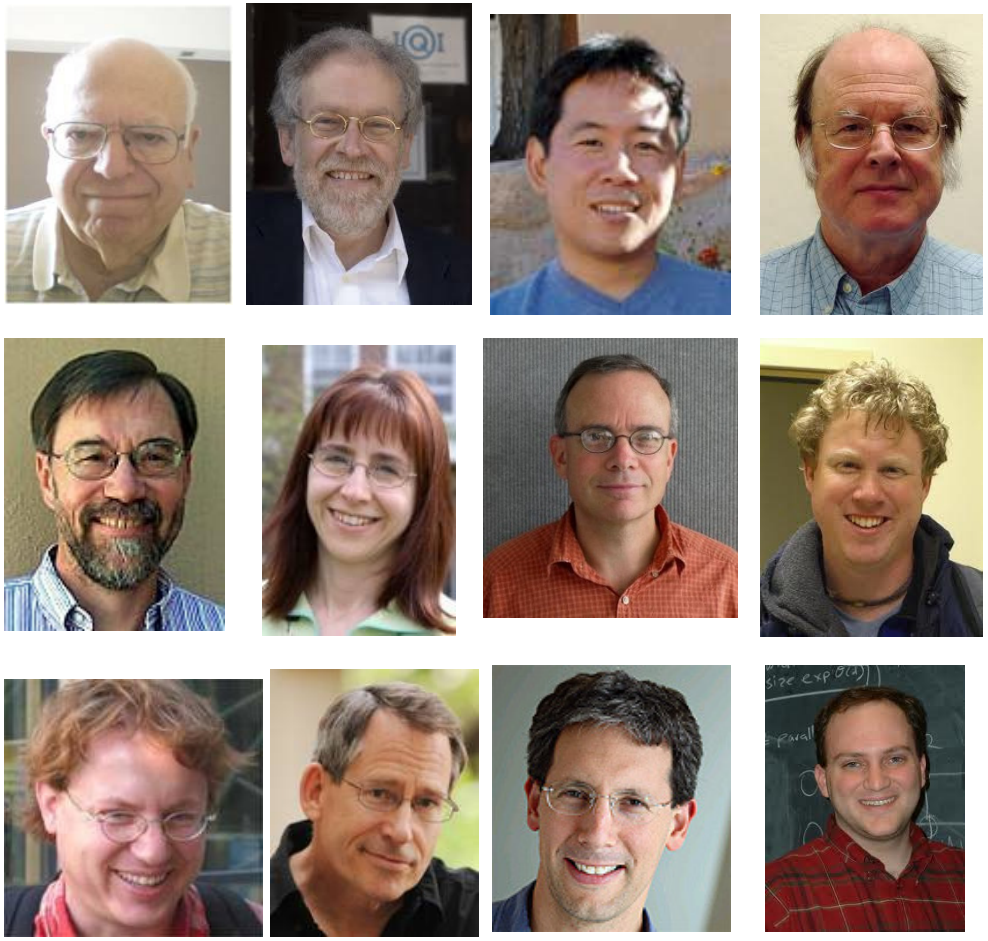
-- Encourage and coordinate participation by quantum information researchers at the APS March meeting.
-- Select and nominate candidates for Fellow of the APS.
-- Publish a newsletter serving the quantum information community.
-- Raise funds and seek APS approval for prizes and awards recognizing quantum information researchers.

Founders:

Danny Greenberger,
Anton Zeilinger

Chairs:

2005 Hideo Mabuchi
2006 Charlie Bennett
2007 Carl Caves
2008 Lorenza Viola
2009 David DiVincenzo
2010 Dave Bacon
2011 Chris Fuchs
2012 John Preskill
2013 Daniel Lidar
2014 Andrew Landahl



Four year cycle: Vice Chair ⟶ Chair Elect ⟶ Chair ⟶ Past Chair

Secretary/Treasurer:
Barry Sanders, Ivan Deutsch, Ian Durham



Members at Large:
Peter Zoller
Chris Fuchs
Raymond Laflamme
Chris Monroe
Ivette Fuentes
Alan Aspuru-Guzik
Howard Barnum
Andrew Doherty








GQI Executive Committee

Chair: John Preskill (01/12 - 12/12)
Caltech

Chair Elect: Daniel Lidar (01/12 - 12/12)
University of Southern California

Vice Chair: Andrew Landahl (01/12 - 12/12)
Sandia National Laboratories

Past Chair: Christopher Fuchs (01/12 - 12/12)
Perimeter Institute

Secretary/Treasurer: Ian Durham (01/12 - 12/14)
St. Anselm College

Member-at-Large: Alan Aspuru-Guzik (01/11 - 12/12)
Harvard University

Member-at-Large: Howard Barnum (01/11 - 12/12)
University of New Mexico

Member-at-Large: Andrew Doherty (01/12 - 12/13)
University of Sydney

From Topical Group to Division?

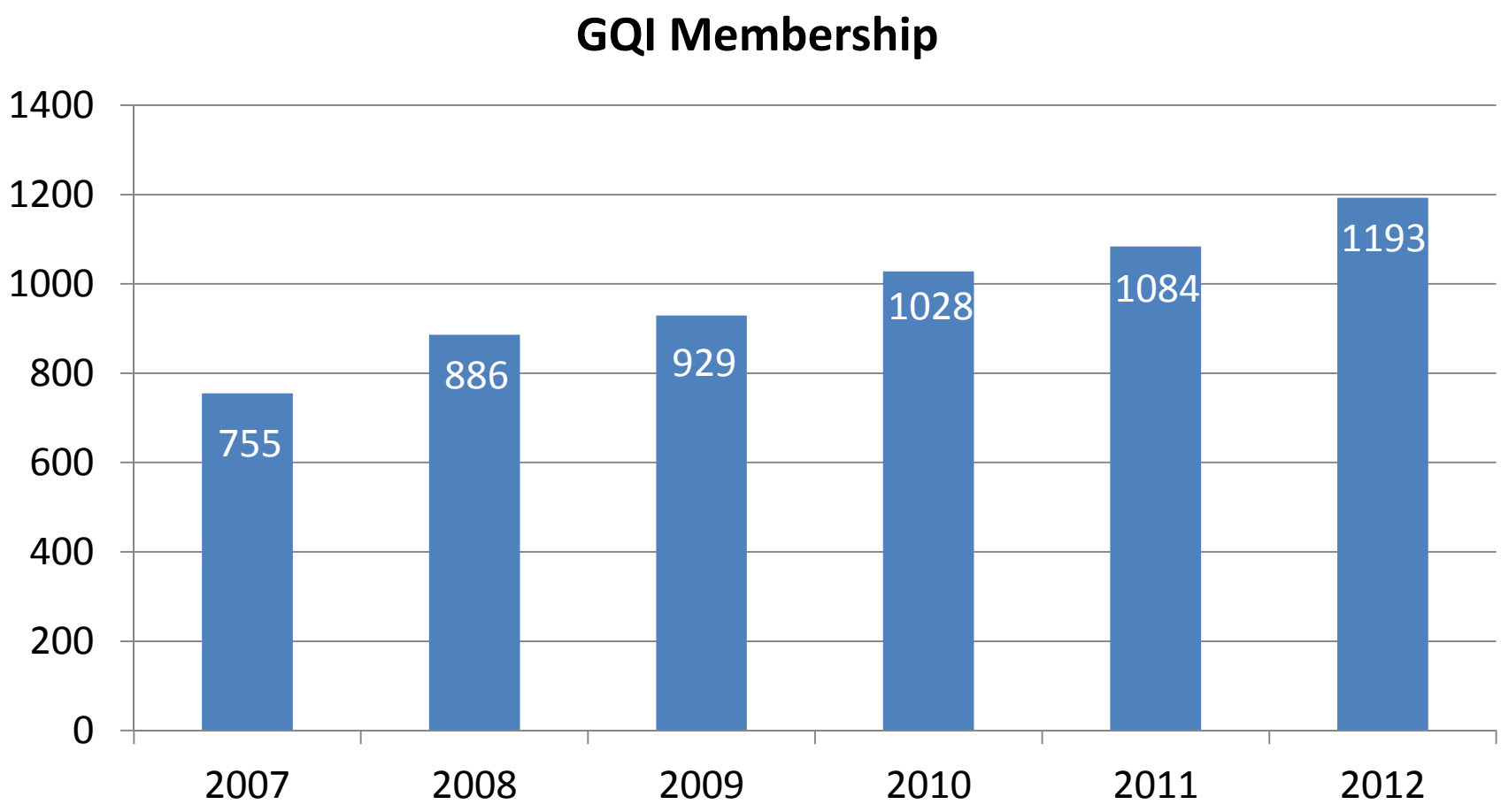
"If the membership of a Topical Group exceeds X percent of the total membership of the Society for two consecutive calendar years, it shall become a Division following application to and approval by Council. A Division shall have one Councilor. If the membership of a Division falls below 0.7X% for four consecutive years, it shall revert to the status of a Topical Group."

Current GQI membership is 1193, which is 2.38% of total APS membership (50,055). He have 696 student members (58%), by far the highest student percentage of any Topical Group.

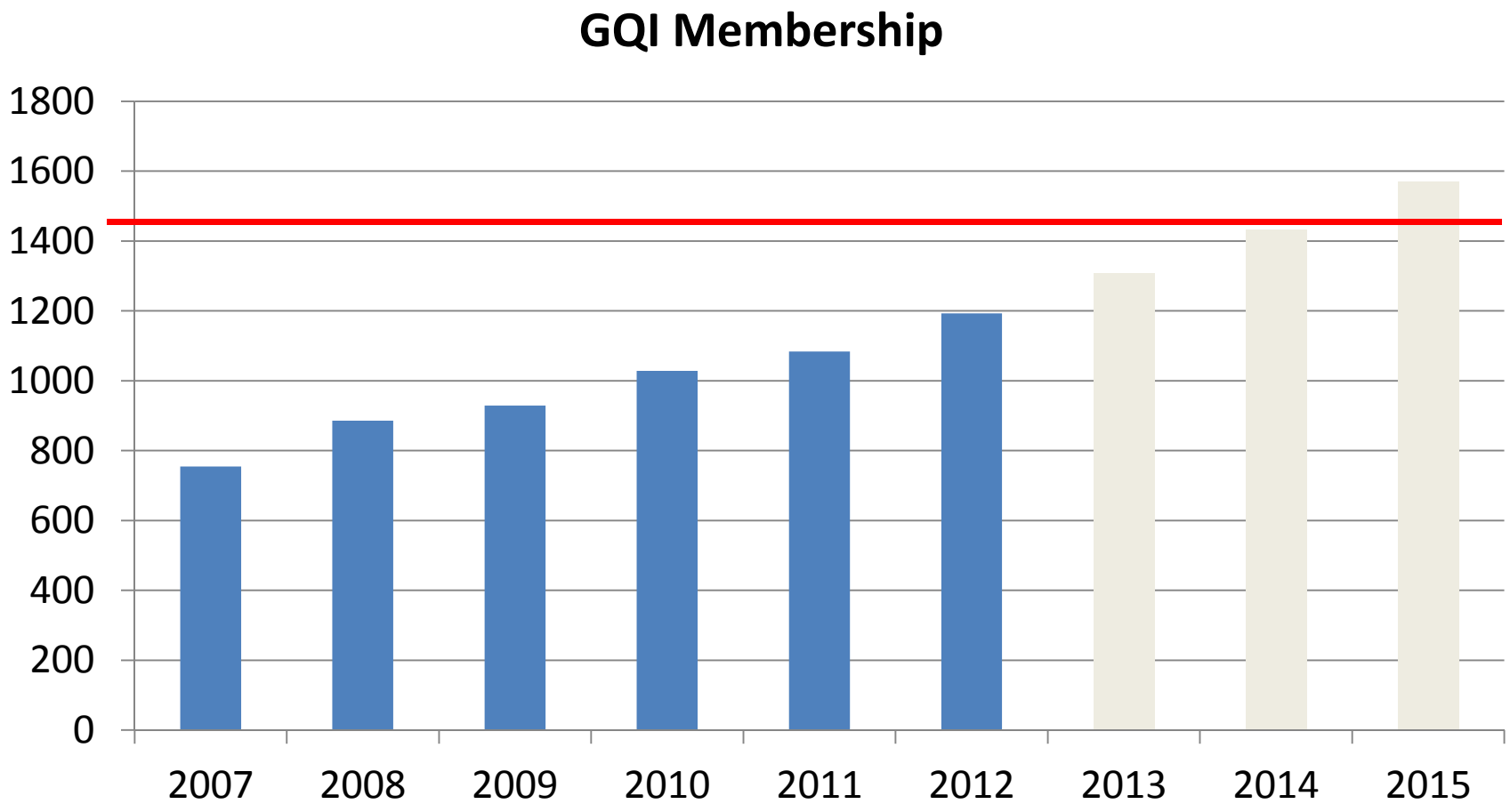
GQI is now the largest of the 12 topical groups, having recently passed Gravitation (GGR, 1086) and Statistical and Nonlinear Physics (GSNP, 1025).

We need 1450 members to become:
The APS Division of Quantum Information
(There are currently 14 Divisions.)

http://www.aps.org/membership/units/statistics.cfm



Please join!


GQI Membership
1800
1600
1400
1200
1000
800
600
400
200
0
2007
2008
2009
2010
2011
2012
2013
2014
2015

GQI Nominated APS Fellows (17)

Leibfried, Dietrich [2006] National Institute of Standards and Technology
Sanders, Barry C. [2006] University of Calgary, Canada

Lidar, Daniel [2007] University of Soutern California
Lloyd, Seth [2007] Massachusetts Institute of Technology
Terhal, Barbara [2007] IBM T. J. Watson Research Center

Duan, Luming [2009] University of Michigan
Zurek, Wojciech H. [2009] Los Alamos National Laboratory

Chuang, Isaac [2010] Massachusetts Institute of Technology
Everitt, Henry [2010] US Army Missile Command
van Enk, Steven [2010] University of Oregon
White, Andrew [2010] University of Queensland

Farhi, Edward [2011] Massachusetts Institute of Technology
Laflamme, Raymond [2011] University of Waterloo
O'Brien, Jeremy [2011] University of Bristol
Smolin, John [2011] IBM T.J. Watson Research Center
Wiseman, Howard [2011] Griffith University
Zanardi, Paolo [2011] University of Southern California

Nomination deadline: May 1, 2012

Edward Farhi, Massachusetts Institute of Technology

For his seminal discoveries of new quantum algorithms and quantum computational paradigms, in particular the quantum walk and quantum adiabatic methods.

Raymond Laflamme, University of Waterloo

For his visionary leadership in the field of quantum information science, and for his numerous fundamental contributions to the theoretical foundations and practical implementation of quantum information processing, especially quantum error correction and linear optical quantum computing.

Jeremy O'Brien, University of Bristol

For his seminal contributions to quantum optics, in particular for founding contributions to the field of integrated quantum photonics and its applications to quantum information processing and quantum metrology.

John Smolin, IBM T.J. Watson Research Center

For his profound contributions to the elucidation of phenomena and techniques central to our current understanding of quantum information theory.

Howard Wiseman, Griffith University

For his seminal contributions to the quantum theory of measurement, particularly to the formulation of continuous measurement, feedback, and control.

Paolo Zanardi, University of Southern California

For his profound theoretical contributions at the interface of quantum information processing and condensed matter physics, in particular his pioneering work on noiseless subspaces, holonomic quantum computation, and the fidelity approach to quantum phase transitions.

APS March Meeting – GQI Program

July: Focus Session Topics and Sorting Categories chosen

October: Symposia scheduled and speakers invited

December: Contributed talks sorted into Sessions

Focus topics -- chosen in July

17.1.1 Superconducting qubits
Matthias Steffen, IBM

17.1.2 Quantum optics with superconducting circuits
Alexandre Blais, Sherbrooke

17.1.3 Semiconductor qubits
Thaddeus Ladd, HRL

17.1.4 Quantum information for quantum foundations
Giulio Chiribella, Perimeter Institute

17.1.5 Qubits in diamond
Ronald Hanson, Delft

17.1.6 Topologically protected qubits
Roman Lutchyn, Microsoft

Symposia (Invited sessions) – finalized in October

A2. Teaching quantum information science at liberal arts colleges, Ian Durham (Schumacher, Westmoreland, Wootters, Bernstein, Galvez) – joint with FEd

D44. Topological quantum computing with Majorana Fermions, Gil Refael (Alicea, Sau, Kouwenhoven, Akhmerov, Brouwer) – joint with DCMP

J3. Quantum computing with superconducting circuits, John Martinis (Siddiqi, Wilson, Steffen, Mariantoni, Reed) – joint with DCMP

P10. Quantum simulations, Eugene Demler (Spielman, Blatt, Girvin, Hafezi, Altman) – joint with DAMOP

Q46. Quantum information processing in diamond, Ronald Hanson (Jelezko, Fu, Harris, Bernien, Bassett)

V10. Quantum entanglement in many-body systems, John Preskill (Polzik, Verstraete, Leibfried, Wen, Aaronson) – joint with DAMOP

W46. Silicon spin qubits: relaxation and decoherence, Mark Eriksson (Simmons, Gyure, Jiang, Witzel, Hu) – joint with DCMP

17.	QUANTUM INFORMATION, CONCEPTS, COMPUTATION	13
17.1.1	Superconducting qubits	86
17.1.2	Quantum optics with superconducting qubits	43
17.1.3	Semiconductor qubits	79
17.1.4	Quantum information for quantum foundations	33
17.1.5	Qubits in diamond	28
17.1.6	Topologically protected qubits	23
17.2	Quantum crypto, communication, measurement	14
17.3	Quantum entanglement	25
17.4	Quantum computing, algorithms, simulations	23
17.5	Quantum error correction, control	21
17.6	Open quantum systems and decoherence	23
17.7	Physical implementations of qubits	6
	TOTAL	436

GQI Sorters
(2 December 2011)

Sorted 420 talks into 30 sessions

Lev Bishop
Qiuzi Li
Ben Palmer
Charlie Tahan
Shuo Yang
Xin Wang
John Preskill

The Quantum Times

Volume 6, Number 3
Fourth Quarter, 2011

Newsletter of the Topical Group on Quantum Information

American Physical Society

Inside this issue

PBR, EPR, and all that jazz

Matt Leifer

In the past couple of months, the quantum foundations world has been abuzz about a new preprint entitled "The Quantum State Cannot be Interpreted Statistically" by Matt Pusey, Jon Barrett and Terry Rudolph (henceforth known as PBR). Since I wrote a blog post explaining the result, I have been inundated with more correspondence from scientists and more requests for comment from science journalists than at any other point in my career. Reaction to the result amongst quantum researchers has been mixed, with many people reacting negatively to the title, which can be misinterpreted as an attack on the Born rule. Others have managed to read past the title, but are still unsure whether to credit the result with any fundamental significance. In this article, I would like to explain why I think that the PBR result is the most significant constraint on hidden variable theories that has been proved to date. It provides a simple proof of many other known theorems, and it supercharges the EPR argument, converting it into a rigorous proof of nonlocality that has the same status as Bell's theorem. Before getting to this though, we need to understand the PBR result itself.

What are Quantum States?

One of the most debated issues in the foundations of quantum theory is the status of the quantum state. On the ontic view, quantum states represent a real property of quantum systems, somewhat akin to a physical field, albeit one with extremely bizarre properties like entanglement. The alternative to this is the epistemic view, which sees quantum states as states of knowledge, more akin to the probability distributions of statistical mechanics. A psi-ontologist (as supporters of the ontic view have been dubbed by Chris Granade) might point to the phenomenon of interference in support of their view, and also to the fact that pretty much all viable realist interpretations of quantum theory, such as many-worlds or Bohmian mechanics, include an ontic state. The key argument in favor of the epistemic view is that it dissolves the measurement problem, since the fact that states undergo a discontinuous change in the light of measurement results does not then imply the existence of any real physical process. Instead, the collapse of the wavefunction is more akin to the way that classical probability distributions get updated by Bayesian conditioning in the light of new data.

Many people who advocate a psi-epistemic view also adopt an anti-realist or neo-Copenhagen point of view on quantum theory in which the quantum state does not represent knowledge about some underlying reality, but rather it only represents knowledge about the consequences of measurements that we might make on the system. However, there remained the nagging question of whether it is possible in principle to construct a realist interpretation of quantum theory that is also psi-epistemic, or whether the realist is compelled to think that quantum states are real.

Continued on next page

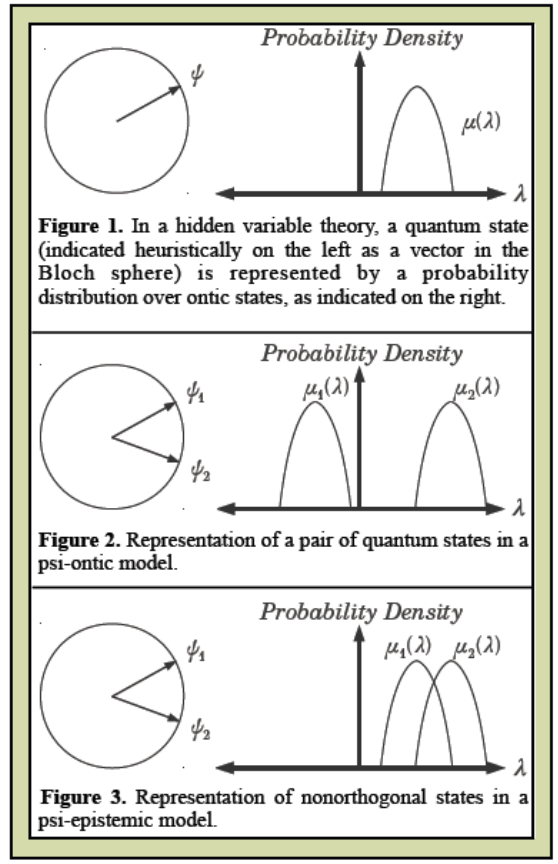


Figure 1. In a hidden variable theory, a quantum state (indicated heuristically on the left as a vector in the Bloch sphere) is represented by a probability distribution over ontic states, as indicated on the right.

Figure 2. Representation of a pair of quantum states in a psi-ontic model.

Figure 3. Representation of nonorthogonal states in a psi-epistemic model.

Figure 2. A mixture of coffee and milk. Adapted from Sean Carroll's figure that appeared in Scott Aaronson's article, *The Quantum Times* **6**, 2 (2011).

Treasury Report

Ivan Deutsch

- **Total Assets: $37,165**
  - Previous Balance 2010: $23,542
  - 2011 Activity: + $13,624
    - Revenue: $17,791
      - APS Dues: $5,420
      - March meeting reg fees: $11,456
      - Investment income: $915
    - Expenses: $4,167
      - March meeting reception: $3,014
      - Other food and beverage: $421
      - Mail: $13
      - Travel: $209
      - Sorters meeting: $510

Topical Group on Quantum Information

Prizes & Awards

Best Student Paper Award

Once again, GQI will award two "Best Student Paper" prizes at the APS March Meeting (2009): one for theory and one for experiment. The awards, each consisting of a $500 cash prize, are sponsored by Perimeter Institute for Theoretical Physics in Waterloo, Canada, and the Institute for Quantum Computing at the University of Waterloo, respectively.

To be registered for the competition, a brief nomination letter from the student's supervisor stating that the results described in the presentation are substantially the student's own work and that the student is currently enrolled at a degree-granting institute, must be sent via email to David DiVincenzo at divince@watson.ibm.com before the March meeting commences.

The two equally weighted criteria for the award are quality of scientific results and quality of the presentation. Judging will be undertaken by an ad hoc committee consisting of senior members of GQI.

Eligibility:

Undergraduate and graduate students who are both first author and presenter of any submitted (or invited) oral or poster presentation on the subject of quantum information, concepts, and computation. To be eligible, the student will be required to provide a brief nomination letter from the student's supervisor or co-supervisor, stating that the results described in the presentation are substantially the student's own work and that the student is currently enrolled at a degree-granting higher education institute.

Judging:

The two equally weighted criteria for the award are quality of scientific results and quality of the presentation. Judging is undertaken by an ad hoc committee comprising senior members of GQI, which is appointed by the GQI executive at the March meeting solely for the purpose of judging GQI student presentations at the same March meeting and presenting its recommendations to the GQI Executive. The committee of judges reports to the GQI Executive, and the GQI Executive is responsible for administering and presenting the awards at the same APS March meeting.

Virtual Museum of Quantum Information

A proposal

Andrew J. Landahl
Vice-Chair, APS GQI
Tuesday, February 28, 2012

(Please thank whomever is giving this talk!)

The VMQI idea

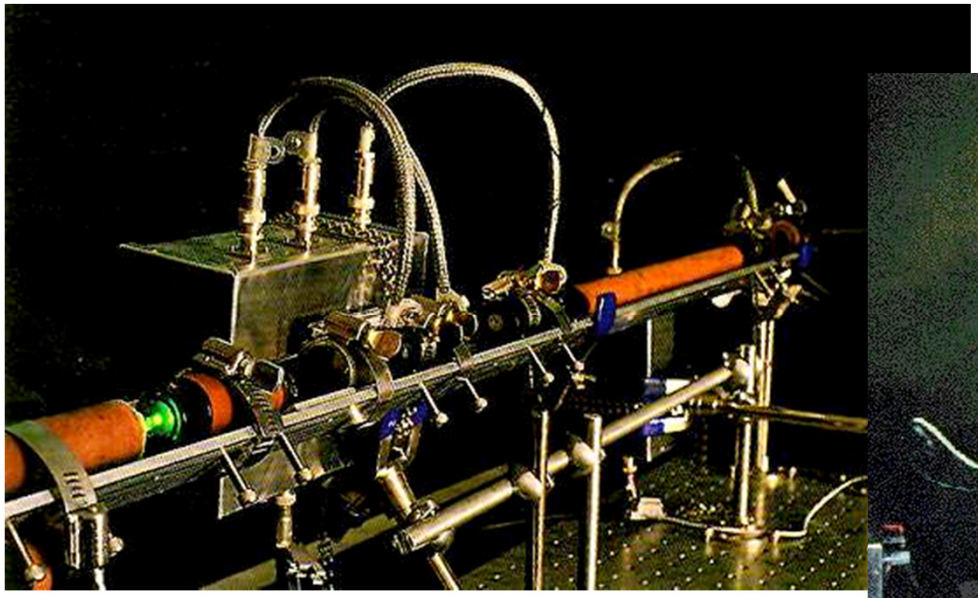
What is it?

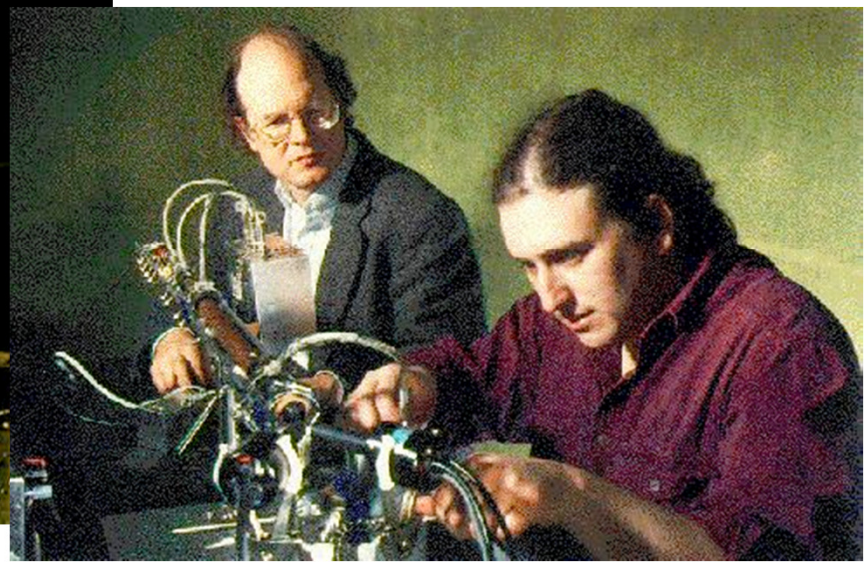
- A multimedia portion of the APS GQI website.
- Content: *Anything in the history of quantum information science that could plausibly end up in a real museum some day.*

What does it achieve?

- Establishes a sense of QIS community.
- Points to the progress the field has made.
- Positions APS GQI as a go-to resource on QIS.
- May inspire others to join QIS and/or GQI.

Good VMQI candidates: Devices



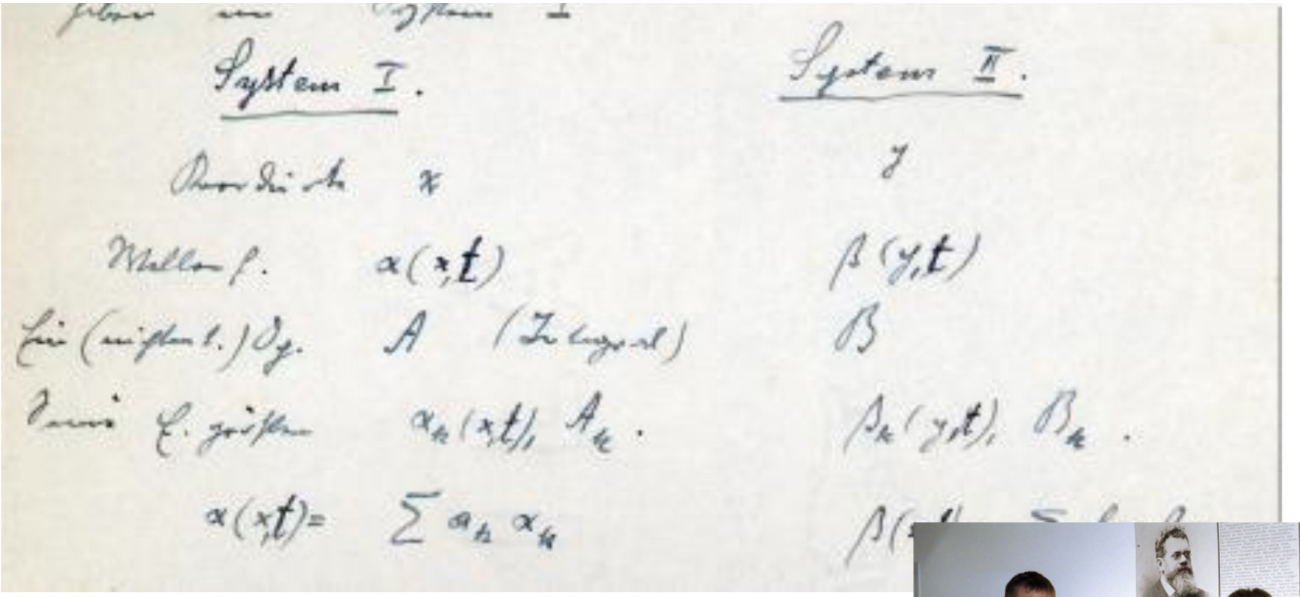


(Left) Experimental quantum key distribution apparatus at IBM.
(Right) Charlie H. Bennett and John Smolin using the device.

Anecdote: "*The power supply hummed at 60 Hz more loudly the fewer Pockels cells were energized.*" –Charlie Bennett. *Some have joked that this device was secure against eavesdroppers who were hearing impaired.*

QIS systems, individual components, special materials

Good VMQI candidates: Notes



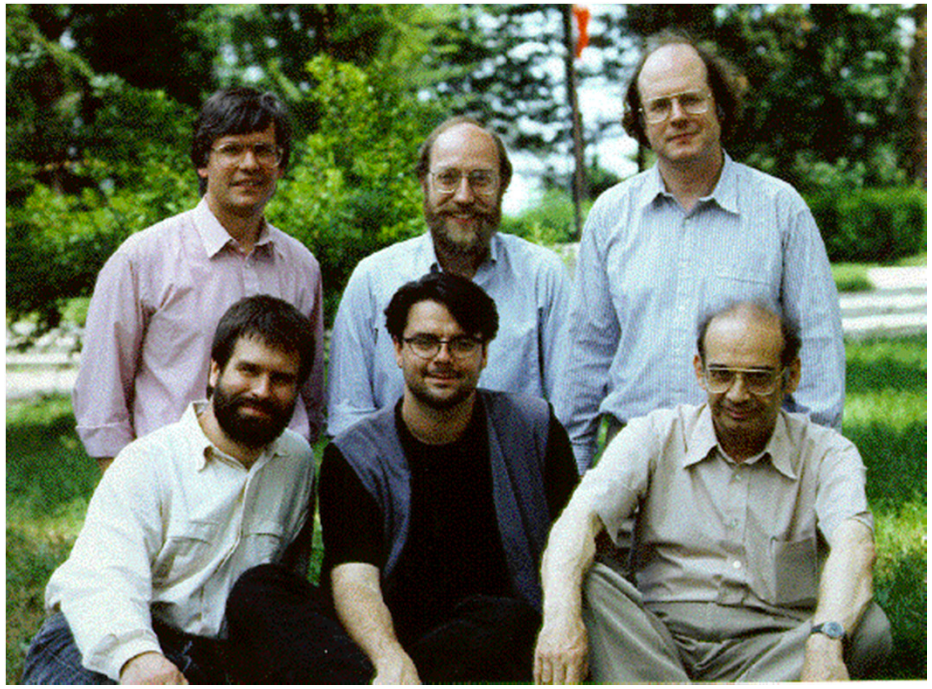
Manuscript by Schrödinger dated back to 1932 or 1933.
Discovered by Matthias Christandl and Lawrence Ioannou in the Schrödinger archive in Vienna.

Anecdote: *Schrödinger coined the words to describe non-separable states in both English (entanglement) and German (Verschränkung).*

"I would not call [entanglement] one but rather the characteristic trait of quantum mechanics, the one that enforces its entire departure from classical lines of thought." –Erwin Schrödinger

Lab notebooks, manuscripts, napkin writings, etc.

Good VMQI candidates: Ephemera



Founders of quantum teleportation. (Top, left) Richard Jozsa, William K. Wootters, Charles H. Bennett. (Bottom, left) Gilles Brassard, Claude Crépeau, Asher Peres. Photo: André Berthiaume.

Flyers, photos, workshop programs, stationery, etc.

Bad VMQI candidates: Full papers

Polynomial-Time Algorithms for Prime Factorization and Discrete Logarithms on a Quantum Computer*

Peter W. Shor†

Abstract

A digital computer is generally believed to be an efficient universal computing device; that is, it is believed able to simulate any physical computing device with an increase in computation time by at most a polynomial factor. This may not be true when quantum mechanics is taken into consideration. This paper considers factoring integers and finding discrete logarithms, two problems which are generally thought to be hard on a classical computer and which have been used as the basis of several proposed cryptosystems. Efficient randomized algorithms are given for these two problems on a hypothetical quantum computer. These algorithms take a number of steps polynomial in the input size, e.g., the number of digits of the integer to be factored.

Keywords: algorithmic number theory, prime factorization, discrete logarithms, Church's thesis, quantum computers, foundations of quantum mechanics, spin systems, Fourier transforms

AMS subject classifications: 81P10, 11Y05, 68Q10, 03D10

* A preliminary version of this paper appeared in the Proceedings of the 35th Annual Symposium on Foundations of Computer Science, Santa Fe, NM, Nov. 20–22, 1994, IEEE Computer Society Press, pp. 124–134.

† AT&T Research, Room 2D-149, 600 Mountain Ave., Murray Hill, NJ 07974.

The VMQI is not the arXiv.

Bad VMQI candidates: Tutorials

Next Up Previous

Next: Computing at the atomic scale

Quantum computation: a tutorial

Samuel L. Braunstein

Abstract:

Imagine a computer whose memory is exponentially lar ger than its apparent physical size; a computer that can manipulate an exponential set of inputs simultaneously; a computer that computes in the twilight zone of Hilbert space. You would be thinking of a quantum computer. Relatively few and simple concepts from quantum mechanics are needed to make quantum computers a possibility. The subtlety has been in learning to manipulate these concepts. Is such a computer an inevitability or will it be too difficult to build?

In this paper we give a tutorial on how quantum mechanics can be used to improve computation. Our challenge: solving an exponentially difficult problem for a conventional computer ---that of factoring a large number. As a prelude, we review the standard tools of computation, universal gates and machines. These ideas are then applied first to classical, dissipationless computers and then to quantum computers. A schematic model of a quantum computer is described as well as some of the subtleties in its programming. The Shor algorithm [1,2] for efficiently factoring numbers on a quantum computer is presented in two parts: the quantum procedure within the algorithm and the classical algorithm that calls the quantum procedure. The mathematical structure in factoring which makes the Shor algorithm possible is discussed. We conclude with an outlook to the feasibility and prospects for quantum computation in the coming years.

Let us start by describing the problem at hand: factoring a number **N** into its prime factors (e.g., the number **51688** may be decomposed as $2^3 \times 7 \times 13 \times 71$). A convenient way to quantify how quickly a particular algorithm may solve a problem is to ask how the number of steps to complete the algorithm scales with the size of the ``input'' the algorithm is fed. For the factoring problem, this input is just the number **N** we wish to factor; hence the length of the input is $\log N$. (The base of the logarithm is determined by our numbering system. Thus a base of **2** gives the length in binary; a base of **10** in decimal.) `Reasonable' algorithms are ones which scale as some small-degree polynomial in the input size (with a degree of perhaps **2** or **3**).

On conventional computers the best known factoring algorithm runs in $O(\exp[(64/9)^{1/3}(\ln N)^{1/3}(\ln\ln N)^{2/3}])$ steps [3]. This algorithm, therefore, scales

The VMQI is not a classroom.

Issues to consider

- Who decides on content? (GQI should add *quality*. The "History of quantum computing" wiki article is poorly written, biased, and erroneous in some places. Should we accept everything but only display some? Should we "rotate" what we display?)
- Who will help maintain the site? (Any volunteers to be "virtual docents?" Need people to solicit artifacts, solicit/write brief technical descriptions of them, upload content to site, *etc.*)
- What are the infrastructure costs? Do we need to do fundraising?
- We do NOT want be in the game of arbitrating priority. Suggestions for how to avoid? APS rules on this sort of thing?
- Cutoff for how old an item must be before inclusion?
- How to organize content? (Exhibits)
- What would *you* like to see in the VMQI?

Further info

- If you are interested in helping, or have suggestions for content ("artifacts"), please e-mail alandahl@sandia.gov.
- This is a nascent idea; I welcome hearing your suggestions, concerns, and follow-on ideas. The goal is to serve our membership in the best way possible.
- Thanks for your attention! And thanks to whomever is presenting this! Sorry I couldn't be here in person.

Virtually yours,

Andrew J. Landahl

Discussion and New Business

March meeting program?
Endowed prize(s)?
Other spending?
Virtual Museum?