

Quantum Computing: Selected Internet Resources for Librarians, Researchers, and the Casually Curious¹

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Introduction

Modern computer components may seem impossibly small, but they are all large in one important sense: they are massive enough to obey the laws of classical mechanics. But what if they weren't? What if computers were built with subatomic particles that behaved according to the rules of quantum mechanics? How would such machines behave? What could they compute? How quickly? How reliably? When researchers asked these questions in the 1980s, they created a new field: quantum computing.

Since then, researchers have shown that quantum computers could make quick work of some problems that classical computers cannot currently (and may never have the ability to) solve efficiently. For example, quantum computers could quickly crack the most common form of cryptography, a task most researchers believe is beyond the capabilities of classical computers. However, there are significant physical obstacles to building quantum computers, and no large-scale, general-purpose quantum computers exist.

Few need or want to understand the scientific details of quantum computing, but many, especially librarians, can benefit from knowing some basics about the field. Here are six facts that will help anyone who chances into a quantum computing conversation, as well as any librarian who receives a quantum computing reference question or materials request:

1. Quantum computing is real science. Despite fantastical article titles such as “Experimental Quantum Teleportation” (Bouwmeester et al. 1997), quantum computing is neither science fiction nor pseudoscience.
2. Quantum computing is an interdisciplinary field that draws from several subjects, including physics, computer science, and mathematics.
3. Quantum computing is a young science, but it is not brand new. Since the field's birth in the early 1980s, researchers have made many important discoveries and published many noteworthy articles. (For more on the history of quantum computing, see “Historical Bibliography of Quantum Computing” (Cirasella 2008a).)
4. Quantum computing is a fast-moving science. Researchers often share their results as soon as they have written them up, before publication. This prepublication sharing allows

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others to respond quickly, independently of journal publication cycles. As a result, many important findings are based on not-yet-published research.

5. Quantum computing is taught at many colleges and universities. Graduate courses are more common, but undergraduate courses exist too.
6. Quantum computing captures the public's imagination. Many people, not just scientists, are fascinated by the seemingly magical powers of quantum computing, and many newspapers and magazines publish articles about it.

Occasionally, librarians or patrons will need to know more. The rest of this article is for those occasions.

Scope and Methods

To the best of my knowledge, this webliography is the first article about quantum computing to appear in the library literature. My goal is to make this first offering as useful as possible, not as comprehensive as possible. What follows is an annotated selection of the most important and informative Internet resources for learning about quantum computing, finding quantum computing literature, and tracking quantum computing news.

All of the quantum computing resources described below are freely available, English-language web sites that fall into one of five categories: overviews, open access publications, research centers, companies, or news and blogs. I include sites that focus on the broader field of quantum information or the related topic of quantum cryptography, but I exclude sites that focus solely on quantum mechanics. Also, I exclude researchers' personal homepages, though it is worth mentioning that many quantum computing researchers maintain homepages that summarize their research interests and link to their papers.

Most of the included resources were familiar to me from my previous research in the theory and history of quantum computing. I found additional resources by following links from known sites and by using Google.

Overviews

Most quantum computing literature falls into one of three categories: gee-whiz articles in the popular press, thick textbooks for serious students, or dense articles by and for researchers. For readers who want to do more than ooh and aah but do not (yet) want to embark on serious study, here are four substantive but still digestible overviews of quantum computing.

“Quantum Computing for Everyone” by Michael Nielsen

<http://michaelnielsen.org/blog/?p=459>

If you know nothing about quantum computing, start with this blog post. Written by Michael Nielsen, co-author of the field's standard text (Nielsen & Chuang 2000), this entry-level essay is informal but authoritative.

“Quantum Computing” from *Stanford Encyclopedia of Philosophy*

<http://plato.stanford.edu/entries/qt-quantcomp/>

The *Stanford Encyclopedia of Philosophy* is a highly regarded open access encyclopedia, and its “Quantum Computing” entry is a serious but not overly technical introduction to the subject. The article includes an extensive bibliography of seminal research papers.

Lectures on Quantum Computation by David Deutsch

http://www.quiprocone.org/Protected/DD_lectures.htm

David Deutsch, one of the world’s preeminent quantum theorists, created a video introduction to the field of quantum computation. The introduction is divided into six lectures: The Qubit, Interference, Measurement, The Schroedinger Picture, A Quantum Algorithm, and Grover’s Search Algorithm. Deutsch’s presentation style is very clear, but those with no knowledge of physics may struggle to follow. The videos are downloadable WMV files that vary in length from 35 to 52 minutes.

Quantiki

<http://www.quantiki.org/>

Quantiki is a wiki with tutorials and encyclopedia-style articles about all aspects of quantum information. As with all wikis, anyone can edit or add Quantiki pages, and some may (intentionally or unintentionally) introduce errors or inconsistencies. So, although Quantiki is wonderful resource full of valuable information, researchers should not rely exclusively on what they find there. (Relatedly, Wikipedia (<http://en.wikipedia.org/>) has some surprisingly clear and citation-rich articles on quantum computing and its underlying concepts. As is well established, Wikipedia content should not be blindly believed, but these entries are solid starting points for research.)

Open Access Publications

Many journals publish articles on quantum computing, and a few are devoted to the umbrella field of quantum information. Unfortunately but not surprisingly, most of these journals are subscription based, not open access. This webliography covers free resources only, but for researchers who cannot limit themselves to open access publications, here is a list of subscription-based journals devoted to quantum information: *Quantum Information & Computation*, *Quantum Information Processing*, *International Journal of Quantum Information*, and *Virtual Journal of Quantum Information*. *Quantum Information Processing*, published by Springer, differs from the others in that it offers some open access articles through Springer Open Choice, a program that allows authors to pay to make their articles available free of charge to readers; however, it is not a true open access journal. Two true open access resources are described below.

Theory of Computing

<http://theoryofcomputing.org/>

Founded in 2005, *Theory of Computing* is an open access journal “dedicated to free global dissemination of research in theoretical computer science.” The journal is peer reviewed and boasts an impressive editorial board, including several leading quantum

computing researchers. Quantum computing articles appear regularly; to browse just these articles, go directly to <http://theoryofcomputing.org/categories/quantum.html>.

arXiv

<http://arxiv.org/>

The biggest and best source of open access quantum computing articles is arXiv, an online archive of over half a million scientific articles. Articles are uploaded by their authors and therefore not peer reviewed, but arXiv's author endorsement system offers some assurance that submitters are reliable researchers. And indeed, many arXiv submissions are excellent research articles that also appear (or will later appear) in top journals or conference proceedings. Quantum computing articles appear in arXiv's quantum physics archive, quant-ph: <http://arxiv.org/archive/quant-ph>. The quant-ph archive is searchable and browsable, and users can stay informed of recent additions by subscribing to the quant-ph RSS feed or email alert service.

Research Centers

Most quantum computing research is conducted at universities, corporate research labs, and government labs. There are many quantum computing research centers and groups around the world; this section lists (alphabetically) some of the largest and most prominent centers in English-speaking countries. Explore their sites for information about researchers, projects, publications, and achievements.

Centre for Quantum Computation, Universities of Oxford and Cambridge

<http://www.qubit.org/>

The Centre for Quantum Computation (CQC) is devoted to the theoretical and experimental study of quantum information processing. Founded by quantum cryptography pioneer Artur Ekert, the CQC began at the University of Oxford and later expanded to the University of Cambridge. The CQC team includes David Deutsch, a trailblazer of the theory of quantum computation and the creator of the videos described earlier.

Centre for Quantum Computer Technology, Australia

<http://www.qcaustralia.org/>

The Centre for Quantum Computer Technology is a collaborative effort of several major Australian universities. The Centre's participating institutions pursue both theoretical and experimental research, including the creation of silicon-based quantum computer chips.

Institute for Quantum Computing, University of Waterloo

<http://www.iqc.ca/>

The Institute for Quantum Computing (IQC) was created in 2002 and is now a major center of quantum computing research. Several IQC faculty are also members of the nearby Perimeter Institute for Theoretical Physics (<http://www.perimeterinstitute.ca/>), an independent, nonprofit research center that is dedicated to the study of foundational theoretical physics, including quantum information.

Institute for Quantum Information, California Institute of Technology

<http://www.iqi.caltech.edu/>

A collaboration between Caltech's Division of Engineering and Applied Science and its Division of Physics, Mathematics, and Astronomy, the Institute for Quantum Information (IQI) is a hub of quantum information research.

Physics of Information Group, IBM Research

<http://www.research.ibm.com/physicsofinfo/>

Since 1945, IBM has run a research arm that pursues both pure and applied research. IBM Research's Physics of Information Group studies quantum information and other information-related topics.

Quantum Information Science, Massachusetts Institute of Technology

<http://qis.mit.edu/>

At MIT, quantum information is studied by many researchers in many departments. This webpage links to the university's various quantum information researchers and resources.

Quantum Institute, Los Alamos National Laboratory

<http://www.lanl.gov/science/centers/quantum/>

Los Alamos National Laboratory (LANL) is a United States Department of Energy laboratory dedicated to advancing national security and researching scientific and medical topics of national interest. LANL's Quantum Institute is a major center of quantum computing and quantum cryptography research.

Companies

This section lists five companies whose primary business is quantum information or quantum cryptography. It does not include larger companies (such as IBM, mentioned in the previous section) that happen to pursue quantum information research or develop quantum technologies.

D-Wave Systems

<http://www.dwavesys.com/>

Founded in 1999, The Canadian company D-Wave Systems aims to produce and sell quantum processors. D-Wave does not yet sell any products, but the company has publicly demonstrated its prototypes. However, many quantum computing experts were unconvinced by the demonstrations and are skeptical of the company's claims.

MagiQ Technologies

<http://www.magiqtech.com/>

id Quantique

<http://www.idquantique.com/>

SmartQuantum

<http://www.smartquantum.com/>

QuintessenceLabs

<http://www.quintessencelabs.com/>

The development of commercial quantum cryptography systems is far ahead of the development of commercial quantum computers. The companies MagiQ Technologies (American, founded in 1999), id Quantique (Swiss, founded in 2001), SmartQuantum (French, founded in 2004), and QuintessenceLabs (Australian, founded in 2006) all produce quantum cryptography systems.

News and Blogs

Quantum computing news and announcements appear in many places, including arXiv, scholarly journals, newspapers, magazines, online news sources, and blogs. Only the most dedicated researchers could read them all. For less voracious consumers of quantum computing news, this section recommends four sites. The first two are clearinghouses for quantum information news and announcements; the second two are blogs by quantum computing experts. Many blogs regularly include posts on quantum computing, but the two included here stand out for their popularity, longevity, engaging styles, and lively comments sections.

For more tips on tracking quantum computing news, see “Keeping Abreast of Quantum News: Quantum Computing on the Web and in the Literature” (Cirasella 2008b).

Quantum Times

<http://www.aps.org/units/gqi/newsletters/index.cfm>

The *Quantum Times* is the newsletter of the American Physical Society’s Topical Group on Quantum Information. Each issue includes long news articles, short news items, and a variety of announcements.

QubitNews

<http://quantum.fis.ucm.es/>

QubitNews posts news and announcements about quantum computing, quantum information, and quantum mechanics. Most items are conference announcements and job openings.

Quantum Pontiff

<http://scienceblogs.com/pontiff/>

The Quantum Pontiff blog is written by Dave Bacon, a professor at the University of Washington. He posts frequently (but not exclusively) on quantum computing.

Shtetl-Optimized

<http://www.scottaaronson.com/blog/>

Written by MIT professor Scott Aaronson, Shtetl-Optimized is a theoretical computer science blog that includes many musings on quantum computing.

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