

# THE QUANTUM TIMES

AMERICAN PHYSICAL SOCIETY • TOPICAL GROUP ON QUANTUM INFORMATION

SUMMER/FALL 2008

VOLUME 3, NUMBER 2

## Quantum Theory at Burning Man

Once a year, over forty thousand survivalists, hippies, freaks, intellectuals, and artists make a pilgrimage to a dried up Nevada seabed to burn a gigantic effigy of a man. The temporary community of Black Rock City is constructed for only one week a year, its citizens offering virtually every amenity imaginable, mostly free of charge. The event's ideology focuses on radical inclusivity, self-expression, self-reliance, and participation. Thus, the plethora of free restaurants, tea houses, dance halls, spas, salons, saloons, educational workshops, healing centres, hardware depots, matchmakers (at the "soulmate depot"), costumers, circuses, pyrotechnic shows, kissing booths, newspapers, postal services and other more bizarre fare (from a larger-than-life game of tetris to a pneumatic spanking machine) are offered pro bono by the attendees themselves. This insane social experiment is called Burning Man (see the list of resources at the end of this article).



Ladies and gentlemen, Nathan Babcock of the University of Calgary. Photo courtesy MathCamp.

NASA and the scientific community at large regularly give interviews on the local radio station (BMIR - Burning Man Information Radio), and there is a whole theme camp dedicated to the desert's ecology ("The Playa Alive"). More adventurous spirits may visit Mad Science Camp, where the motto is "Better living through reckless experimentation!" For years the legendary Dr. Megavolt gave shocking electricity shows with his nine foot tesla coil, dressed, of course, in his homemade Faraday cage "suit."

So after attending last year, I was determined to discover what a humble quantum physicist could contribute to this mad mad mad community. Ultimately, I decided you're always wisest to "go with what you know," and I contacted the proprietors of MathCamp about running a lecture series on quantum theory. They accepted my offer with unbridled enthusiasm.

*Continued on next page*

### Inside...

As you can tell from the picture on the left, this isn't your mother's *Quantum Times*. Or, perhaps it is if your mother were the type to attend the Burning Man festival in Nevada.

While Burning Man has a reputation for all sorts of oddities, it also includes some very intelligent, deep thinking folks passionate about a variety of topics including math and physics. Nathan Babcock, a graduate student at the Institute for Quantum Information Science at the University of Calgary, attended Burning Man this year and gave a seminar on quantum information (wearing nothing but a sarong) to a rapt audience of math enthusiasts. While certainly unconventional, it provided a forum by which quantum information can reach an interested audience at a level of depth beyond popularization while still remaining informal (next year Nathan plans to wear a hand-knit loincloth).

With that said, *The Times* is always in need of material! This is your newsletter! I am merely a conduit. If you have an idea for an article, position announcement, meeting announcement, or even a piece of humor, write it up and send it along. This is your chance to have your work appear *in color!*

*-Ian T. Durham  
Saint Anselm College*

### **March Meeting Deadlines** **Abstract submission**

Friday, November 21, 2008

To propose a session, please contact GQI Chair-Elect David DiVincenzo at [divince@watson.ibm.com](mailto:divince@watson.ibm.com).

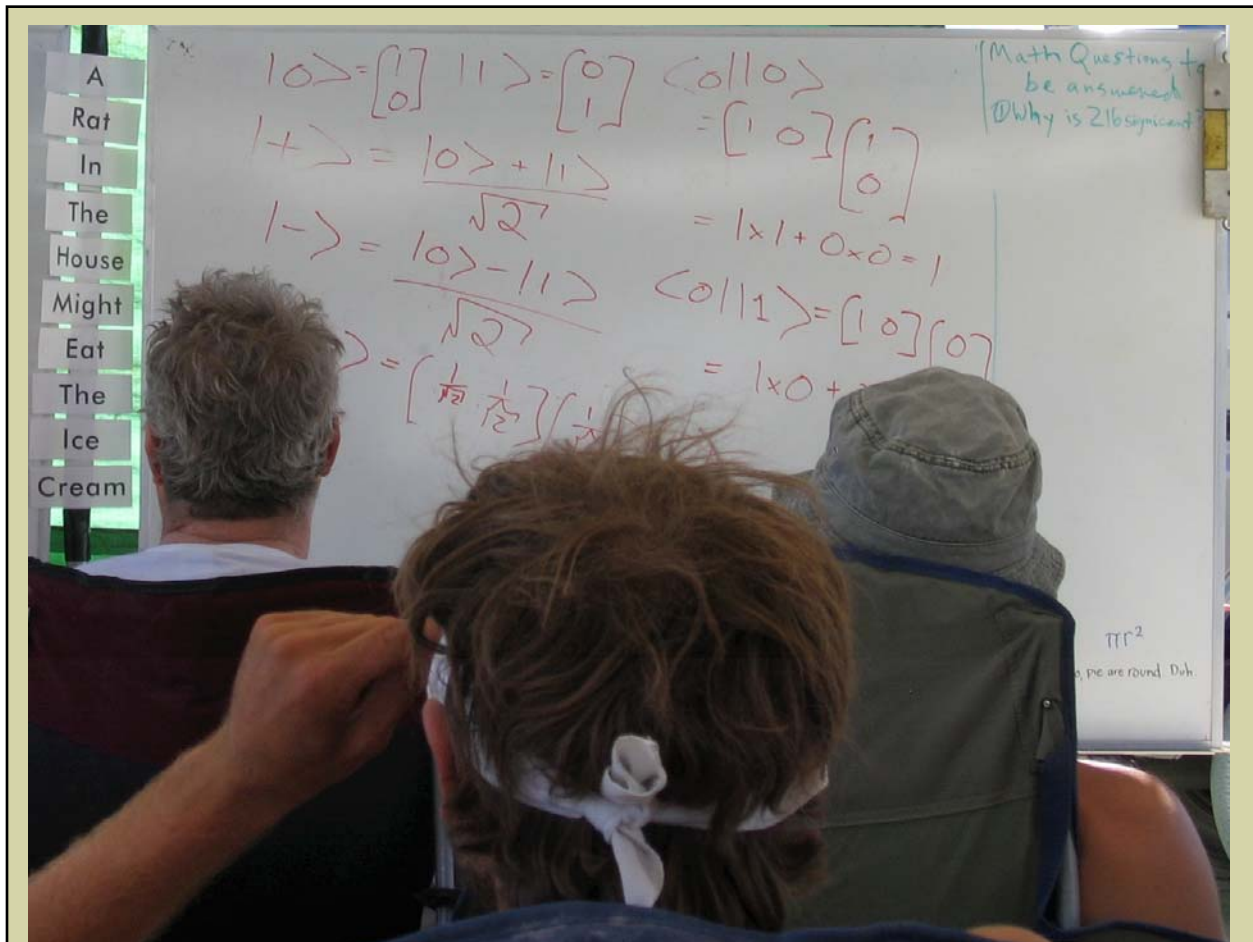
MathCamp is located on Black Rock City's concentric clock-shaped street plan at an address of "2.71 hours and the letter 'e'." They bill themselves as "a safe place for mathematics." Late Tuesday evening when I rode up on my bike, asking where I could find MathCamp, I was countered with the question, "Does that look like a giant slide rule to you?" The inhabitants greeted me graciously, showed their makeshift lecture hall, and offered me a cup of tequila. We shared math jokes and I told the one about integrating the inverse of 'cabin' (see left side of photo of author above).

So it came to pass that I found myself in the heat of the Nevada desert wearing nothing but a sarong, lecturing for two hours a day to an audience of about twenty people (many in costume) about quantization, measurement, uncertainty, entanglement, teleportation, and the interpretations of quantum mechanics.

Lectures were interrupted only at 3:14 PM for pie time. MathCamp's proprietors and visitors were extremely accommodating, offering unlimited access to whiteboards, math textbooks, the aforementioned giant slide rule, and an ongoing flow of tequila shots and unbearably spicy Bloody Marys.

Despite the unseemly surroundings, surprisingly little of my lecture time was spent discussing astral projection, telekenesis, or Jungian synchronicity. To the contrary, the audience was more interested in hard physics than philosophy. They did not shy away from any mathematical aspects, but rather encouraged me to go into grueling detail about bra-ket notation, matrix algebra, and inner product spaces. I hadn't even planned to discuss the Bloch sphere, but they compelled me to draw it once they learned such a geometric picture of the qubit existed. The discussion on  $SU(2)$   $SO(3)$  equivalence was limited more by my own comprehension of group theory than by any lack of interest from the audience! During the discussion on quantum teleportation, they insisted I draw the circuit

*Continued on next page*



This, of course, is one of the author's whiteboards filled with a variety of vectors and inner products familiar to quantum physicists everywhere. In the upper right is a list entitled "Math Questions to be answered" [sic] and, in case you can't read the only entry, it asks "Why is 216 significant?" (Ans. p. 4) *Photo courtesy of MathCamp.*

## Quantum Theory at MathCamp

### Quantum Theory comes to Burning Man, Black Rock City, NV

*A three part lecture series introducing various topics in quantum theory*

#### Part I: Quantization & Uncertainty

- waves & particles
- the ultraviolet catastrophe
- Planck's quick & dirty fix
- Einstein's courageous guess
- operator algebras for fun & profit
- bras, kets, & inner products
- quantum bits
- Fourier's transformation
- sampling theory & the uncertainty principle

#### Part II: Spooky Action at a Distance

- conceptual review (quantization & matrix algebra)
- the superposition principle
- measurement & wavefunction collapse
- Hadamard's basis
- entanglement & shared randomness
- no superluminal signaling!
- John Bell challenges Einstein's reality
- hidden variable theories
- gremlins & free will

#### Part III: Interpretation & Beyond

- conceptual review (quantization & entanglement)
- how to test Nature's spookiness (in a laboratory)
- incomprehensible physics jargon
- the measurement problem
- the eerie magic of wavefunction collapse
- the Orthodox interpretation ("Don't ask, don't tell.")
- the Many Worlds interpretation ("No collapse, multiply me.")
- the Statistical interpretation ("Ain't no wavefunction anyhow.")
- quantum consciousness?
- synchronicity & human nature

and explain the meaning of Hadamard and controlled-NOT gates. They demanded I describe physical realizations of Bell tests and I found myself outlining parametric down conversion and atomic collision schemes. They even interrogated me about neutrino oscillations and symmetry breaking. Their lust for physics was truly insatiable!

By the time it was done I was impressed and exhausted but I was invited to come back next year, which I will. I'm already thinking about my next "lesson plan." Keeping with the "lust for physics" theme, my first topic will have to be penetration of the classical forbidden barrier. When you're lecturing in a sarong with a Bloody Mary in hand, anything goes.

If this kind of environment appeals to anyone else in the Quantum Information community out there, you're welcome to join me. There were a couple other math talks, as well as one on relativity, but the lecture roster was hardly filled. There'll be lots of and white board space-time and Blood Marys for QI lecturers next year.

But, should you decide to venture out to the desert, do not be fooled. Despite their goofy appearance, the Burning Man community is not comprised of your usual breed of naked hippie. These are hippies forged in the searing sun and sand of the Nevada desert. Hard math and physical rigour don't frighten them. Indeed, these are Nietzschean überhippies, and they are poised to conquer the world (or at least the Nevada desert).

–N. S. Babcock

*Institute for Quantum Information Science  
University of Calgary*

## BURNING MAN RESOURCES

Your first stop should be at the official website of the festival:

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

For more information on those wacky MathCampers, purveyors of Fabulous Electric Cupcakes and free temporary tatoos:

[http://www.mathcamp.us/mediawiki/index.php/Main\\_Page](http://www.mathcamp.us/mediawiki/index.php/Main_Page)

What about the rest of the year?

[http://www.burningman.com/blackrockcity\\_yearround/](http://www.burningman.com/blackrockcity_yearround/)

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## QCMC Round-up

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On August 19-24 this year, the University of Calgary hosted the ninth international Conference on Quantum Communication, Measurement and Computing (QCMC). This bi-annual meeting has been the leading conference in our field for more than two decades and has a long standing tradition of bringing together top researchers and students from the mathematics, computer science, engineering, experimental and theoretical physics communities.

The conference featured a strong set of 46 invited speakers, including patriarchs of the field, such as Peter Knight and Anton Zeilinger. Additionally, we had 16 contributed talks and 248 posters. Altogether, the meeting was attended by 312 delegates, of which 112 were students. The proceedings of QCMC 2008 will be published by the American Institute of Physics.

An integral part of QCMC is the International Quantum Communication Award for outstanding achievements in quantum communication research. This award is sponsored by the Tamagawa University and is presented at each QCMC meeting since 1996. This year, the winners were Jeffrey Shapiro (MIT), Akira Furusawa (University of Tokyo), and Anton Zeilinger (University of Vienna).

In addition to the scientific program, we had many fun special events, such as an outing to Heritage Park Historical Village, a banquet (which featured a performance by the native Canadian Kehewin Dance Theatre), and a reception "Quantum Information in Canada". A definite highlight was the soccer tournament among four teams composed of conference delegates from different part of the world. The winner, Europe (not surprisingly), was awarded medals and a challenge trophy.

The tradition of the QCMC conference series has evolved over the past couple of years. The founder of the series, Osamu Hirota from Tamagawa University, will be retiring, and the QCMC Steering Committee felt a need to establish the QCMC Charter to formalize the rules of organizing and running the conference. The Steering Committee membership term is now limited.

The next QCMC conference will be held in 2010 in Brisbane, Australia and will be organized by Timothy Ralph from the University of Queensland and Ping Koy Lam from the Australian National University.

The main sponsors of the meeting were Tamagawa University (Japan), Research Laboratory of Electronics at MIT, National Institute of Information and Communications Technology (Japan), Canadian Institute for Advanced Research, QuantumWorks Innovation Platform (Canada), Pacific Institute for the Mathematical Sciences (Canada), Informatics Circle of Research Excellence (Alberta, Canada), and several

departments at the University of Calgary. We very much appreciate their support.

Additional information about the meeting can be viewed at <http://www.qcmc2008.org>.

–Alexander Lvovsky  
*Institute for Quantum Information Science  
& Department of Physics and Astronomy  
University of Calgary  
QCMC 2008 Principal Organizer*

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### Quantum Error Correction '07 POST-CONFERENCE RESOURCES

Last December, the Center for Quantum Information Science and Technology (CQIST) at the University of Southern California hosted the First International Conference on Quantum Error Correction. If you were unable to make it, you're in luck! Thanks to the conference organizers, Daniel Lidar (Chair), Todd Brun, and Paolo Zanardi, the entire program - including tutorials, invited talks, and contributed talks - is available online in *two* formats: video (a small number of talks lack audio) and PowerPoint.

#### Tutorial speakers:

Dave Bacon (U. Washington), Daniel Gottesman (Perimeter), Raymond Laflamme (IQC/Waterloo), and Lorenza Viola (Dartmouth).

#### Keynote speakers:

David Cory (MIT), John Preskill (Caltech), Peter Shor (MIT), and David Wineland (NIST).

There were an additional 16 invited speakers and 25 contributing speakers.

All electronic files of presentations are available at:

<http://qserver.usc.edu/qec07/program.html>

216 is the "Product of the Beast."



|0⟩ **We're still here - or so we think** Physicists and other crackpots worldwide eagerly anticipated the first test of the Large Hadron Collider at CERN in Switzerland. So far, concerns that the LHC would create a black hole that would devour the earth have proven unfounded. Note, however, that Patrick Hayden (McGill) has correctly pointed out that it is not *impossible* that we are already inside a black hole to begin with. There's a pleasant thought with which to curl up on a fine September evening...

⟨1|0⟩ **Oded Schramm (1961-2008)** One of the world's premier probabilists, Oded Schramm, died tragically in a climbing accident on September 1. Schramm was a member of the Theory Group at Microsoft Research at the time of his death. He is best known for what is now referred to as Schramm-Loewner evolution, that laid the foundation for subsequent proofs of various scaling limit relations, mostly in statistical mechanics, including self-avoiding random walks. Schramm was a graduate of Hebrew University and Princeton University. After receiving his PhD from Princeton in 1990, he spent two years performing post-doctoral research at the University of California, San Diego before moving to the Weizmann Institute. In 1999 he moved to Microsoft. He was awarded a number of prizes, mostly related to the development of Schramm-Loewner evolution, including a Clay Research Award of the Clay Mathematics Institute in 2002 and the Henri Poincaré Prize of the International Congress on Mathematical Physics in 2003. He is survived by his wife and two children.

⟨1|0⟩ **Breakthrough in transmitting shaped light waves through opaque materials** Using random matrix theory, theorists have, since the 1980s, known that the eigenvalues for the transmission matrix of some randomly scattering material are either very nearly zero or very nearly one. As such any wave entering such a material can be represented as a sum a modes, some of which are entirely transmitted and some of which are entirely reflected. Any "pathway" through such a material is called a "channel" and, logically, thicker and denser materials have fewer open channels through which the wave may pass. In theory it stands to reason that one should be able to create a wave that couples solely to the open channels. Recently Allard Mosk and Ivo Vellekoop at the University of Twente in the Netherlands have developed a method for "shaping" light that

increases the intensity of the transmitted light. In the process it appears they have proven the existence of open channels in opaque material. The results could potentially prove useful for practical realizations and experimental tests of various quantum information processes. Their most recent results are in press at *Physical Review Letters*. A general article that includes references may be found in the September issue of *Physics Today*.

⟨1|0⟩ **Spatial entanglement from four-wave mixing** Entanglement is often associated with discrete-valued measures such as spin and polarization. In 1992 researchers at Caltech first demonstrated entanglement between *continuous* variables via the fluctuations in optical electric fields (that is fields associated with visible portions of the electromagnetic spectrum). Recently, Vincent Boyer, Alberto Marino, Raphael Pooser, and Paul Lett of the Joint Quantum Institute (JQI), a partnership between the University of Maryland, College Park, NIST in Gaithersburg, and the National Security Agency (NSA), have created pairs of entangled beams whose *cross sections* can be represented as entangled pixels. Essentially the pair of light beams have highly correlated quadratures where a quadrature is some multiplicative constant multiplied by the sine or cosine wave. Rather than utilizing parametric down-conversion, the JQI team produced their entangled beams utilizing four-wave mixing. What they discovered, somewhat by accident, was that the output beams retained some spatial information from the mixing process. As such it was not too far a stretch to conclude that the fluctuations in these beams also maintained this information and were thus entangled. Practical applications in quantum information will require detecting and manipulating different modes simultaneously and, so far, the JQI teams has only looked at one mode at a time. But the advantage such a system would provide is that, in effect, it would produce one-hundred independent sets of entangled quantum fluctuations as easily as the standard parametric down-conversion process could produce just one. A more detailed article that includes references may be found in the August issue of *Physics Today*. ⟨1|

-Ian T. Durham  
Saint Anselm College

## Position Announcements

### Tenure-track positions (2) Saint Anselm College

The Mathematics Department of Saint Anselm College invites applications for two tenure-track appointments, to begin fall 2008. We are looking for excellence in teaching and scholarship. Saint Anselm College is an undergraduate, liberal arts college. The teaching load is 3/3, and the class sizes are small. There is little teaching below the rigorous calculus level (at most, one course a semester). Area of research specialization is open and a small quantum information group is being formed on campus. The college is located in southern New Hampshire; the seacoast, the White Mountains, and the cultural and academic resources of Boston and Cambridge are all within an hour's drive. Applications, including letters of recommendation, should be addressed to: Gregory Buck, Chair, Department of Mathematics, Box 1641, Saint Anselm College, Manchester, NH 03102-1310. Electronic submissions can be sent to [gbuck@anselm.edu](mailto:gbuck@anselm.edu). Saint Anselm College is a Catholic college in the Benedictine tradition. The college is committed by its mission to actively build a diverse academic community that fosters an inclusive environment. It therefore encourages a broad spectrum of candidates to apply. The successful candidate will be supportive of the college's mission.

### Tenure-track position University of Calgary

The Department of Physics & Astronomy - <http://www.ucalgary.ca/phas/> - at the University of Calgary invites applications for a tenure-track faculty position in Experimental Quantum Nanoscience at the Assistant or Associate Professor level to start July 1, 2009. A description of the position can be found by entering Job ID 6943 at [http://www.ucalgary.ca/hr/careers/careers\\_search](http://www.ucalgary.ca/hr/careers/careers_search).

This position will be associated with the University of Calgary's Institute for Quantum Information Science - <http://www.iqis.org> - and will be cross appointed at the National Research Council National Institute for Nanotechnology - <http://www.nint.ca> - in Edmonton. All applicants must have completed a PhD in Physics or equivalent, have postdoctoral experience in experimental nanoscale physics, demonstrated excellence in teaching, and a strong record of research achievements in the nexus between nanoscience and quantum information. The successful candidate will be required to teach at the undergraduate and graduate levels and to conduct a vigorous research program.

Established in 2001, the National Institute for Nanotechnology is an integrated, multidisciplinary institution involving researchers in physics, chemistry, engineering, biology, informatics, pharmacy, and medicine. The Institute's focus is on revolutionary nanoscale research including: synthesis and characterization of nanocrystals, nanowires, and supramolecular-based nanomaterials; fabrication and characterization of molecular-scale devices and nanosensors; and development of nano electro-mechanical systems.

The multidisciplinary Institute for Quantum Information Science, with seven faculty members in the three Departments of Computer Science, Physics & Astronomy, and Mathematics & Statistics, is active in optical and atomic quantum information processing, quantum information theory, and quantum algorithms and complexity. Calgary, with a population of one million and located in the foothills of the Rocky Mountains, is Canada's fourth largest metropolis and features a vibrant culture and outstanding outdoor recreation.

Applications will be reviewed commencing November 1, 2008 and will be considered until the position is filled. Applicants should provide a cover letter, curriculum vitae, a research statement including impact of past results and plans for the future, three selected publications, a teaching statement, and arrange for at least three letters of reference to be sent to:

Professor Russ Taylor  
Head, Department of Physics & Astronomy  
University of Calgary  
2500 University Drive NW  
Calgary, Alberta T2N 1N4  
Email: [admin@phas.ucalgary.ca](mailto:admin@phas.ucalgary.ca)

All qualified candidates are encouraged to apply; however, Canadians and permanent residents will be given priority. The University of Calgary respects, appreciates, and encourages diversity.

PLEASE DO NOT APPLY ONLINE, AS WE ARE NOT ACCEPTING ONLINE APPLICATIONS FOR TEACHING OR RESEARCH POSITIONS AT THIS TIME.

**PhD position  
Booz Allen Hamilton**

**Position Description:**

Serve as a strategic consultant to government science and technology research and development clients. Contribute to DoD investment in advancing the state of the art in a wide range of physical sciences-based technologies by combining strategic planning and technical analysis. Assist clients with developing and researching ideas for the formulation of new programs. Provide in-depth expertise in the assessment of proposals to determine the technical merit of proposal objectives and methodologies. Conduct background research and interface with the research community at large to evaluate the feasibility of new technological concepts and shape research program goals. Assist with the management of high-risk research programs. Generate and present comprehensive technical briefings, technical papers, and strategic recommendations to colleagues and clients. Perform and publish original technical analysis in support of client needs.

Please submit cover letter and CV electronically to [parra\\_enrique@bah.com](mailto:parra_enrique@bah.com).

**Basic Qualifications:**

PhD degree in Physics

4+ years of experience with active research

Experience with government-sponsored research and development activities

Ability to commute to Arlington, VA

Ability to obtain a security clearance

**Additional qualifications:**

Experience with research in the areas of condensed matter physics, mathematical physics, computational physics, optics, lasers or quantum information sciences preferred

Ability to convey complex technical insights to specialist and generalist audiences in oral and graphical formats

Ability to apply expertise across a wide variety of technical problems

Possession of excellent oral communication skills

**Clearance:**

Applicants selected will be subject to a security investigation and may need to meet eligibility requirements for access to classified information.

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## Meetings & workshops

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**From Qubits to Black Holes**

INTERNATIONAL PHYSICS SCHOOL HONORING ASHER PERES

**November 17-22, 2008, Sydney, Australia**

For more information see: <http://web.mac.com/quests/PeresSchool/Welcome.html>

**Quantum Simulation/Computation with Cold Atoms and Molecules**

ASPEN CENTER FOR PHYSICS SUMMER WORKSHOP 2009

**May 24 - June 14, 2009, Aspen, Colorado**

For more information see: <http://www.aspenphys.org/documents/program/summer09.html>

## Topical Group on Quantum Information

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## Contributors wanted!!

*The Quantum Times* is seeking contributions from readers for all areas of the newsletter. In particular we are interested in articles, meeting summaries, and op-ed pieces. If you would like to contribute something to *The Times* please contact the editor or a member of the editorial board.

## Newsletter Information

*The Quantum Times* is published four times per year, usually in February, May, August, and November, though times can vary slightly.

Electronic submissions are strongly encouraged and may be sent to the editor at [edurham@anselm.edu](mailto:edurham@anselm.edu). Acceptable forms for electronic files (other than images) include TeX, Word (*not* Word '08), RTF, PDF, and plain text.

Hard copies of submissions must first be approved by the editor. If they are approved they may be sent to the editor at:

Department of Physics  
100 Saint Anselm Drive, Box 1759  
Manchester, NH 03102 USA

## *the lighter side*

**Quotes from Asher Peres, the Yogi Berra of quantum physics (he even looked a little like Yogi, don't you think?).**

“Quantum phenomena do not occur in a Hilbert space; they occur in a laboratory”

“Unperformed experiments have no results.”

“Quantum mechanics needs no interpretation.”

“Never underestimate the ingenuity of experimental physicists.”