THE QUANTUM TIMES

AMERICAN PHYSICAL SOCIETY ◆ TOPICAL GROUP ON QUANTUM INFORMATION

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John Archibald Wheeler, 1911-2008

"How come the photon?" This question troubled John Archibald Wheeler during his whole life as a physicist. He frequently mentioned that he would give his right arm to know the answer to just this riddle. According to him, all secrets of quantum mechanics that are still waiting for us to be uncovered are contained in the photon. By now he knows the answer to his favorite problem. On April 14, 2008 this last giant of the second generation of the creators of quantum mechanics passed away at the age of 96.

On the occasion of his death many aspects of his life have been illuminated: his work on nuclear fission with Niels Bohr, the collaboration with his most famous student Richard Feynman, his role in the Manhattan and the Matterhorn projects, and his numerous contributions to general relativity including his coining of the term "black hole". However, most obituaries did not cover the quest that was always closest to his heart: obtaining a deeper understanding of quantum mechanics. For this reason the present note about this great scientist and wonderful human being is devoted to this topic.

Wheeler at Black Hole Cove on the Bay of Fundy in Nova Scotia, September 17, 1981. *Photograph by Roy Bishop. Reprinted with permission.*

In 1976, Wheeler retired from Princeton University and took up an endowed chair at the University of Texas (UT) at Austin directing the Center of Theoretical Physics. In the spirit of the Copenhagen Institute under his idol Bohr, he had collected for his center a very unique group of young scientists working on quantum mechanics. His seminars with Wojciech Zurek gave rise to their book *Quantum Theory and Measurement*. Around the same time Zurek collaborated with Bill Wootters, who was also part of Wheeler's group, on the development of the no-cloning theorem while simultaneously David Deutsch wrote his seminal papers on the quantum computer. These are only a few of the many highlights of that time.

The photon as a "smoky dragon" in the delayed-choice experiment is a typical example of Wheeler's way of pushing a theory to its limits.

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Inside...

Death is something that is rarely a topic of polite conversation, particularly among physicists, considering the spiritual overtones usually associated with it. Yet it is something we simply cannot avoid.

In addition to the passing of John Wheeler, the quantum physics community also recently witnessed the passing of Willis Lamb and Jürgen Ehlers. One of Wheeler's former post-docs, Wolfgang Schleich, has penned a wonderful obituary that highlights some of Wheeler's contributions to quantum theory and Bill Wootters has added an anecdote of his own from his time with Wheeler.

For Lamb and Ehlers, we have included two shorter obituaries, also highlighting their contributions to quantum theory.

While compiling this issue I was also shocked by the sudden death of journalist Tim Russert. Though Russert had no connection to physics, he did have a connection to me as we were both graduates of Canisius High School in Buffalo, New York, and his death is an enormous blow for that often unfairly maligned city.

While reading Wolfgang's obituary of Wheeler, I discovered I also shared a geographic connection to Wheeler. Apparently he owned an island off the coast of Maine, not all that far from my current home in Kennebunk (Lamb's brother also makes his home in Maine).

In any case it is my sincere hope that our next issue will be obituary-free. I wish you a safe and sorrow-free summer.

–Ian T. Durham
Saint Anselm College

"Interference" or "which way" information in a Mach-Zehnder interferometer, depending on the presence or absence of the second beam splitter, has continued to bother generations of physicists. However, to make the decision to put it into the light path, or remove it long after the photon had already entered the interferometer, added one more layer of strangeness. The experiments by the groups of Carroll Alley (Maryland), Werner Martienssen (Frankfurt), and Herbert Walther (Munich) and most recently by Alan Aspect (Orsay) confirmed, as Wheeler put it so vividly, that "the past has no existence except as it is recorded in the present" – "[r]eality is an illusion."

The example of the smoky dragon also shines some light on the wonderful human side of Wheeler and his sense of humor. After the completion of his delayed choice experiment Alley received a huge box from Wheeler addressed to the "Dragon Department" containing a Chinese paper dragon.

To establish a connection between quantum theory and information was Wheeler's ultimate goal. "It from bit" is a famous Wheelerism summarizing the intimate relationship between the photon "it" and the unit of information "bit". In this way he became one of the pioneers of today's field of quantum information.

Wheeler was famous for his love of fire crackers and explosions. As a young man he had blown off the top of one of his fingers trying to get an explosive to go off. Whenever someone in his group got an exciting result, he took a fire cracker from his collections in his office and lit it off in the corridor of the ninth floor of the Robert L. Moore building of UT Austin. Needless to say, these explosions caused a lot of excitement in the department, but eventually his colleagues got used to them and simply commented: "Oh it's just Wheeler again."

Not many physicists own an island. Wheeler was one of them. In the mid fifties of the last century he bought a peninsula close to Damariscotta (Maine). Here he spent the summer months writing his papers and his books. He had frequent visitors who came to discuss physics with him or work on a joint paper. One of the highlights of these trips to High Island was firing off his cannon from the Spanish-Mexican war. He frequently used to shoot beer cans into the ocean. For this purpose one had to first remove the beer and then fill the cans with sand. We were always willing to help him with this task.

In the fall of 1986 Wheeler moved back to New Jersey into a retirement home close to Princeton. He still kept an office at the university and came in periodically. He dedicated this part of his life exclusively to the mysteries of quantum mechanics and to his wife Janette. She passed away last fall. They had been married for over 70 years.

Wheeler always smiled at people and was upbeat. "Two thumbs up" was his motto. I was very fortunate to have been able to know him. In our more than 25 years of lasting friendship, first as his postdoc, and then as his colleague I have never heard him say anything negative about anybody. He serves as a role model, not only as a scientist but also as a human being. We shall all miss him terribly.

–Wolfgang P. Schleich
Universität Ulm

"In a lunchtime conversation in Austin around 1980, John Wheeler wondered whether psychology or neuroscience would ever be able to identify the part of a person that serves as the "conductor," the part that sets the tempo for one's life and maintains the forward momentum of ideas and actions. I had the sense that he regarded this part as crucially important. And there is no doubt that the conductor was very strong in John. For him, every day was a precious opportunity to make progress, especially on the great questions of the physical world, questions like "how come the quantum?" But even when he wasn't obviously working on physics, he enjoyed making progress on more down-to-earth projects. I recall, for example, a summer day at the Wheelers' property in Maine. Saying "the best vacation is a change of vocation," he found it refreshing to finish clearing a path through the woods with the help and companionship of children, grandchildren and guests."

–William K. Wootters
Williams College

2009 Dannie Heineman Prize for Mathematical Physics

The APS Dannie Heineman Prize recognizes outstanding publications in the field of mathematical physics. We would like to encourage nominations from every subfield of physics with connections to mathematical physics. The deadline for submission of nominations for the 2008 prize is July 1, 2008. More information on the award and the nominations process can be found at the website http://www.aps.org/programs/honors/prizes/heineman.cfm or by contacting the chair of the selection committee, Beverly K. Berger, at bberger@nsf.gov.

Op-Ed

The science funding cuts in the US, and the general apathy toward research funding in general, is a direct consequence of the fact that we don't do enough as scientists to promote the public's understanding of science. Even worse, we don't provide enough support to the people who *are* doing things to bring science to the masses.

At the DAMOP meeting recently, when I mentioned that I had just missed Bill Phillips to other people, several said "Oh, yeah, he was going off to some science festival thing..." in a tone that suggested that this was an early indicator that the Brain Eater was getting to him, as it does many Nobel laureates.

Similarly, a few years ago, when Carl Wieman moved to Canada and donated part of his own Nobel winnings to fund physics education research, people practically made "screw loose" signs when talking about his move. Everybody thought he was crazy to care about teaching undergraduates enough to leave his research lab.

These reactions are typical, but exactly wrong. We ought to be celebrating the people who reach out to a broader audience, because they are the backbone of what we do. Science is a tremendously expensive endeavor these days, and paying for it requires the continued good will of the populace and government. Selling science to a general audience isn't some side activity to be pursued by senior scientists who have gone a little loopy. It's an absolutely essential part of what we do.

But that's not how modern academic science is structured. Science outreach won't advance your career, and may, in fact, sink it. Scientists are rewarded for producing technical publications aimed at the narrowest possible audience of other scientists, and it's no surprise that the result of this reward system is a culture that looks down on people who attempt to do anything other than produce narrow technical publications. The result of that is a general culture in which science funding is a luxury item to be supplied or rescinded on a whim because there is not a large and vocal constituency of people who are excited by science and want to see it funded. We don't have adequate science funding, because we don't have enough good popular science books and we don't have enough good popular science books, because we don't reward and encourage scientists who are interested in writing them.

What I'm calling for here is a general change in the culture of academic science. Of course grand changes won't happen overnight, but they *do* start with small actions.

- Buy popular science books, and *celebrate* them. Don't just write negative reviews complaining that the book was "dumbed down" and didn't get some technical detail right. Find what is good in the books, and promote that. If there are deficiencies, steer people to better sources.
- Support events like the World Science Festival and science cafes. Take part in local outreach activities – if someone from your college or university asks you to take part in some event for the broader community, do something to help them (if you don't have a talent for public lecturing, send a student or post-doc). Don't just complain that they're taking you away from your research – this is ultimately what makes your research possible.
- Support science education, across the board, not just on hot-button political topics. It's not enough to scratch and claw to get correct coverage of evolution, or global warming, or the Big Bang – we need to do a better job teaching people about *everything* in the sciences. It does no good to teach biology correctly if we don't also teach math and chemistry and physics correctly.
- Make a stink when science is "put in the corner," as Jennifer Ouellette recently reported was the case at Book Expo America. Ask your local library and bookstore to carry more science books. If the *New York Times Review of Books* shafts science again this year, express your displeasure.

And above all else, support the people who promote science to the general public. You don't have to do it yourself. Writing for and lecturing to a general audience is hard, and not everybody will have the skill or patience. But recognize it as a valuable endeavor and encourage people who are good at it. If you're an academic and have a student or colleague with an interest in outreach, support them. Don't crush them, or tell them to stop blogging and get back in the lab, but encourage them, and push them to do a good job with it. If you're in a position to evaluate junior academics, don't just ignore their general-audience writing and outreach or count it against their research productivity. It's a good thing, not a bad one. If you want to get really radical, start asking people who *don't* perform outreach why they aren't contributing – and not in the NSF-grant "Broader Impact" checkbox sense, where the comment "[i]f funded, we'll train some graduate students" discharges the obligation.

The good news is, as events like the World Science Festival show, there are people out there who are receptive to science, and willing to turn out in large numbers for well-done science events. All we need to do is reach out to them, not look down on them.

–Chad Orzel
Union College

Bits, Bytes, and Qubits

QUANTUM NEWS AND NOTES

$|0\rangle$ **Cost reductions for quantum key distribution (QKD)** Researchers at the National Institute of Standards and Technology have found a way to reduce the cost of producing QKD devices. Normally, QKD devices implementing photon polarization techniques such as the BB84 protocol, for example, make use of four single-photon detectors that can cost from $5000 to $20,000 apiece. The new method that is called detector-time-bin-shift (DTBS), places - or shifts - the photons into two "time bins" which means a set of two detectors can sequentially record two sets of photons instead of having the four simultaneously record all the photons. In this manner the number of photon detectors can be halved. In fact, further implementation of their method can reduce the number even more. Initially the group was implementing the B92 protocol, thus reducing the number of detectors from two to one, but since publishing their paper they have succeeded in cutting the required number of detectors in the BB84 protocol from four to one. There is a drawback, however. The new method does reduce transmission rates by half, though NIST does claim it still works at broadband speeds.

$\langle 1|0\rangle$ **IBM gets serious about spintronics** Computing giant IBM is betting that quantum mechanics will provide the next major storage technology. Presently data storage comes in two forms: the traditional magnetic drive form and the solid state or "flash" drive form. While adherents could argue quantum mechanics plays a role in both of these types of technologies, at least on some level, there is no arguing its fundamental role in IBM's newest storage method, based on spintronics. In this method the reading and writing of data is accomplished through manipulation of electron spin. While some remain skeptical that this technology is nearing commercial readiness, others point to the fact that the field of spintronics, particularly spintronic material engineering, has been around for two decades. In addition, the IBM group, headed by IBM Fellow Stuart Parkin, is proposing the utilization of exotic carbon compound nanowires, a presently well-tested and commercially available technology. The method Parkin has proposed transfers information via spin angular momentum through closely spaced domain walls within the carbon nanowire. Obstacles raised by the domain walls can be overcome by using spin polarized current along with the domain walls to produce a spin transfer torque that "moves" the domain wall. The major advantages of this type of drive include an increase speed and the fact that the new method would involve no moving parts, limiting degradation.

$\langle 1|0\rangle$ **Willis Eugene Lamb, Jr., 1913-2008** The world of physics lost another giant on May 15, 2008, when Nobel laureate Willis Lamb passed away at the age of 94. Lamb was a student of J. Robert Oppenheimer, receiving his PhD from the University of California at Berkeley for a dissertation on the electromagnetic properties of nuclear systems under Oppenheimer's direction in 1938. From there he moved to Columbia University where he worked in the radiation laboratory until 1951. It was in April of 1947 that he discovered the Lamb shift, a minute but significant shift of energy in the spectrum of hydrogen. The Lamb shift provided what is still one of the most accurate measurements of the fine-structure constant, α - to better than one part in a million - posthumously proving Arthur Eddington was wrong in his conviction that α was exactly 1/137 and setting the stage for modern quantum electrodynamics. For his work, Lamb was awarded the Nobel Prize in Physics in 1955. Lamb was also a National Medal of Science recipient. In addition to Columbia, he taught at Oxford, Yale, Stanford, and finally Arizona where he had been since 1974. He is survived by his wife Elsie Wattson Lamb (the two married on January 26th of this year, though they met 27 years ago) and his brother Perry Lamb of Maine.

$\langle 1|0\rangle$ **Jürgen Ehlers, 1929-2008** While Jürgen Ehlers' name does not readily come to mind when one thinks about quantum physics, Ehlers, who passed away on May 20th, was a student of Pascual Jordan at Hamburg University and spent several years at the University of Texas at Austin, preceding John Wheeler by a few years. While his work focused primarily on applications of general relativity in cosmology, gravitational lenses, and gravitational waves, up until his death he was a collaborator on a project concerned with the history and foundations of quantum theory at the Max Planck Institute for the History of Science in Berlin.

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–Ian T. Durham
Saint Anselm College

March Meeting Highlights

Quantum Entanglement

The second session on quantum entanglement - `Quantum Entanglement II' at the 2008 APS March meeting was an especially worthwhile experience for me as it was my first time chairing a session, filling in for James Franson who could not attend. I just happened to walk through a door at the right time. I soon realized it was tricky business though. I knew giving a 10 minute talk was challenging. Charing a session of 10 minute talks was none the easier, as I soon learned.

The session began with a talk by H. Weinfurter (Munich/MPIQO) that brought together experimental quantum optics, anyons and entanglement very nicely. Quite picturesque, the slides presented the demonstration of anyonic statistics using photonic entanglement. This was followed by a series of talks on entanglement entropy and its role in condensed matter systems. Very much in the spirit of the March meeting, these talks dealt with entanglement in spin systems.

The talk by S. Papanikolaou (Illinois-UC) dealt with the stability of topological phases by way of calculating the entanglement entropy. In particular, systems with finite correlation lengths add corrections to the usual definition that affect the stability of the topological phases in the system. The next talk by H. Tran (Florida State) studied the validity of Monte Carlo methods in studies of chains of non-ableian anyons.

N. Bray-Ali (USC) carried on the proceedings with his study of the difference between metals and insulators. He used the ground state metric to study metal-insulator transitions and discussed how its behavior has signatures of a Mott insulator and other transitions. Next, C. Castelnovo (Oxford) showed just how fragile topological order was in the face of thermal fluctuations. In two dimensions, all is lost at a finite temperature in the thermodynamic limit. All is not lost, however, in *three* dimensions as Castelnovo showed. I personally found this quite fascinating.

The next talk by E. Sorensen (McMaster) dealt with another interesting question: what is the role of impurities in the entanglement of a quantum spin chain? He showed how a quantum spin chain with impurities can be reduced to the universality class of Kondo problems, and thereby extract useful information about its entanglement entropy. The subsequent talk by R. Yu (Tennessee) dealt with numerical simulations on the random transverse field Ising model. He provided corroboration of the usual area law, but interestingly, they also found a logarithmic correction, that was explained through some percolation theory arguments.

The subject of the next two talks was also entanglement entropy, in random systems and the disordered golden chain respectively. The former, by R.-L Javier (Carlos-III) used the entanglement entropy to study the structure of quantum critical points. The latter, by L. Fidkowski (Caltech) was about the effect of perturbations in the disordered golden chain. A golden chain really is a chain of Fibonacci anyons that has a quantum dimension equal to the golden ratio. Entanglement entropy can tell us about the effect of ferromagnetic and anti-ferromagnetic perturbations in such chains as well. A powerful tool indeed!

Over the last few years, the study of entanglement entropy has served as a large part of entanglement research. This is one of the areas where quantum information has merged with an older, more traditional discipline, in this case condensed matter physics.

After the series of talks on entanglement entropy, we moved on to a talk by C. Trail (New Mexico) on entanglement in quantum limits of classical chaotic systems. He showed how well the entanglement distribution reflected the classical integrability of the system.

The last two talks dealt with very different topics. I. Neder (Weizmann Institute) described an experiment that showed the entanglement of two non-interacting electrons in a semiconductor heterostructure. The behavior was the first of its kind in a solid state setup. The last talk of the session was on the entanglement of multi electron quantum dots. C. Yannouleas (Georgia Tech) presented his results on the exact diagonalization of 4-6 electron systems under various forms of anisotropies, inter-electron repulsions and external magnetic field. And, in a result I personally found surprising, he demonstrated how some of these wavefunctions were very similar to Werner states!

In sum, this was an excellent session. The variety of results was a showcase on entanglement research at present. I intend to be there next year, if not as a session chair again, then certainly as a member of the audience!

–Animesh Datta
University of New Mexico

Quantum Information Meets Gravitation

Information theory addresses questions about communication and computation and in general, about how information is stored and processed. For example, canonical questions of interest to the field are what problems are computable and how these problems can be classified in complexity classes based on how hard it is to solve them. Since information is processed in physical systems, the ultimate answers to these questions depend upon the physical theory considered.

It has been shown that processing information using quantum systems is fundamentally different from its classical counterpart. Exploiting quantum properties such as entanglement allows for more efficient ways of processing information.

Most investigations in quantum information assume that the world is non-relativistic and thus, that there is no gravity. However, considering quantum information in space-time is ultimately necessary since the world is fundamentally both quantum and relativistic. In fact, many of the physical systems used to implement quantum information, such as photons, are indeed relativistic. By incorporating relativity in quantum information we will be able to understand how to exploit relativistic resources to further improve quantum information tasks.

The invited talks presented at the Quantum Information Meets Gravitation session showed that cross-fertilization between these fields gives rise to mutual benefits. The speakers explained how several aspects of quantum information, such as entanglement and complexity classes, are modified when studied in the light of gravity. Important challenges to overcome in the study relativistic quantum information were discussed and possible applications where outlined. We also learned how quantum information, in particular error correction and noiseless subsystems, can be used to address open questions in gravity such as the information loss problem in black holes and the emergence of locality in quantum gravity.

The session began with a talk by Dave Bacon (Washington) entitled Quantum computational complexity in the presence of closed time-like curves. Bacon's main message was that complexity classes might change by considering quantum processing in space-time. Specifically, he showed that by allowing the evolution of quantum systems to follow closed time-like curves it is possible to solve harder problems. This gives rise to a more powerful computational model in which NP problems can be solved with a polynomial number of gates.

The information loss problem in black holes is one of the most interesting unsolved theoretical questions in all of physics. The information contained in a pure state of a quantum field in the presence of a black hole seams to disappear as the black hole evaporates and radiates the information in the form of thermal radiation (Hawking radiation). In the talk Black holes as mirrors: quantum information in random subsystems, John Preskill (Caltech) applied quantum information techniques, such as error correction and quantum communication through erasure channels, to show how efficiently information can be retrieved from an evaporating black hole within which internal evolution is assumed to be an instantaneous random unitary. His results show that, in fact, under these assumptions, black holes radiate information very quickly.

Ivette Fuentes-Schuller (Potsdam), in her talk Entanglement in non-inertial frames and curved space-time, pointed out that conceptually important qualitative differences between relativistic and non-relativistic treatments of quantum information arise and underline the fact that a thorough understanding of (and likely future progress in) quantum information requires us to take relativity into account. For instance, she showed that entanglement is an observer dependent property that can be degraded or created by the presence of gravity. As an application of her results to gravity and cosmology she showed how entanglement can be used to learn about the dynamics of space-time. She remarked that an important challenge to overcome in incorporating relativity into quantum information is that the concept of a subsystem, widely used in quantum information, breaks down in the quantum-relativistic framework.

One of the most ambitious tasks to be accomplished in relativistic quantum information is to describe entanglement in general curved space-times. Paul Alsing (New Mexico), in his talk Spin-induced

2008 Student Paper Awards

Each year GQI sponsors two student awards, one in theory and the other in experiment. These awards are generously supported by the Perimeter Institute for Theoretical Physics and the Institute for Quantum Computing at the University of Waterloo respectively. The winners receive a 500 USD cash award and are invited by the sponsoring organizations to present longer versions of their talks. The judging panel consisted of Prof. John Sipe, chair (Toronto), Dr. Howard Barnum (LANL), Prof. Dagmar Bruss (Duesseldorf), Prof. Barry Sanders (Calgary), Prof. Lorenza Viola (Dartmouth), and Prof. Harald Weinfurter (Ludwig Maximilians, Munich). The candidates were judged on four equally weighted categories: content, clarity, style, and Q&A. This year's winners, from another excellent field of nominees, were **Bilal Shaw** of the University of Southern California in the theory category for a talk entitled "Encoding One Logical Qubit Into Six Physical Qubits," and **David B. Hume** of the University of Colorado, Boulder, in the experiment category for a talk entitled "Phonon-mediated detection of trapped atomic ions." GQI heartily congratulates the winners and thanks all the students, their advisors, and the judges. We also thank Chris Fuchs (Perimeter Institute) for organizing the awards.

non-geodesic motion, Wigner rotation and EPR correlations of massive spin-1/2 particles in a gravitational field, demonstrated progress towards an understanding of entanglement in curved space-time by describing the state of massive spin-1/2 particles moving in non-geodesic trajectories in arbitrarily curved space-times. He considered trajectories that correspond to geodesics in the case when spin is ignored, and studied the effects of spin in such motion. He considered, as an example, the entanglement between two massive spin-1/2 particles moving in the presence of a black hole when the particles either fall into the black hole or follow circular geodesic trajectories.

In order to understand the true nature of a quantum and relativistic world, a full theory of quantum gravity is necessary. However, quantizing the gravitational field has proven to be a highly non-trivial task. An important question to consider is how can locality emerge from a quantum theory of gravity that is fundamentally non-local. Fotini Markopoulou (Perimeter Institute), in her talk Quantum graphity: a model of emergent locality, demonstrated that concepts defined in the context of quantum information, such as noiseless subsystems, can be used to construct quantum gravity models in which locality emerges naturally. In the quantum graphity model she presented, subsystems cannot be defined at high temperatures. However, in the ground state subsystems (which can be interpreted as matter) emerge naturally and present local dynamics. This allows for a definition of geometry that is meaningful from a physical point of view.

–Ivette Fuentes-Schuller
Universität Potsdam

Positions Available

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 idurham@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 envrionment. 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 at the University of Calgary invites applications for a tenure-track faculty position in Theoretical Quantum Optics at the assistant or associate professor level to start January 2009. All applicants must have a PhD in Physics or equivalent, postdoctoral experience in theoretical quantum optics, demonstrated excellence in teaching, and a strong record of research achievements in quantum optics, especially in the nexus between quantum optics and quantum information science; will have a track record of successful collaboration with experimentalists; and will be required to teach at the undergraduate and graduate levels and conduct a vigorous research program. More information on the department can be found at http://www.phas.ucalgary.ca and more information on the multidisciplinary Institute for Quantum Information Science, including areas of research, can be found at http://iqis.org/. Applications will be reviewed commencing August 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 future goals, selected reprints, 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 (e-mail: 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.

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the lighter side

MONEY & QUANTUM MECHANICS

$$|\text{money}\rangle = c_1|\text{there}\rangle + c_2|\text{not there}\rangle$$

A measurement is performed when one checks one's bank account.

Rule #1: During a recession or other economic downturn, generally

$$c_2 \gg c_1$$

with c_1 presently hovering near zero.

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 idurham@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:

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