The Quantum Times

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Newsletter of the Topical Group on Quantum Information

American Physical Society

Inside this issue

The First Law of Complexodynamics

Scott Aaronson

A few weeks ago, I had the pleasure of attending FQXi's Setting Time Aright conference, part of which took place on a cruise from Bergen, Norway to Copenhagen, Denmark. This conference brought together physicists, cosmologists, philosophers, biologists, psychologists, and (for some strange reason) one quantum complexity blogger to pontificate about the existence, directionality, and nature of time (see pp. 4-5 for additional thoughts, links, and photographs).

Sean Carroll (Caltech) delivered the opening talk of the conference, during which (among other things) he asked a beautiful question: why does "complexity" or the "interestingness" of physical systems seem to increase with time before hitting a maximum and decreasing, in contrast to the entropy, which of course increases monotonically? In this article I will sketch a possible answer to Sean's question, drawing on concepts from Kolmogorov complexity.

First, some background: we all know the Second Law, which says that the entropy of any closed system tends to increase with time until it reaches a maximum value. Here "entropy" is slippery to define—we'll come back to that later—but somehow measures how "random" or "generic" or "disordered" a system is. As Sean points out in his wonderful book *From Eternity to Here*, the Second Law is almost a tautology: how could a system *not* tend to evolve to more "generic" configurations? If it didn't, those configurations wouldn't be generic! So the real question is not why the entropy is increasing, but why it was ever low to begin with. In other words, why did the universe's initial state at the big bang contain so much order for the universe's subsequent evolution to destroy? I won't address that celebrated mystery in this article, but will simply take the low entropy of the initial state as given.

The point that interests us is this: even though isolated physical systems get monotonically more entropic, they don't get monotonically more "complicated" or "interesting." Sean didn't define what he meant by "complicated" or "interesting" here—indeed, defining those concepts was part of his challenge—but he illustrated what he had in mind with the example of a coffee cup (see Figure 1, p.2). Entropy increases monotonically from left to right, but intuitively, the "complexity" seems highest in the middle picture: the one with all the tendrils of milk. The same is true for the whole universe: shortly after the big bang, the universe was basically just a low-entropy soup of high-energy particles. A googol years from now, after the last black holes have sputtered away in bursts of Hawking radiation, the universe will basically be just a *high*-entropy soup of *low*-energy particles. But today, in between, the universe contains interesting structures such as galaxies and brains and hot-dog-shaped novelty vehicles. The pattern is illustrated in Figure 2 (p. 3).

In answering Sean's provocative question (whether there exists some "law of complexodynamics" that would explain his graph), it seems to me that the challenge is twofold:

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1. Come up with a plausible formal definition of "complexity."
2. Prove that the "complexity," so defined, is large at intermediate times in natural model systems, despite being close to zero at the initial time and close to zero at late times.

To clarify: it's not hard to explain, at least at a hand-waving level, why the complexity should be close to zero at the initial time. It's because we assumed the *entropy* is close to zero and entropy plausibly gives an upper bound on complexity. Nor is it hard to explain why the complexity should be close to zero at late times: it's because the system reaches equilibrium (i.e., something resembling the uniform distribution over all possible states) which we're essentially *defining* to be simple. At intermediate times, neither of those constraints is operative, and therefore the complexity *could* become large. But *does* it become large? If so, *how* large? Can we actually predict? And what kind of "complexity" are we talking about, anyway?

After thinking on and off about these questions, I now conjecture that they can be answered using a notion called sophistication from the theory of Kolmogorov complexity. The Kolmogorov complexity of a string x is the length of the shortest computer program that outputs x (in some Turing-universal programming language—the exact choice can be shown not to matter much). Sophistication is a more … well, sophisticated concept, but we'll get to that later.

As a first step, let's use Kolmogorov complexity to define entropy. Already it's not quite obvious how to do that. If you start, say, a cellular automaton, or a system of billiard balls, in some simple initial configuration, and then let it evolve for awhile according to dynamical laws, visually it will look like the entropy is going up. But if the system happens to be *deterministic*, then mathematically, its state can always be specified by giving (1) the initial state, and (2) the number of steps t it's been run for. The former takes a constant number of bits to specify (independent of t), while the latter takes $\log(t)$ bits. It follows that, if we use Kolmogorov complexity as our stand-in for entropy, then the entropy can increase at most *logarithmically* with t—much slower than the linear or polynomial increase that we'd intuitively expect.

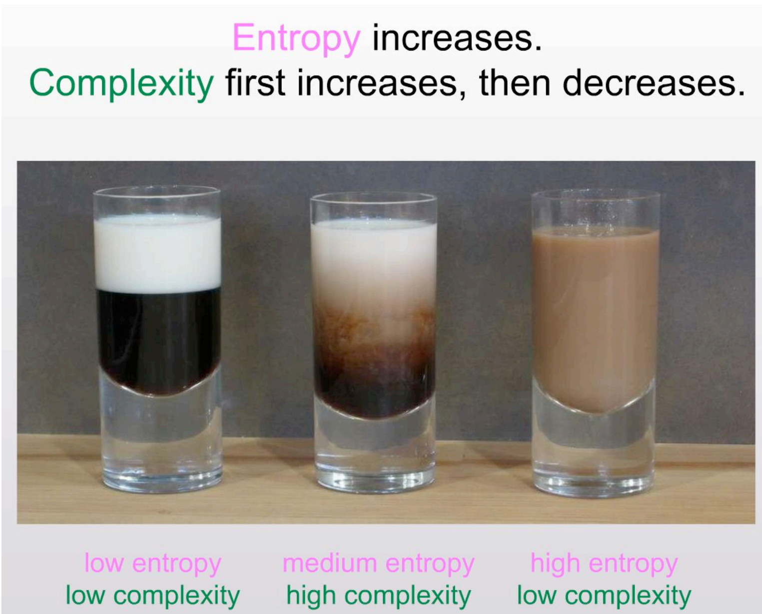

Figure 1. Complexity peaks in the middle glass while entropy continues to increase as the substances become more mixed. (*Courtesy Sean Carroll.*)

There are at least two ways to solve this problem. The first is to consider probabilistic systems, rather than deterministic ones. In the probabilistic case, the Kolmogorov complexity really does increase at a polynomial rate, as you'd expect. The second solution is to replace the Kolmogorov complexity by the *resource-bounded Kolmogorov complexity*: the length of the shortest computer program that outputs the state *in a short amount of time* (or the size of the smallest, say, depth-3 circuit that outputs the state—for present purposes, it doesn't even matter much what kind of resource bound we impose, as long as the bound is severe enough). Even though there's a computer program only $\log(t)$ bits long to compute the state of the system after t time steps, that program will typically use an amount of *time* that grows with t (or even faster), so if we rule out sufficiently complex programs, we can again get our program size to increase with t at a polynomial rate.

OK, that was entropy. What about the thing Sean called "complexity"—which, to avoid confusion with other kinds of complexity, from now on I'm going to call "complextropy?" For this, we're going to need a cluster of related ideas that go under names like sophistication, Kolmogorov structure functions, and algorithmic statistics. The backstory is that, in the 1970s (*after* introducing Kolmogorov complexity), Kolmogorov made an observation that was closely related to Sean's observation above. A uniformly random string, he said, has close-to-maximal Kolmogorov complexity, but it's also one of the *least* "complex" or "interesting" strings imaginable. After all, we

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can describe essentially everything you'd ever want to know about the string by saying "it's random!" But is there a way to formalize that intuition? Indeed there is.

First, given a set S of n-bit strings, let $K(S)$ be the number of bits in the shortest computer program that outputs the elements of S and then halts. Also, given such a set S and an element x of S, let $K(x|S)$ be the length of the shortest program that outputs x, given an oracle for testing membership in S. Then we can let the *sophistication* of x, or Soph(x), be the smallest possible value of $K(S)$, over all sets S such that

1. $x \in S$; and
2. $K(x|S) \geq \log_2(|S|) - c$, for some constant c. (In other words, one can distill all the "nonrandom" information in x just by saying that x belongs to S.)

Intuitively, Soph(x) is the length of the shortest computer program that describes, not necessarily x itself, but a set S of which x is a "random" or "generic" member. To illustrate, any string x with small Kolmogorov complexity has small sophistication since we can let S be the singleton set $\{x\}$. However, a uniformly-random string also has small sophistication, since we can let S be the set $\{0,1\}^n$ of all n-bit strings. In fact, the question arises as to whether there are *any* sophisticated strings! Apparently, after Kolmogorov raised this question in the early 1980s, it was answered in the affirmative by Alexander Shen. The construction is via a diagonalization argument that's a bit too complicated for this article.

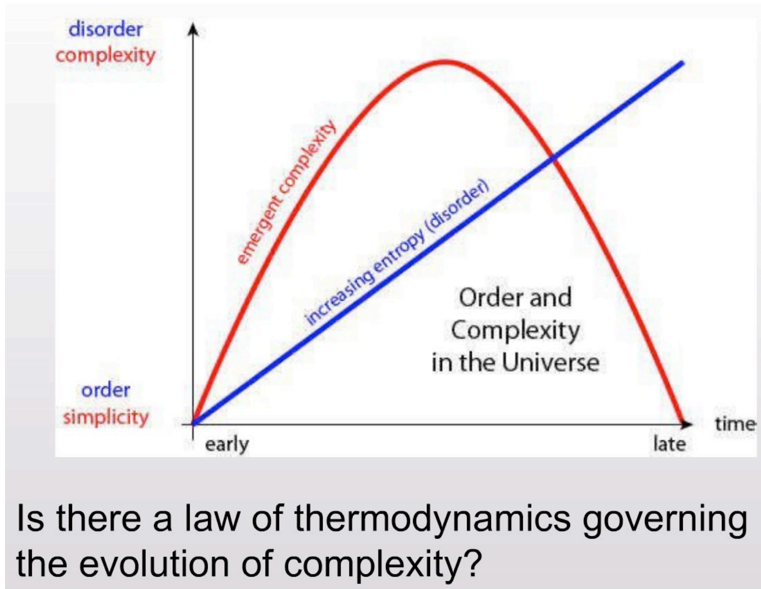

Figure 2. Order and complexity in the universe versus time. (*Courtesy Sean Carroll.*)

But what does any of this have to do with coffee cups? Well, at first glance, sophistication seems to have exactly the properties that we were looking for in a "complextropy" measure: it's small for both simple strings *and* uniformly random strings, but large for strings in a weird third category of "neither simple nor random." Unfortunately, as we defined it above, sophistication still doesn't do the job. For deterministic systems, the problem is the same as the one pointed out earlier for Kolmogorov complexity: we can always describe the system's state after t time steps by specifying the initial state, the transition rule, and t. Therefore the sophistication can never exceed $\log(t) + c$. Even for probabilistic systems, though, we can specify *the set S(t) of all possible states* after t time steps by specifying the initial state, the probabilistic transition rule, and t. And, at least assuming that the probability distribution over $S(t)$ is uniform, by a simple counting argument the state after t steps will almost always be a "generic" element of $S(t)$. So again, the sophistication will almost never exceed $\log(t) + c$. (If the distribution over $S(t)$ is *nonuniform*, then some technical further arguments are needed, which I omit.)

How can we fix this problem? I think the key is to bring computational resource bounds into the picture. (We already saw a hint of this in the discussion of entropy.) In particular, suppose we define the complextropy of an n-bit string x to be something like the following:

> the number of bits in the shortest computer program that runs in $n \log(n)$ time, and that outputs a nearly-uniform sample from a set S such that (i) $x \in S$, and (ii) any computer program that outputs x in $n \log(n)$ time, given an oracle that provides independent, uniform samples from S, has at least $\log_2(|S|) - c$ bits, for some constant c.

Here $n \log(n)$ is just intended as a concrete example of a complexity bound: one could replace it with some other time bound, or a restriction to (say) constant-depth circuits or some other weak model of computation. The motivation for the definition is that we want some "complextropy" measure that will assign a value close to 0 to the first and third coffee cups in the picture, but a large value to the second coffee cup. And thus we consider the length

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Aaronson, continued

of the shortest efficient computer program that outputs, not necessarily the target string x itself, but a sample from a probability distribution D such that x is not efficiently compressible with respect to D. (In other words, x looks to any efficient algorithm like a "random" or "generic" sample from D.)

Note that it's essential for this definition that we imposed a computational efficiency requirement in *two* places: on the sampling algorithm, and *also* on the algorithm that reconstructs x given the sampling oracle. Without the first efficiency constraint, the complextropy could never exceed $\log(t) + c$ by the previous argument. Meanwhile, without the second efficiency constraint, the complextropy *would* increase, but then it would probably keep right on increasing, for the following reason: a time-bounded sampling algorithm wouldn't be able to sample from *exactly* the right set S, only a reasonable facsimile thereof, and a reconstruction algorithm with *unlimited time* could probably then use special properties of the target string x to reconstruct x with fewer than $\log_2(|S|) - c$ bits.

But as long as we remember to put computational efficiency requirements on *both* algorithms, I *conjecture* that the complextropy will satisfy the "First Law of Complexodynamics," exhibiting exactly the behavior that Sean Carroll wants: small for the initial state, large for intermediate states, then small again once the mixing has finished. I don't yet know how to prove this conjecture. But crucially, it's *not* a hopelessly open-ended question that one tosses out just to show how wide-ranging one's thoughts are, but a relatively-bounded question about which actual theorems could be proved and actual papers published.

If you want to do so, the first step will be to "instantiate" everything I said above with a particular model system and particular resource constraints. One good choice could be a discretized "coffee cup," consisting of a 2D array of black and white pixels (the "coffee" and "milk"), which are initially in separated components and then subject to random nearest-neighbor mixing dynamics (e.g., at each time step, we pick an adjacent coffee pixel and milk pixel uniformly at random, and swap the two). Can we show that for such a system, the complextropy becomes large at intermediate times (intuitively, because of the need to specify the irregular *boundaries* between the regions of all-black pixels, all-white pixels, and mixed black-and-white pixels)?

One could try to show such a statement either theoretically or empirically. Theoretically, I have no idea where to begin in proving it, despite a clear intuition that such a statement should hold: let me toss it out as a wonderful (I think) open problem! At an empirical level, one could simply try to *plot* the complextropy in some simulated system, like the discrete coffee cup, and show that it has the predicted small-large-small behavior. One obvious difficulty here is that the complextropy, under any definition like the one I gave, is almost certainly going to be intractable to compute or even approximate. However, one could try to get around that problem the same way many others have, in empirical research inspired by Kolmogorov complexity: namely, by using something you *can* compute (e.g., the size of a gzip compressed file) as a rough-and-ready substitute for something you *can't* compute (e.g., the Kolmogorov complexity $K(x)$). In the interest of a full disclosure, a wonderful MIT undergrad, Lauren Oullette, recently started a research project with me where she's trying to do exactly that. So hopefully, by the end of the semester, we'll be able to answer Sean Carroll's question at least at a physics level of rigor! Answering the question at a math/CS level of rigor could take a while longer.

***Scott Aaronson** is Associate Professor of Electrical Engineering and Computer Science at MIT, and is the creator both of the Complexity Zoo and of the sporadic blog Shtetl-Optimized. His research interests center around quantum computing and computational complexity theory more generally. He was born in Philadelphia.*

FQXi CONFERENCES

SETTING TIME ARIGHT *An international and inter-disciplinary meeting investigating the Nature of Time*

Bergen – Copenhagen, August 27 – September 1, 2011

Among those in attendance from the quantum information and foundations community were Scott Aaronson, Howard Barnum (GQI Executive Committee member), Caslav Brukner, Peter Byrne, Bob Coecke, Ian Durham (editor of this rag), Nicolas Gisin, Claus Kiefer, Fotini Markopoulou, and Jeff Tollaksen.

Videos, slides, photos, and more: http://fqxi.org/conference/home/2011

Select photographs appear on the next page.

The house in which Neils Bohr was born (top left, including inset); University of Copenhagen as seen from the King's Garden (top right); Times editor Ian Durham just prior to being admonished by the ship's crew (left); a strangely apropos sign discovered in a random neighborhood of Bergen (above, middle); the National Geographic Explorer as seen through the spray of a Zodiac on Åbyfjorden, Sweden (above, right); the buildings at the Neils Bohr Institute where Bohr carried out much of his work (bottom, including inset). All photographs by Alyson Durham except sign (above, middle) by Ian T. Durham.

Quantum Information for Foundations at the APS March Meeting 2012

Giulio Chirabella

As most of you probably know, this coming year the APS March Meeting will be held at the Boston Convention Center (Boston, Massachusetts) from February 27 to March 2, 2012. As in past years, this year's program will feature a number of stimulating sessions on quantum information. In particular, I would like to draw your attention to the focus session "Quantum Information for Quantum Foundations" that will be dedicated to the contribution of quantum information to the understanding of quantum mechanics.

The presence of a foundational session at the March Meeting has been a far-sighted achievement of the Topical Group on Quantum Information. Among other things, this session is a reminder that quantum information is not only a technological endeavor, but also a key chapter of fundamental physics that should become part of the shared knowledge of the whole scientific community. However, every achievement has to be maintained by our active participation: we need to prove that the space dedicated to foundational research at the APS March Meeting is well deserved, and that our research field is healthy, creative, and authoritative.

How do we achieve that? The answer is simple: by responding with a visible participation at the meeting, by presenting talks demonstrating the best of foundational research in quantum information, and by inviting researchers outside our own field to attend. It is important to show that in our community there is novelty, excitement, and fresh ideas whose impact goes far beyond the borders of a small group of experts.

The good news is that we don't have to fake any of these things: It is simply true that the synergy between quantum information and quantum foundations has brought fundamental research on quantum mechanics into a new golden age. Thanks to the injection of ideas from quantum information, the field of quantum foundations is now growing, with many researchers joining the community and with a burst of exciting new results. Over the past few years we saw derivations of quantum theory from basic operational principles, we learned about non-local games and principles that could eventually lead to an operational characterization of the set of quantum correlations, we discovered new links about fundamental quantum features like non-locality and the uncertainty principle, and we witnessed great progress in the diagrammatic, Bayesian, and modal approaches to quantum theory. Ideas from quantum information are currently providing deep insights into the foundations of thermodynamics (in particular on the resource theory of thermal machines and on equilibration in closed systems) and of field theory. Also, there are ongoing explorations of the role of causal structures in quantum circuits and the study of quantum protocols that go beyond the causal scenario. Finally, we should not forget the numerous results in quantum information that, even without being explicitly foundational, continue to shed a bright light on the operational features of quantum theory. It is enough to have such a vibrant scientific landscape represented next March in Boston to make the foundational session memorable.

Another encouraging point is the success of last year's foundations session organized by Chris Fuchs, who succeeded in attracting a remarkable number of top-quality contributors and participants. The broad interest associated with last year's session can be seen as part of a positive trend for fundamental and conceptual research. Let us confirm the trend and maintain a strong foundational presence at the next APS March Meeting!

This year's session will start with an invited talk by Valerio Scarani (Centre for Quantum Technologies, Singapore), who will speak about "Information causality as a physical principle". Valerio's talk will then be followed by a lineup of contributed talks, which will hopefully be as profuse and lively as those from last year's session. Abstracts for contributed talks can now be submitted here: http://www.aps.org/meetings/abstract/index.cfm. Please spread the word and remind your colleagues that the deadline for submissions is November 11th 2011.

Regarding contributed talks, chatting with colleagues, I have sometimes noticed that potential speakers and participants are discouraged by the 12 minute format, which seems too short to present all the relevant details. It is useful to remember, however, that presenting details is not really the point here: the APS Meetings are huge events with over 7,000 in attendance where the primary aim is to highlight new advancements and advertise new ideas across a broad range of fields. The format of the March Meeting is designed to rapidly disseminate new results. If you discover that you would like to know more about one particular result, there is still enough free time where you can interact directly (and more efficiently) with the speaker about the details of her/his work.

So, let's make the foundational space at the March Meeting an exciting forum for the exchange of new ideas! And let us also try to attract researchers outside our field, to show how valuable foundational research in quantum information can be. We can promise them that they will hear something stimulating, that they will not be overloaded by a flood of hyper-technical details, and that they will bring back home some new insights on the charming mysteries of quantum mechanics!

Giulio Chirabella *is a Senior Postdoctoral Fellow at the Perimeter Institute for Theoretical Physics.*

Bits, BYTES, *and Qubits*

QUANTUM NEWS & NOTES

Kochen-Specker contextuality test

In 1967 Simon Kochen and Ernst Specker proved mathematically that in the quantum world, the result of a measurement of some property depends on the context in which it is measured. This is taken by many as proof that there is no independent reality outside of the measurement process. In 2008 Alexander Klyachko of Bilkent University in Ankara, Turkey and his colleagues proposed an experiment to test the Kochen-Specker contextuality result. They calculated that repeated measurements of five different pairs of properties of a quantum particle that was in a superposition of three states would give results entirely inconsistent with hidden variable models. It took until only recently for that proposal to finally be realized experimentally. In what has been called a "beautiful experiment" (by Aephraim Steinberg of the University of Toronto in an interview with *New Scientist*), Radek Lapkiewicz, Anton Zeilinger, and their colleagues with the University of Vienna and the Austrian Academy of Sciences have repeated a sequence of five pairs of measurements on various properties of photons where each photon was in a superposition in which it simultaneously took three paths. They repeated these measurements tens of thousands of times and the resulting statistics were skewed in such a way that hidden variable models were definitively ruled out.

A conundrum of probabilities ... or not

Two years ago cosmologists Alan Guth of MIT and Vitaly Vanchurin of Stanford came up with the following interesting conundrum. Suppose you are in a back room in a casino, perhaps in Las Vegas or Monte Carlo (cue the James Bond theme music) and you are given a fair coin to flip. You won't be allowed to see the outcome and the instant the coin lands you will fall into a deep sleep ... zzzzzz. What? Oh, right. Anyway, if the coin turns out to be heads, the dealer will wake you up after you've been asleep for one minute. If it's tails, you get to nap for an hour. When you wake up you will have absolutely no idea how long you've slept and so you won't be able to infer the outcome from the way you feel or the way the room appears. So the dealer smiles - a particularly evil smile - and asks you what you'd like to put your money on - heads or tails. Knowing it's a fair coin you *assume* that your chances are 50/50 and, envisioning a bird clutching something in its talons, you choose tails. But if we inhabit an infinite multiverse and the dealer knows this, then the dealer also knows that you will almost certainly lose. Why?

In an infinite multiverse anything that *can* happen, *will* happen an infinite number of times (it's like Murphy's Law ... over and over and over again). But if that's the case, how can anything be any more or less probable than anything else? In an infinite multiverse, if one needs to rely on probabilities for predictive purposes (how 'bout that alliteration?), one would run into a serious problem. One method for dealing with this apparent problem involves arbitrarily choosing some finite time cut-off, tallying all the results that occurred prior to that cut-off, and taking those results as a representative sample.

Now here's the conundrum - and how the dealer can guarantee that you will lose your money. Suppose in the casino example that the dealer (who is rather talented, I might add) "chooses" the cut-off to be less than an hour but more than a minute. This "slices" through all the one-hour naps that copies of you have taken making it appear as if those copies of you never woke up. So if you *did* wake up, the result ought to be heads and so *heads ought to be more probable than tails*. Last year, Raphael Bousso of UC Berkeley (and another one of the speakers at the FQXi conference) along with some colleagues noted that in order for this to be a true conundrum and not just a bit of mathematical trickery, *time really has to end at the cut-off*! When you wake up, you are confronted with new information: time didn't end which means you slept for a minute rather than an hour and the coin was thus heads. So it was assumed, then, that time has to end in order for probabilities to make sense (at least in the context of a multiverse).

But now, Guth and Vanchurin (who were apparently bugged by their own result) have found a way around the problem (recently posted to the arXiv: http://arxiv.org/abs/1108.0665). They begin by constructing a mathematical model for an infinite multiverse that doesn't require a measure. This allows probabilities, which obey all the standard requirements for a probability measure, to be be defined by mathematical limits. However, the probabilities acquire an unusual feature in the Guth-Vanchurin model: if the outcome of an experiment is reported with a time delay *that depends on the outcome* (exactly as it does in the conundrum), then the observation *of the reports* will be biased in favor of the shorter time delay. The idea is that you really don't need any new information to understand that the probabilities are no longer 50/50. In other words, you ought to be at least as smart as the dealer. Hmmm. Seems like there's quite a bit that is worth some additional analysis. I wonder what Charlie Bennett would have to say about all of this...

–ITD

Perturbation Theory
Nicole Yunger Halpern

MY REACTION
TO PERTURBING
MIGHT APPEAR
A MITE DISTURBING.

BRING TO LIGHT
MY IMPERFECTIONS
ONCE, AND YOU'LL
FORSWEAR CORRECTIONS.

TRUTHFULNESS
INTOXICATES,
BUT ALL WHO LIVE
APPROXIMATE.

CORRECT ME, AND
I'LL CEASELESSLY
PLOT MURDER OF
THE FIRST DEGREE.

APS Topical Group on Quantum Information

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Editor
Ian T. Durham
Department of Physics
Saint Anselm College
Manchester, NH
idurham@anselm.edu

Contributions
Contributions from readers for any and all portions of the newsletter are welcome and encouraged. We are particularly keen to receive

- **op-ed pieces and letters** (the APS is *strongly* encouraging inclusion of such items in unit newsletters)
- **books reviews**
- **review articles**
- **articles describing individual research** that are aimed at a broad audience
- **humor** of a nature appropriate for this publication

Submissions are accepted at any time. They must be in electronic format and may be sent to the editor at idurham@anselm.edu. Acceptable forms for electronic files (other than images) include LaTeX, Word, Pages (iWork), RTF, PDF, and plain text.

Editorial policy
All opinions expressed in *The Quantum Times* are those of the individual authors and do not represent those of the Topical Group on Quantum Information or the American Physical Society in general.

Special Symposium on "Exploring the Frontiers of Quantum Communications"
at CLEO:2012, 6-11 May, 2012, San Jose, CA

Contributed papers due by 17:00GMT 5 December, 2011.

Tom Chapuran (Telcordia), Richard Hughes (LANL), Bob Jopson (Bell Labs) and Jane Nordholt (LANL) are organizing a Special Symposium on "Exploring the Frontiers of Quantum Communications" at CLEO:2012, which will have three sessions:

Session 1: "Quantum Limits to Classical Communications"
Session 2: "Quantum Channel Capacities and Quantum Memory"
Session 3: "Device-independent QKD and Quantum Random Numbers"

with invited talks by: Marcos Curty, Hamid Hemmati, Stefano Pironio, Jeffrey Shapiro, Wolfgang Tittel and Jon Yard.

Please consider submitting a contributed paper on your latest quantum communications research results to this CLEO:2012 Symposium.

More information about the Symposium will be available shortly at the CLEO:2012 web site:

http://www.cleoconference.org/home.aspx

Openings of Tenure-Track Faculty Positions at Tsinghua University
http://iiis.tsinghua.edu.cn/en/

Led by the famous computer scientist and the Turing Award laureate, Prof. Andrew Chi-Chih Yao, the Center for Quantum Information (CQI) and the Institute for interdisciplinary Information Science (IIIS) are supported by Tsinghua University and Chinese government, with an aim to build a world-class research and education center for Quantum Information and Interdisciplinary Sciences. The CQI adopts the management method of top western institutions and provides excellent support for young researchers.

The CQI and IIIS currently invite applications for tenure-track and research-track faculty positions. The interested areas include but are not limited to Quantum Computation, Communication, Network, Cryptography, Quantum Simulation, Metrology, Many-body Physics, Modeling of Complex Systems, Econophysics, Financial Engineering, etc. People with backgrounds in experimental or theoretical quantum information, atomic optical physics, condensed matter, computer science, electric engineering, and other interdisciplinary fields are encouraged to apply.

Depending on qualification of the applicants, the CQI will offer corresponding positions and internationally competitive salary and benefits. The CQI will also support the qualified applicants to apply the Chinese National Recruitment program the "Youth 1000-Talents" fellowship. Interested applicants should send a detailed curriculum vita with publication list, a teaching and research statement, names and contact addresses of 3 to 5 people who can provide reference letters, by email to the following address:

iiisdean@mail.tsinghua.edu.cn

Tenure Track Position in Department of Physics and Astronomy
University of New Mexico
Quantum Information Theory

The Department of Physics and Astronomy (P&A) at the University of New Mexico invites applications for a tenure-track position (probationary appointment leading to a tenure decision) in Theoretical Physics, specializing in Quantum Information Theory. The successful applicant will be expected to participate in the teaching of undergraduate and graduate classes. They will be engaged in building a strong research group in quantum information science that enhances the activities of the Center for Quantum Information and Control (CQuIC) and strengthens P&A's degree programs. A minimum requirement for this position is a PhD in Physics or a closely related field. Preference will be given to candidates who possess a breadth of research experience, a strong publication record, promise of scholarship, and a strong commitment to teaching at both graduate and undergraduate levels, the potential to supervise student researchers, and the potential to enhance activities of CQuIC. The expected starting date for this position is August 2012. The University of New Mexico is an Equal Opportunity/Affirmative Action Employer and Educator. Qualified women and minorities are strongly encouraged to apply.

Application procedure: Applicants must apply online at http://www.unm.edu/jobs/ (posting number 0813055), where they will submit a CV and a statement of research interests and teaching philosophy. After the application is submitted, applicants will be asked to supply the names and contact information of three references to the Search Committee. For best consideration application materials should be received by December 1, 2011, but applications will be accepted until the position is filled. Enquiries can be addressed to the Search Co-ordinator, Lina Sandve, at lsandve@unm.edu.

Tenure-Track Theory Position
Assistant Professor in Physics
Southern Illinois University Carbondale (SIUC)

The Physics Department, Southern Illinois University Carbondale (SIUC) invites applications for one full-time, tenure-track, Assistant Professor in the Department of Physics, starting August 16, 2012.

We are seeking a theorist working in computational physics in one of the following areas: quantum computing or soft condensed matter, especially those that will complement our current areas of research and strengthen our doctoral program in Applied Physics. Generous start-up funds are available at a level that will enable the successful applicant to establish a nationally competitive research effort. Applicants must hold a Ph. D. in Physics or closely related field, must have postdoctoral research experience with evidence of excellence in scholarship, and must have experience in teaching physics.

The successful candidate is expected to pursue a vigorous research program, publish in high quality professional journals, actively seek and attract external funding, and teach and develop undergraduate and graduate courses.

Applicants should send a letter of application, curriculum vitae, a research plan (no more than two pages long), a statement of teaching philosophy (no more than one page) and the contact information including e-mails of four references to:

Theory Search Committee
Department of Physics, Mail Code 4401,
Southern Illinois University Carbondale
1245 Lincoln Dr.
Carbondale, IL 62901
or submit the requested materials electronically to: spleasure@physics.siu.edu

We will begin reviewing applications on 11/15/2011 and will continue until the position is filled.

SIUC is an affirmative action/equal opportunity employer that strives to enhance its ability to develop a diverse faculty and staff and to increase its potential to serve a diverse student population. All applications are welcomed and encouraged and will receive consideration.